# 1

333en01

# ORIGIN OF EARTH AND EVOLUTION OF THE ENVIRONMENT

We live on a beautiful planet called earth, along with a wide variety of plants, animals and other organisms. Our earth, however, is part of a vast universe. The universe is about 15 to 20 billion years old. The age of the earth is approximately 4 to 5 billion years, while human beings evolved only around 2 million years ago. In this lesson, you shall learn how the earth originated, how it got its own environment and in what ways human beings have been using the environmental resources for their welfare and development.

## OBJECTIVES

After completing this lesson, you will be able to:

- *trace the origin of the earth;*
- *list the conditions, which make the earth a unique planet for supporting life;*
- *describe the sequence of steps in the origin and evolution of life prior to the appearance of humans;*
- *explain the term environment;*
- *enumerate the various biotic and abiotic constituents of the environment.*

## 1.1 EARTH AS PART OF THE UNIVERSE AND THE SOLAR SYSTEM

Our earth, with all its diversity alongwith other planets and their satellites, the sun, the moon, the many galaxies (huge groups of millions of stars) form the universe. There are also countless asteroids and comets in orbit around the sun. All these are also part of the universe. It extends much farther than can be seen by the most powerful telescope. No one knows where the universe ends.

When you look up at the sky on a clear night, you see many points of light – most of which are stars. Stars are huge balls of bright, hot glowing gases. The 'Sun' is also a star. It is the star nearest to earth – about 150 mk (million kilometers) away. **A solar system** consists of a star in the middle with a number of planets orbiting around it. The earth is a part of its solar system. It is one of the eight planets of the solar system that has the sun (a star) in the middle and the eight planets moving around it. Until recently solar system was believed to have nine planets. However, on the basis of the latest scientific assessment, Pluto, is no longer regarded as a planet of earth's solar system. (Fig. 1.1)

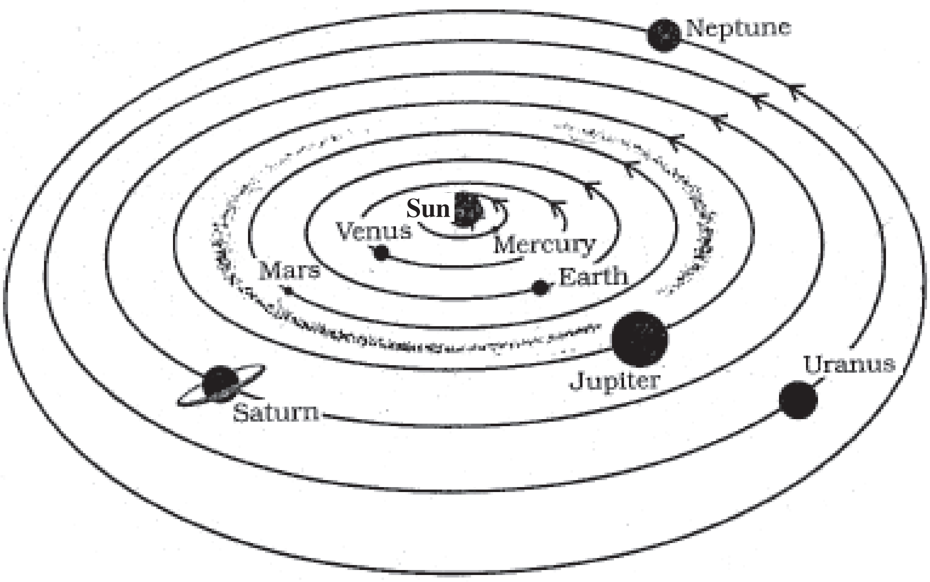
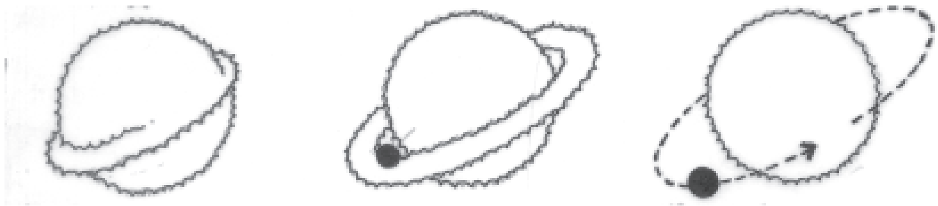



***Fig. 1.1:** Planets orbiting the sun*

## 1.2 ORIGIN OF THE UNIVERSE AND ORIGIN OF THE EARTH

The widely accepted theory of the origin of universe is the "BIG BANG" theory. According to this theory, universe started with a huge explosion and matter (dust and gases) filled the entire space. The temperature of the universe then, was about hundred billion degrees Celsius. Scientists believe that the big bang occurred about 15 to 20 billion years ago. The huge collection of dust and gases then began to spin. As it spun faster and faster, the centre became very hot. It became the Sun. From the edges of this ball of dust and gas, big blobs or chunks of dust broke off and formed eight ball shaped planets. This founded our solar system (Fig. 1.2). The earth broke off about 4.5 billion years ago with an explosion. It was a burning hot white mass of gas and dust. Over a long period of time, dust and gas gradually condensed to form solid rock. Such condensation and shrinking made the earth heat up so much that the rock melted into a gluey liquid. After millions of years, the outer surface of the earth or the earth's crust cooled and formed hard rock again, just as melted chocolate or wax solidifies upon cooling. The interior of the earth is still very hot.



Vast rotating mass of gas becomes spherical and bulges at its equator
(a)

Ring of matter flung off from central mass
(b)

Ring of matter cools, contracts becoming a solid planet in the oribit of the central mass which becomes sun
(c)

*Fig. 1.2: Formation of planets*

The **crust** of the earth was formed from cooling and hardening of the molten matter and hot gases. With cooling of the earth the crust hardened and formed the land. Cooling of the earth also condensed water vapour into liquid water filling the depressions to form seas.

### 1.2.1 The earth

The earth with its blue skies, vast oceans and lush green forests is the home to wide variety of organisms. It has its own unique atmosphere. The atmosphere also helps to regulate the ambient (surrounding) temperature which is suitable for supporting life.

If you could dig a deep hole into earth the deeper you go, the hotter it becomes. At the depth of about eight km it is hot enough to roast a human body. About 32 km deep you would reach the part of earth which is called **mantle.** This is made of hard rock. The centre or **core** of the earth is approximately 6,400 km from the surface having a temperature close to 5000ºC. Much of the earth's core is hot liquid (Fig. 1.3a)

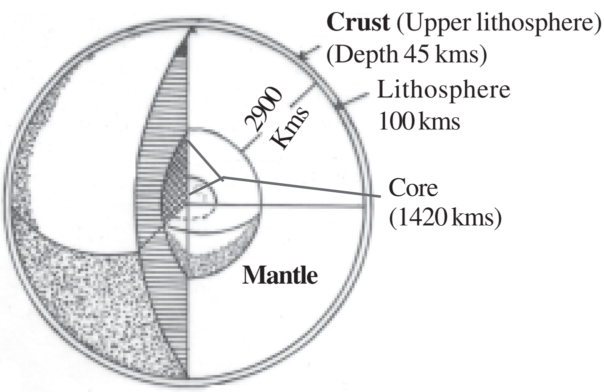



*Fig. 1.3a: Interior of the earth*

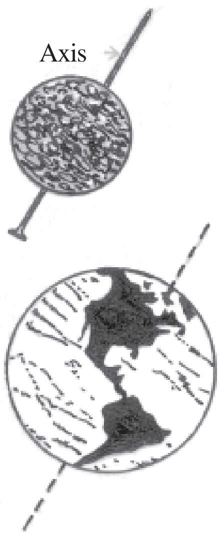



*Fig. 1.3b: Rotation of the earth*

As you already know, once every 24 hours, the earth rotates on its axis like a spinning top. So the day and night cycle is of 24 hours. A planet's axis is an imaginary line passing through the centre of the planet. (Fig. 1.3b). The earth not only rotates around its axis but also revolves around the sun . The earth completes one full circle around the sun or completes one orbit of the sun in 365¼ days. An orbit is the path along which a planet moves around the sun.

While earth revolves around the sun, moon orbits the earth. The moon completes one orbit in 27.33 days. The moon, as we know today, is without water and air and life. From the space, the earth looks like a beautiful bright bluish planet because of its blue oceans.

## INTEXT QUESTIONS 1.1

1. Approximately how old is the earth?

   ______________________________

2. Name the star around which the earth revolves along with other planets of the solar system.

   ______________________________

3. What do you mean by "solar system"?

   ______________________________

4. Why does the day and night cycle consist of only 24 hours?

   ______________________________

5. If you were to view earth from space, which colour would earth reflect?

   ______________________________

## 1.3 EARTH–THE UNIQUE PLANET WHICH SUSTAINS LIFE

In our solar system, earth is the only planet which is known to sustain life. Only earth has air and water to support life.

Let us briefly review the conditions on the other seven planets of the solar system.

- **Mercury** (Buddha) is closest to the sun. It has a temperature range of 427ºC on its side facing the Sun and – 270ºC, on its dark side. It has no atmosphere.
- **Venus** (Shukra) is the closest neighbour of the earth. It is about 40 mk away. It is an extremely hot planet with a temperature of 480ºC. Its atmosphere has 96% carbon dioxide and poisonous gases like sulphur dioxide and carbon monoxide.
- **Mars** (Mangal) is also close to earth. It is called the red planet. It has 95% carbon monoxide and reddish dust. It is relatively a very cold planet and as of now presence

of life on it has not been conclusively established.

- **Jupiter** (Brahaspati) is the largest planet of the solar system. It is mainly a rapidly spinning ball of gas specially clouds of ammonia, and has no solid surface.
- **Saturn** (Shani) consists mainly of hydrogen and helium. Its atmosphere has 90% nitrogen and a temperature of (-184ºC). It is also made up of hydrogen cyanide which is a highly poisonous gas. It is characterized by a ring that surrounds it.
- **Uranus** (Arun) is also a very cold planet. Uranus is a distant planet of solar system and $7^{th}$ in order from the sun. Uranus and Neptune are the outermost planets of the solar system. Uranus has a highly tilted rotational axis.
- **Neptune** (Varun) is much smaller than earth, cold and dark with its surface coated with frozen methane.
- **Earth** is the only planet known to sustain life.

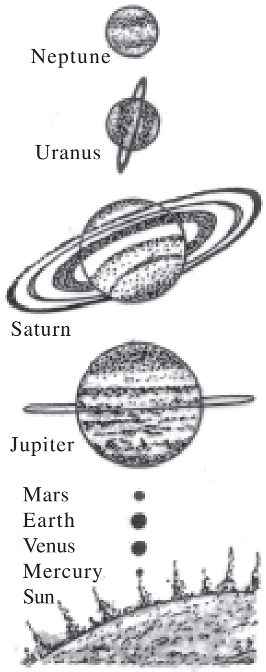



***Fig. 1.4:*** *Our solar system*

Scientists do not know of any other planet in the universe besides the earth, where there is life. There are hundreds of stars in the universe and they have planets orbiting round them. But whether the necessary conditions to support life exist there is not known.

As compared to other planets mentioned above, earth has the following unique conditions which have enabled it to sustain life.

### 1.3.1 Conditions necessary for sustaining life

#### a. Presence of water

As already mentioned, during the evolution of the earth, water vapour in the primitive atmosphere condensed into liquid water. This gave rise to the formation of oceans, rivers and other fresh water bodies. Three-fourth of earth's surface is covered with water.

Water is a universal solvent and life originated in water. Two thirds of a living organism consists of water and 90 percent of cell content is also water. Biochemical reactions in living organisms require an aqueous medium. Therefore, water is important for the survival of living organisms.

#### b. Atmosphere

The earth is enveloped by a gaseous atmosphere that supports life. The earth's atmosphere consists of nitrogen (78%) and oxygen (21%), small amounts of carbon dioxide, water vapour, ozone and rare gases like argon, neon etc.

Oxygen from the atmosphere is used by the living organisms during respiration. Oxygen is necessary to oxidize food for liberating energy required for various activities in the living organisms. Green plants utilize carbon dioxide from the atmosphere during photosynthesis.

**c. Temperature**

The average temperature of the earth is 16ºC. This is the most comfortable temperature for the living organisms to survive.

**d. Buffering capacity of earth**

The most unique feature of the earth is its buffering action due to which a neutral pH (pH-7) is maintained in the soil and water bodies. The neutral pH is congenial for the survival and sustenance of living organisms.

Earth gets light from the sun, the star nearest to earth, approximately 150 km away. It is the ultimate source of energy.

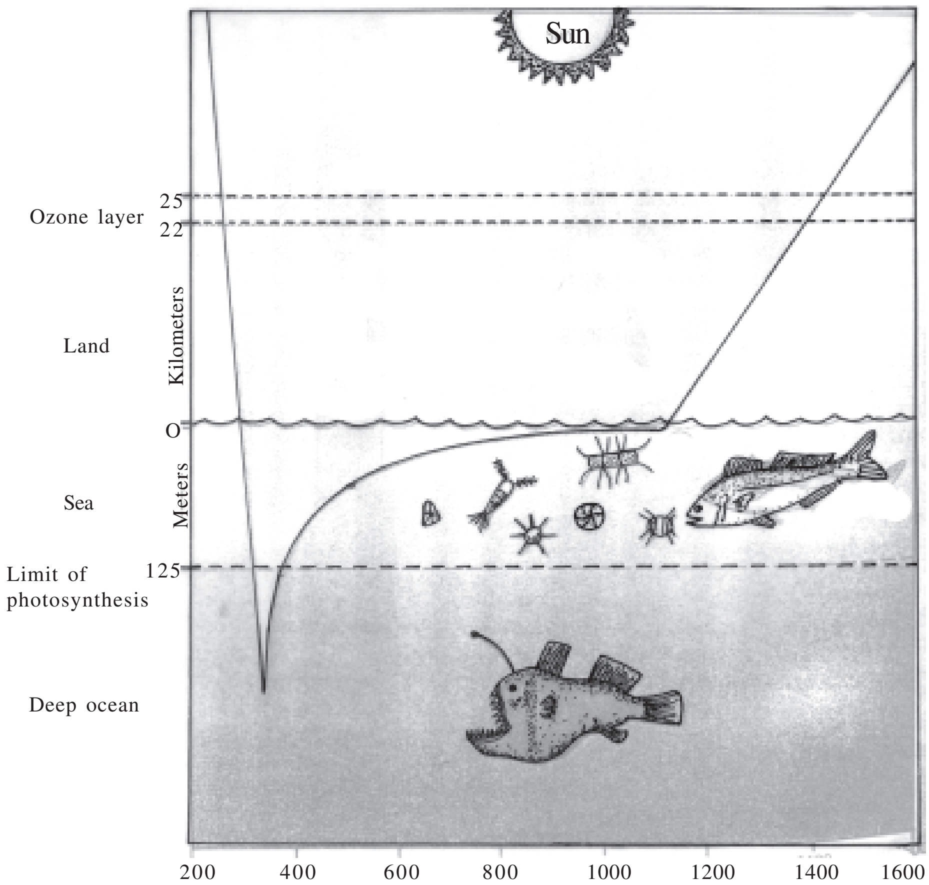



***Fig. 1.5:*** *Solar radiations and life on the earth*

## INTEXT QUESTIONS 1.2

1. List the conditions that make earth a unique planet.

______________________________________________

2. From where earth gets energy?

3. Why oxygen is essential for life?

## 1.4 ORIGIN AND EVOLUTION OF LIFE PRIOR TO THE APPEARANCE OF HUMAN BEINGS

To begin with, conditions on earth were inhospitable for life. Gases of the primitive atmosphere were primarily methane, ammonia, carbon dioxide and hydrogen. Water vapour filled the atmosphere but there was no free oxygen. It was thus a reducing atmosphere on primitive earth and no life existed.

**Biological evolution- from the simple organisms to complex organisms**

As earth cooled, water vapour condensed to form liquid water. Rains poured to form water bodies on earth. The molecules of life were formed in the water.

From the molecules of the life evolved bacteria, the earliest and simplest organisms. The oldest fossils of bacteria which were the first living organisms on earth have been found in rocks that are 3-5 billion years old.

For almost two billion years, different kinds of bacteria lived on earth. One of these evolved a green pigment called chlorophyll. These chlorophyll-containing bacteria used carbon dioxide and water and released oxygen through photosynthesis and started accumulating in the atmosphere.

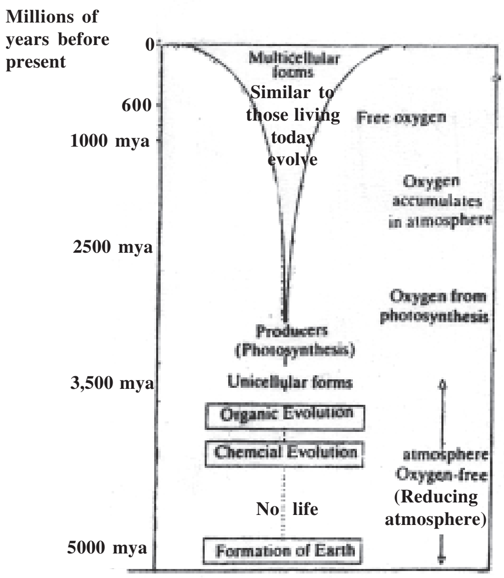



***Fig. 1.6:** Diagrammatic representation of major events of life on earth (mya = millions of years ago)*

Continued photosynthesis by such bacteria progressively accumulated oxygen in the atmosphere. Thus the atmosphere gradually transformed from reducing to oxidizing. At one point of time oxygen content in the atmosphere become 21%.

Such changes served as a big trigger for biological evolution to begin and progress and this led to the invasion of land by living organism.

As time passed, protists evolved from bacteria. Both bacteria and protists are unicellular. Then came multicellular organisms, the fungi followed by plants and animals. Today the diversity of living organisms is comprised of five kingdoms of life. Monera, Prototictista, Fungi, Plantae and Animalia.

**THE GEOLOGICAL TIME SCALE**

| Era | Period | Epoh | Age (million year) | Some important events in the history of life |
|---|---|---|---|---|
| | | Recent | 0.01 | Historic time |
| | Quaternary | Pleistocene | 1.8 | Ice ages; humans appear |
| | | Pliocene | 5 | Ape like ancestors of humans appear |
| Cenozoic | | Miocene | 23 | Continued radiation of mammals and angiosperms |
| | Tertiary | Oligocene | 34 | Origins of most modern mammalian orders, including apes |
| | | Eocene | 57 | Angiosperm dominance increases; further increase in mammalian diversity |
| | | Paleocene | 65 | Major radiation of mammals, birds, and pollinating insects |
| | Cretaceous | | 144 | Flowering plants (angiosperms) appear; dinosaurs and many groups of organisms become extinct |
| Mesozoic | Jurassic | | 208 | Gymnosperms continue as dominant plants; dinosaurs dominant first birds |
| | Triassie | | 245 | Gymnosperms dominate landscape; first dinosaurs and mammals |
| | Permain | | | Radiation of reptiles, origin of mammal-like reptiles and most modern orders of insects; extinction of many marine invertebrates |
| | Carboniferous | | 285 | Extensive forests of vascular plants; |
| Paleozoic | | | 360 | first seed plants; origin of reptiles; amphibians dominant |
| | Devonian | | 408 | Diversification of bony fishes; first amphibians dominant |
| | Siturian | | 438 | Diversity of jawless vertebrates; colonization of land by plants and arthropods; origin of vascular plants |
| | Ordovician | | 505 | First vertebrates (jawless fishes); marine algae abundant |
| | Cambrian | | 544 | Origin of most invertebrate phyla; diverse algae |
| | | | 700 | Origin of first animals |
| | | | 1500 | Oldest eukaryotic fossils |
| Precambrian | | | | 2500 Oxygen begins accumulating in atmosphere |
| | | | 3500 | Oldest definite fossils knows (prokaryotes) |
| | | | 4600 | Approximate origin of Earth |

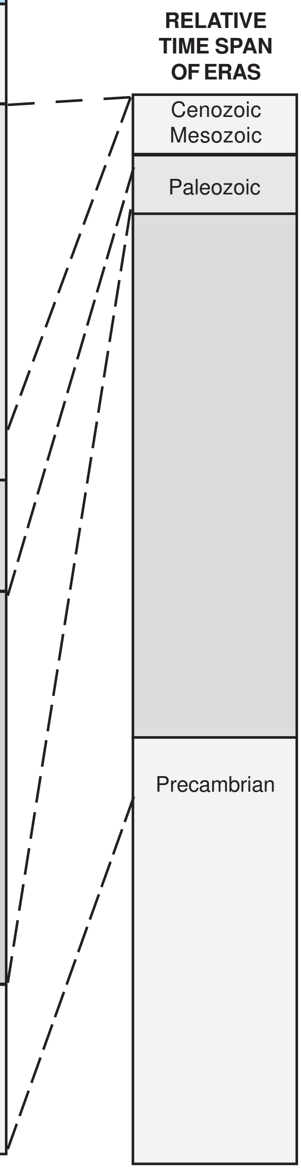



*Fig. 1.7: Geological time scale*

## INTEXT QUESTIONS 1.3

1. Name the gases that were found in the primitive atmosphere.

_______________

2. Which were the earliest organisms that evolved on earth?

_______________

3. How did oxygen come into atmosphere?

_______________

4. Name the five kingdoms of life

_______________

## 1.5 WHAT IS ENVIRONMENT

Every living organism is constantly interacting with its environment comprised of air, light, water, land or substratum and the various kinds of living organisms.

The environment may be defined as the **surroundings or conditions in which an organism lives or operates.** The environment broadly includes living and non living components which are listed in the table given below.

***Table 1.1:*** *Components of the environment*

| Abiotic | Biotic |
|---|---|
| Light, climate (humidity and temperature) atmospheric gases, water, substrata (soil, river/sea bed). | Living organisms including plants, animals, microorganisms (bacteria, fungi, protozoa), and human beings. |

### A. Abiotic components

**i. Light –** Sunlight provides energy. Green plants utilize sun light for photosynthesis for synthesizing food for themselves as well as all other living organisms.

**ii. Rainfall –**Water is essential for all living beings. Majority of biochemical reactions take place in an aqueous medium. Water helps to regulate body temperature. Further**,** water bodies form the habitat for many aquatic plants and animals.

**iii. Temperature**– Temperature is a critical factor of the environment which greatly influences survival of organisms. Organisms can tolerate only a certain range of temperature and humidity.

iv. **Atmosphere -** The earth's atmosphere is made of 21% oxygen, 78% nitrogen and 0.038% carbon dioxide. Rest are inert gases (0.93% Argon, Neon etc).

v. **Substratum-** Organisms may be terrestrial or aquatic. Land is covered by soil and a wide variety of microbes, protozoa, fungi and small animals (invertebrates) thrive in it. Roots of plants pierce through the soil to tap water and nutrients. Terrestrial animals live on land. Aquatic plants, animals and microbes live in fresh water as well as in the sea. Some microbes live even in hot water vents under the sea.

**B. Biotic components**

i. **Green Plants –** Prepare food through photosynthesis for all living organisms.

ii. **Animals** – Individuals of the same species occur in a particular type of habitat. They also live with other species. One species forms food for another. Micro-organisms and fungi decompose dead plants and animals releasing nutrients locked in bodies of dead organisms for reuse by the growing plants.

Living organisms, therefore, need both abiotic and biotic components of the environment for survival. A delicately balanced relationship between living organisms and their environment is critically important for their survival.

## INTEXT QUESTIONS 1.4

1. Define environment.

   ______________________________

2. Name its biotic components.

   ______________________________

3. List its abiotic components.

   ______________________________

4. In a sentence, mention why environmental degradation should be prevented.

   ______________________________

## WHAT YOU HAVE LEARNT

- The universe consists of galaxies of stars.
- Stars are huge balls of hot glowing gases. Sun is also a star.
- Our solar system is composed of the sun and eight planets moving around it.
- Earth is one of the planets of our solar system.

- The universe originated when there was a huge explosion that filled all the space with dust and gases.
- The ball of dust and gases spun fast which gave out great heat and the very hot centre broke off as the sun.
- It is believed that planets broke off from the periphery of this hot ball of dust and gases.
- The earth has three parts namely the core, the mantle and the outermost crust.
- The earth rotates in its orbit around the sun; and also rotates upon on its own axis. This rotation causes day and night cycle.
- The earth is the only planet in the solar system which can sustain life as it has water, atmosphere, suitable temperature and gets sufficient light from the sun.
- The age of the earth is 4 to 5 billion years and life first originated on earth 3.5 billion years ago as evidenced by the oldest fossils found till now.
- The atmosphere of primitive earth was very different – hot and full of gases carbon-di-oxide, water vapour, methane, ammonia and hydrogen but no oxygen. When earth cooled, water vapour condensed into liquid water and fell as rains.
- How the first cell came into existence is still unknown, but perhaps the single celled bacteria were among the earliest organisms. Through biological evolution millions of different kinds of organisms have evolved subsequently.
- All organisms depend on their environment for survival.
- All organisms live in close association with their environment.
- Environment is defined as the surroundings of an organism.
- The environment comprises of non living (abiotic) components like temperature, light, water, humidity etc. and living or biotic components such as other organisms sharing those surroundings.

## TERMINAL EXERCISE

1. Trace the origin of the earth.
2. Describe briefly the solar system to which the earth belongs.
3. State the big bang theory of origin of universe.
4. Why is earth able to sustain life while no other planet is known to have life?
5 Name the five kingdoms of living organisms.
6. Define environment. List the various components of the environment.

## ANSWER TO INTEXT QUESTIONS

**1.1**

1. 4.5 billion years
2. Star
3. Planets orbiting central star
4. Because earth completes one full rotation s on its axis in 24 hours
5. Blue

**1.2**

1. (i) Presence of water (ii) Presence of Air (iii) Comfortable range of temperature (iv) Buffering capacity
2. Sun
3. Oxygen is used in respiration to oxidize food for liberating energy.

**1.3**

1. Methane, ammonia, carbon dioxide and hydrogen
2. Bacteria
3. Because of photosynthesis
4. Monera, Protista, Fungi, Plantae and Animalia

**1.4**

1. Surroundings or condition in which an organism lives and operates.
2. Biotic- living organism of all kinds including microbes.
3. Abiotic – light, humidity temperature, atmosphere and substratum
4. Because it threatens the survival of living organisms including humans.

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# ENVIRONMENT AND HUMAN SOCIETY

The human beings (***Homo sapiens sapiens***), evolved more than two million years ago. They evolved with a large brain, that enabled them to think, and use their judgment. Humans walked erect on two legs, which made their hands free to negotiate manual functions.

As is with other animals, the survival of humans also entirely depended on their obtaining food from the environment. Being intelligent, human beings exploit environmental resources for many purposes other than just for procuring food. In the last few centuries, the exploitation of environmental resources has dramatically increased, leading to serious damage and degradation of the environment. In this lesson you shall learn about the utilization and exploitation of natural resources and how, they are being overexploited.

## OBJECTIVES

After studying this lesson, you will be able to:

- *list the natural resources obtained from the environment;*
- *describe the interaction between primitive society and environment in terms of food gathering, food hunting and nomadic life;*
- *describe the tools used by primitive humans and discovery of fire;*
- *explain how settled life began;*
- *discuss the origin and evolution of agriculture including domestication of animals;*
- *state the importance of the invention of wheel;*
- *explain how industrialisation began;*
- *identify factors that led to the growth of industrialisation;*
- *explain how exploitation of natural resources started.*

## 2.1 NATURAL RESOURCES AVAILABLE IN THE ENVIRONMENT

Primitive humans interacted with environment for survival. As humans became more and more cultured, they devised means of using environmental resources for making life comfortable and protecting themselves from various environmental stresses (danger).

### 2.1.1 Abiotic resources

Abiotic resources are the physical resources of nature that are described below.

a. **Land:** Many organisms including humans live on land. Land forms just approximately 29% of earth's surface includes mountains, rocks, deserts, swamps, forests and grasslands. Humans use land for growing crops that provide them with food. They also need land to build shelters, roads and cattle sheds. The need for land usage is steadily growing. To cater to the needs of the growing population, urbanization and industrialization, land is being used for building dams, flyovers, subways and factories. Land resources are fast diminishing.

b. **Water:** The natural water bodies include oceans, seas, and surface water bodies such as rivers, lakes, water falls and ponds. Almost 80% of the earth's fresh water remains frozen at higher latitude and on mountains tops. Only 20% is available in liquid form. The primary source of water on land is the rainfall. Water is an essential requirement of all living beings. Water is required for

- irrigation of agricultural crops.
- industries
- building construction
- culture of fish, prawn, aquatic plants (aquaculture)
- drinking, bathing, cleaning, washing, gardening, pottery making etc.

Water though a naturally replenishable resource, but overuse and wastage of water is leading to its scarcity.

c. **Energy:** The prime source of energy is solar radiation**.** Primitive humans used firewood and cow dung and other animal wastes for heating and cooking. Oil extracted from seeds and fish was used by them to light caves and shelters. Another major source of energy is fossil fuel such as coal. Coal as you know has been formed from vegetation which grew millions of years ago, fell and got trapped in sediments. Under immense pressure and intense heat for years, tress and vegetation burned in sediments transformed into coal. Coal is used as a fuel for cooking, for running locomotives, furnaces industries and generating electricity. Coal is also used for extraction of metals and minerals and in thermal power generation.

**d. Petroleum and natural gas** are also fossil fuels. Petroleum probably originated from marine animals that lived during past geological periods, just as coal was formed from vegetation. Petroleum and natural gas are obtained from deep inside the earth and they are non-renewable energy resources. Petroleum products are used for running automobiles, steamers, aeroplanes and for making plastics and fertilizers. Petrol and diesel are refined petroleum products. You might have heard about CNG (compressed natural gas), which is now being used to run automobiles and considered to be a relatively clean fuel. Natural gas and diesel are used for electricity generation. LPG (Liquid Petroleum Gas) comes in cylinders or through pipes and is used as fuel for cooking.

*Petroleum is also called mineral oil. Like petroleum, natural gas is a mixture of gaseous hydrocarbons.*

Energy is also harnessed from sun (**solar energy**), wind **(wind energy),** animal excreta **(biogas),** sea **(tidal energy)** and radioactive minerals (**nuclear energy).**

**e. Metal ores or minerals:** Metal ores are chemical compounds (salts) of metal such as Aluminium, iron, copper, lead, zinc, manganese etc. These ores are found as deposits in earth. Aluminium is used to make utensils, parts of vehicles, aircraft, and spacecraft. Iron and its alloys are used for making armaments, heavy machinery, railway engines, railway lines and a wide variety of articles. . Copper is used for making industrial containers, electric wire and also used in electronic and telecommunication industries. Alloys such as brass and bronze contain copper. However, the availability of metal ores is limited and their increasing mining depletes them fast. Silver, gold and platinum are among the precious metals used and treasured by humans.

### 2.1.2 Biotic resources (living natural resources)

**Biotic resources-** These include plants, animals and microorganisms.

**a. Plants:** The natural food resources included in human diet are the various cereals, legumes, vegetables and fruits. Humans cultivate plants to obtain good grains, pulses, spices, vegetables, fruits, sugar and oil. Fibre yielding plants are grown to humans obtain cotton, jute and flex etc. Flowers of various kinds are cultivated for ornamental purposes. Some plants having medicinal value have been extensively used from time immemorial. Industrial raw material such as rubber, resins, wood are irreplaceable plant products.

**b. Animals:** Goat, fish, eggs, poultry, prawns and crabs are source of food for human beings. Horses, bullocks, elephant, oxen, camels, donkeys, yaks etc. are used for transportation as draught animals. Yaks and sheep yield wool for woolens. Silk worm are grown for silk.

c. **Microorganisms:** provides antibiotics. Their use in fermentation and in breweries is an age old practice. Microbes are responsible for processing waste and dead plants and animals.

*The environmental resources provide humans, substances for survival, entertainment, maintenance, decoration and for several other purposes. But for how long?*

On the one hand natural resources are fast depleting because of overexploitation by humans. On the other hand, earth is becoming a big dumping ground for waste generated by the activities of the fast growing human population. This is fast becoming cause for deterioration of human, animal and plant life.

## INTEXT QUESTIONS 2.1

1. Name two natural resources without which life cannot exist.

   ______________________________

2. State two uses each for (i) land and (ii) metals are used by humans.

   ______________________________

3. State two uses of animals for humans.

   ______________________________

## 2.2 RELATIONSHIP BETWEEN PRIMITIVE HUMAN SOCIETY AND ENVIRONMENT

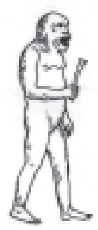
Human beings have lived on earth for approximately more than 2 million years. Records of primitive humans and their activities are buried in the rocks along with their fossils. The fossil records show not only dipicts the various stages of human evolution but also the life style and behaviour of primitive humans.

### 2.2.1 Story of human evolution

When human evolution began, forests had dwindled because of glaciation. Much of the land surface was however, still covered by forest. The common ancestors of apes and humans had to come down from trees where they lived. They walked on all fours on the ground using all four limbs. Recent molecular studies have revealed that from common ancestors, evolution of apes (chimpanzee, gorilla, gibbon and orang-utan) and that of humans diverged about 6 million years ago.

The earliest human ancestors, the ***Australopithecines*** which walked upright, evolved around 3.5 million years ago in South Africa. They made tools with various materials. (See pictorial table 2.1)

**Table 2.1: Evolutionary stages of humans species**

| | | | |
|---|---|---|---|
| Name of stages<br><br>Time Period of existence | <br>*Australopithecus*<br>5 million years | <br>*Homo habilis*<br>2.5 million years | <br>*Homo erectus*<br>1.5 million years |
| Tools | <br>Crude tools made of bones and pebbles | <br>Pebble tools with a flake removed for making cutting edge | <br>Simple hand axes made of stones |
| Behabiour | Ape-man who walked erect | Hunter-gatherers | Hunted large animals |

Australopithecines gave rise to ***Homo habilis*,** probably around 2 million years ago. These human ancestors had ape like long arms but larger brain than the apes. The next stage, ***Homo erectus*,** is supposed to have existed between 1.5 million years to 200,000 years ago. Their fossils have been found in China (Peking man), Jawa (Jawa man), Germany (Heidelberg man). This suggests that they evolved in Africa and then spread to Asia and Europe. Their brain size was intermediate between apes and humans. Also they had heavy ridges above eyes like the apes. ***Homo erectus*** made stone axes.

Next to evolve from ***Homo erectus*,** were the Neanderthal man (***Homo sapiens neandertalensis***) but they belonged to the same species as do the modern humans ***Homo sapiens.*** Remains of Neanderthals have been found in Europe, Asia and Africa. They fashioned a large variety of well-made tools and were successful hunters. For almost about 35,000 years, ***Homo sapiens sapiens*** or modern humans are the only living human species.(Fig. 2.1) (Homo: belonging to family Hominidae, sapiens:wise)

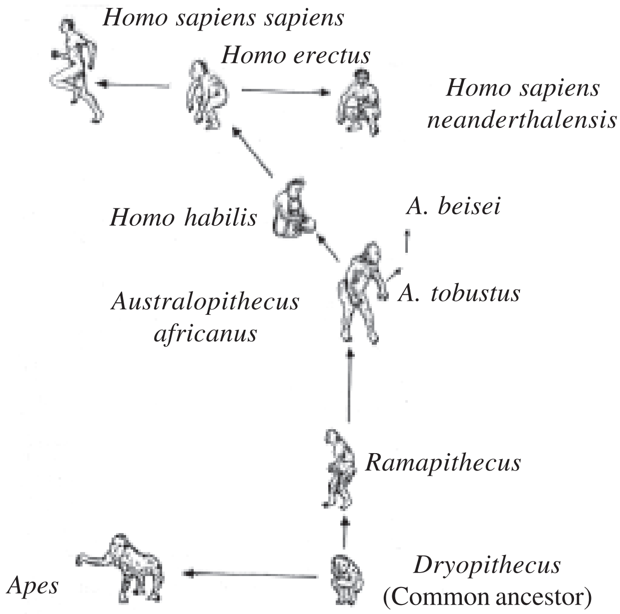



***Fig. 2.1:*** *Evolution of humans showing ancestor common to apes and humans*

### 2.2.2 Primitive humans as 'hunters-gatherers' and nomads

Primitive humans lived in forests, near water bodies such as rivers and lakes located on the edges of forests. Their main preoccupation in life was to "procure food". Their diet consisted of seeds, roots and fruits of plants and small animals which they killed with tools they made from pebbles and stones. They roamed in the forests in search of food during the day and returned to the caves at sunset to save themselves from the attack of wild animals.

Walking on hind limbs, primitive humans were free to use their hands to

- uproot plants for edible roots,
- pluck fruits and vegetables,
- pick up pebbles from banks of rivers and stones from other places and
- make tools from them
- hunt animals, skin them and then eat them.

Thus primitive humans were 'hunters and gatherers'. They lived in groups of 20 to 30 and apart from collecting plant food, they collected eggs of birds and caught fish. They hunted animals with pebble and stone tools. Women hunted small animals and collected fruits and seeds from trees. Males hunted big animals. Primitive humans also ate turtles, oysters and mussels.

There is evidence to show that primitive humans shared food and also gathered knowledge about edible plants, ripening seasons of fruits, animal dens and methods of capturing wild animals.

Primitive humans, the 'hunters and gatherers' moved from place to place as foragers. They led a nomadic life. As nomads, they roamed large and distant areas. They had no permanent abode. They lived near riverbeds where plants and animals were abundant. They also lived in caves. As they moved along, they left behind their stone and bone implements. (see pictorial table 2.1)

## INTEXT QUESTIONS 2.2

1. Name the first stage of human evolution.

   ______________________________

2. When did the 'modern humans' evolve?

   ______________________________

3. What do you mean by "hunters and gatherers"? Answer in one sentence.

   ______________________________

4. Where did primitive humans live?

   ______________________________

5. State the advantage of their being able to walk on their two feet?

   ______________________________

## 2.3 TOOL MAKING BY PRIMITIVE HUMANS AND DISCOVERY OF FIRE

The gathering of food from plants and hunting animals served as stumuli for making a variety of tools. There is evidence that australopithecines made tools probably to (i) drive away wild animals and (ii) hunt animals for food. Pebble tools have been found in fossil sites of australopithecines in Africa.

***Homo erectus*** made better tools with stones and the tradition of making tools passed on to ***Homo sapiens neandertalensis*** or Neandertal man as well as to ***Homo sapiens sapiens*** or modern man.

Tools of ***Homo erectus*** were flint tools and the rocks they used for making tools were quartz, quartzite and other volcanic rocks.

The stone hand axes that ***Homo erectus*** made had sharp edges which were achieved by hammering and chipping away flake after flake with a piece of bone or hard wood. They were far superior to pebble tools (of ***Australopithecines*** and ***Homo habilis***) and could easily uproot edible roots and other plant parts from the ground. The sharp edges could cut up animal prey and skin it. The wooden spears and bone daggers that they made helped to hunt animals as large as elephants, horses, rhinoceros and giant baboons.

- **Tools of the Neanderthals**

The techniques of tool making and the tools of the Neanderthals were more advanced. The idea of chipping out flakes from flint stones was already known and they used an antler, bone, wooden hammer and hammer stone to chip off uniform flakes from the rock.

They also made knives, pins, needles and fishhooks and harpoons with bones.

Neanderthals, like their predecessors did cooperative hunting and killed large animals like elephants (mammoths), woolly rhinoceros, bisons, wild horses, bear, wild cattle and wild boars. They were called 'big game hunters'. There is evidence of that they used spear like tools that could be hurled at animals from a distance.

Tools made by primitive humans from stones ushered in the **Neolithic or New Stone Age** (Fig. 2.2). The tools were more grand and polished but their use diminished as humans stepped into the "age of agriculture".

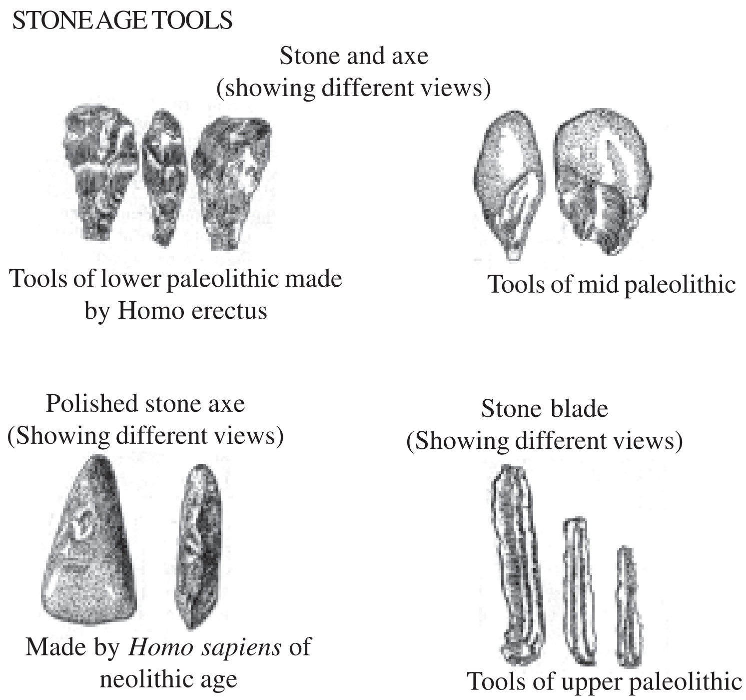



***Fig. 2.2:*** *Tools made by Primitive man*

- **Use of Fire**

The primitive human ***Homo erectus*,** discovered fire more than 200,000 years ago. Discovery of fire had a profound influence on their life style. Primitive humans used fire for various purposes

They realised that use of fire also enabled them to colonise the colder parts of the earth and meat becomes tender when cooked in fire, making it more digestible. Fire was also used to scare away dangerous animals.

Fire brought about "cultural evolution" of humans as well as increasing **exploitation** of natural resources.

## INTEXT QUESTIONS 2.3

1. With what did primitive humans make tools?

_______________________________________________

2. State two uses of these tools.

_______________________________________________

3. State two uses of fire by primitive humans.

_______________________________________________

## 2.4 SETTLED LIFE BEGINS

The "hunters and gatherers" finally began to give up nomadic life. By this time they had moved over and dispersed to many parts of the world probably as "foragers" (searchers of food). Their temporary shelters, as you have learnt, were the caves in mountains.

From an archaeological study, it is clear that foragers lived in temporary oval hut like shelters (Fig. 2.3) which they often covered with plants.

***Fig.2.3:*** *Shelters of primitive humans (wearing clothes made of animal hide)*

Once tools were improved, fire discovered and cultivation of fields begun, humans started settling down. They made shelters and lived in groups.

## 2.5 ORIGIN AND EVOLUTION OF AGRICULTURE AND DOMESTICATION OF ANIMALS

You have learnt that lives of primitive humans depended largely on the availability of food. They had small families which included children and grand children. They roamed forests for food and lived in caves. Man, the hunter was dependent on his luck in chasing, and hunting, as also on the abundance of animals.

As humans built temporary shelters and began to stay together for three to four months at a place, they discovered that seeds of fruits and grains thrown in front of their huts sprouted into saplings. Intelligent beings as they were, they realized that instead of foraging they can grow food plants for themselves. Around 12,000 years ago human learnt to cultivate crops. Cultivation also attracted animals, which they could trap for eating. This idea of agriculture for getting continuous and relatively stable food supply led to the formation of a "primitive agricultural society" about 10,000 years ago.

As time passed, humans learnt to use metal tools for agriculture and used plant and animal residues as manure. They also began irrigation of their cultivated fields. Thus evolved the so-called "agro-horticultural societies".

Soon in fertile valleys, food became surplus through continuous cultivation. Humans also began domestication of animals and raising cattle. The first domesticated animal was the dog. They also maintained fisheries. Further improvement in cultivation and domestication of animals encouraged human settlements by the river banks and valleys. Thus primitive "agrarian society" evolved and practised traditional agriculture. (Fig. 2.4a and 2.4b)

*Fig. 2.4a: Beginning of agriculture and domestication of animals*

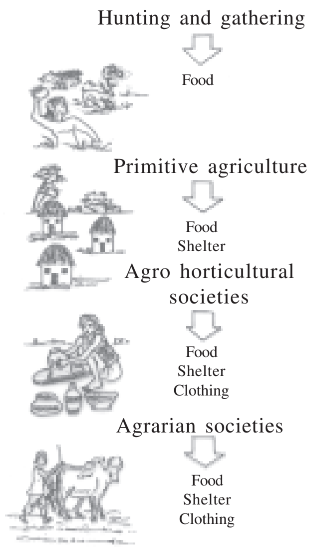



*Fig. 2.4b: Evolution of induced agroecosystem*

### Domestication of animals

These primitive humans needed to till the land for farming and to move from place to place so they started using bullocks to till the land and many some other animals such as camels, elephants, bullocks etc. were used (Fig 2.5) to transport humans and their wares from one place to another. The animals used for carrying goods from one place to another are called "draught animals". (Fig. 2.5)

Early humans also reared animals for food such as the goat, sheep, pig, deer, poultry birds and kept them with them.

Once humans became permanent settlers, their population began to increase. Natural resources got depleted, and then arose the need to get material from outside. Also culturally they moved one step further and their requirement for clothes, ornaments and agricultural implements etc. increased. Those not directly involved in farming became craftsmen. Surplus agricultural produce was bartered for non-essential goods such as pottery, ornaments etc.

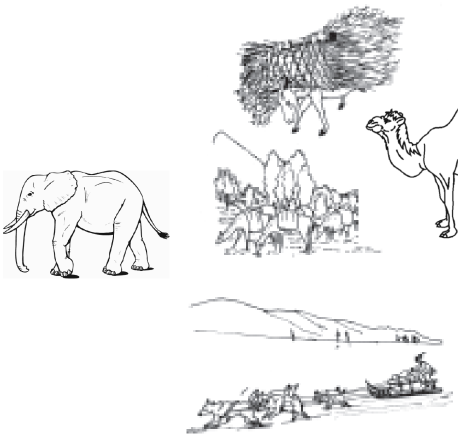


***Fig. 2.5:*** *Animals used for transportation of self and materials*

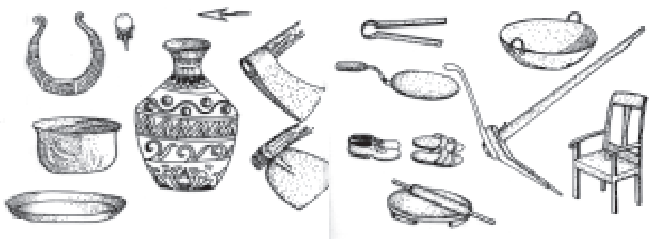


***Fig. 2.6:*** *Humans use various kinds of substances and metal, clay, wood, leather etc*

## 2.6 INVENTION OF THE WHEEL

Earliest humans walked to go from one place to another. But traveling by feet was slow and took very long time. So they used mules and camels to carry them.

No one knows exactly who invented wheel. But people were using it around 5000 years ago in Iraq, Syria, Turkey etc. The first wheels were probably round slices of log. The logs could roll objects on a plank of wood kept on the logs.

The first wheeled vehicle was a chariot which was a two wheeled cart pulled by donkeys and then by horses. Greeks and Romans used them when fighting wars.

The discovery of the wheel was prior to the making of metal tools. By about 3000 BC wheels made of logs were being used in primitive carts. The solid wooden wheels were used for other purposes too, such as by the potters to mould earthen and terracotta pots around 1000 BC. (The potter's wheel) (Fig. 2.7).

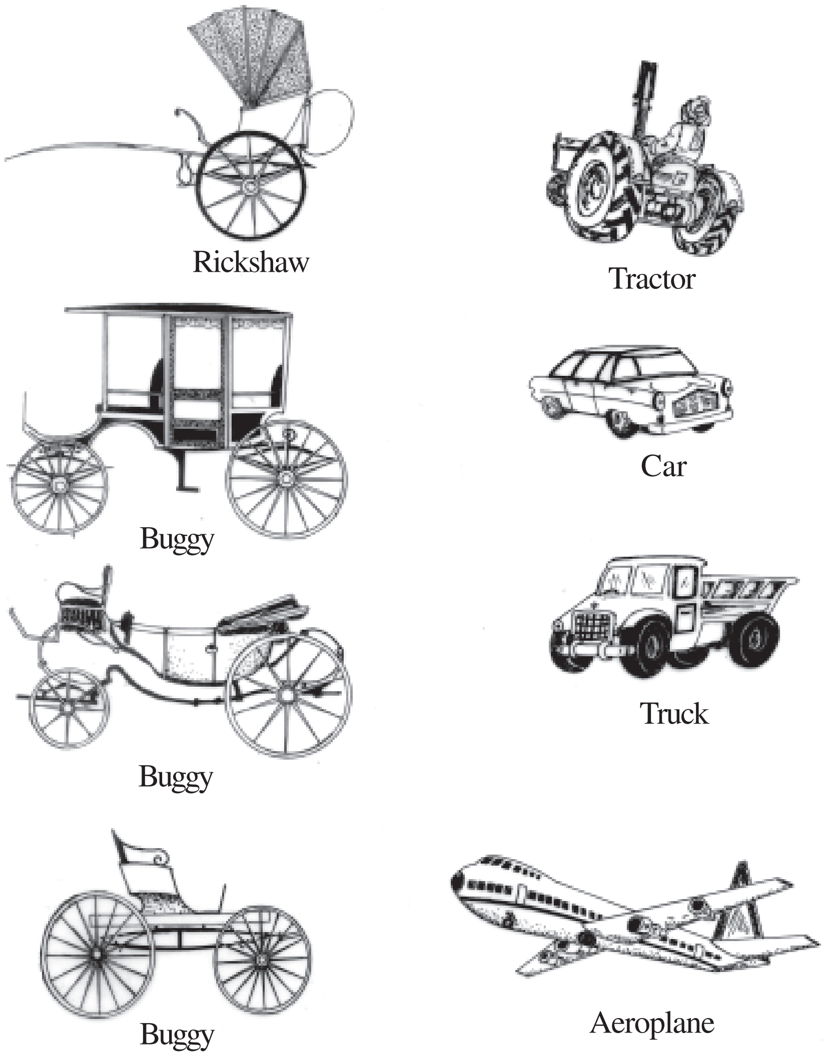



***Fig. 2.7:*** *Innovation of wheels*

Wooden wheels were heavy and once metals were discovered, metal wheels with spokes replaced wooden wheels as they were much lighter and stronger.

## INTEXT QUESTIONS 2.4

1. According to an archaeological study, how did foragers live?

2. When was primitive agricultural society formed?

3. Which was the first domesticated animals?

4. Name three draught animals.

5. When and where was wheel invented?

## 2.7 BEGINNING OF INDUSTRIALIZATION

A more secure food supply and improved diet made agricultural communities move to new lands for farming. It also led to a substantial increase in population. Some people became miners. They mined flint to make flint axes. Thus growth of agriculture was accompanied by growth of tool making that provided crude agricultural implements.

The earliest indications of industrialization were the engineering in wood and stone that primitive men undertook. It was unspecialized and required hard labour. To mine flint from rocks, miners used deer antlers and shovels made from shoulder blades of cattle. They worked by the light using small lamps made from hollowed pieces of chalk containing animal fat and wicks made of moss. (Fig. 2.8)

***Fig. 2.8:*** *Beginning of industrialization*

Flint (a type of rock) axes were important for farmers for clearing dense forest land to raise their crops. Stone axes were used to fell trees.

Thus making wheels, constructing buildings, mining ores to make tools and ornaments were a step towards industrialization.

### 2.7.1 Discovery of Metal

Humans discovered that copper, iron, bronze made stronger tools. This discovery brought humans out of the Stone Age and marked the beginnings of industrial revolution.

The potters were using high temperature kilns or ovens to fire their wares. Accidentally they discovered that lumps of gold and copper also melted at high temperature and could be moulded into shape. So the metal smiths discovered that intense heat could extract copper from metal bearing ore buried in rocks. this process is now called 'smelting'.

The use of metal was first discovered in Iran and Turkey approximately 8000 years ago. The early use of copper and gold was for making ornaments. Two thousand years later, human began to make copper axes and weapons with sharp cutting edges. Soon smiths mixed metals and produced bronze from copper and tin. This alloy was harder and easier to cast into knives and axes. By 2500 BC, bronze became the dominant metal.

From 1000 BC, farmers had better axes, sickles and knives. Carpenters also had better tools.

**From Bronze age to Iron Age**

From 7$^{th}$ and 6$^{th}$ century BC, humans began to use iron to make weapons and found it to be much superior to bronze. By 1200 BC, western Asia (Iran, Turkey etc.) had come out of the Bronze Age and entered into the Iron Age. Iron tools and weapons replaced those made from bronze.

## 2.8 FACTORS THAT LED TO GROWTH OF INDUSTRIALIZATION

Several factors were responsible for the growth of industrialization.

| | |
|---|---|
| **Technical development**: | The discovery of metals for making better tools and weapons initiated technology. |
| **Economic development**: | (i) The establishment of agrarian societies engaged people in selling surplus produce or bartering it. This made them economically sound.<br><br>(ii) In the agrarian society, people got busy with occupations other than agriculture. |
| **Invention of wheel**: | This led to faster transportation and marked the beginning of the **transportation industry.** Not so long ago man traveled by bullock carts. Today the car, the bus, the train and above all the aeroplane are a common sight. |

**Beginning of mining**: It was related to unearthing flint. Later ores containing copper, iron, and aluminum are mined. This led to the formation of mining industry. Mining of mineral and metalous fossil fuels like coal and natural gas are common even today.

**Agriculture**: Agriculture began with primitive humans. But today agriculture furnishes means of livelihood for millions of people. They produce food, fibers and raw materials for industry. Modern farming methods have produced food for teeming millions. Agriculture itself has become an industry. It has also led to the formation of **food industry** so much so that even readymade breakfasts are now available.

**Bronze age and Iron age**: Bronze age and Iron age and the discovery of fire much earlier led to the making of **machine tool industry**. Machines for making synthetic cloth, for printing cloth ushered in textile industry.

**Language**: Human are the only animals endowed with a well developed capacity for speech. Spoken communication led to development of language. Language helped in working in groups which enhanced the pace of economic development

Thus not one but several factors led to industrialization.

## 2.9 BEGINNING OF EXPLOITATION OF NATURAL RESOURCES

Since human beings first evolved they have been completely dependent on forests and their produce. Seeds, fruits and wild animals living in the forest constituted the diet of primitive humans. Leaves, branches and bark were used as clothes and pebbles, stones and bones of dead animals were used as weapons.

Forests were cut down to make agricultural fields. They produced enough food and developed shelters and this lead to a sizeable increase in the population. More mouths to feed and to be provided with facilities. With advancement of civilization and growth of urban culture forests were wiped out from large areas of forest. Trees were felled for wood, for making shelters, carts for transportation, etc and also as a source of fuel.

With the discovery of fire, more wood was needed for cooking. Humans began to mine not only coal for fuel but also ores of metals to make wheels and ornaments etc. Initially the damage was not so great. After the industrial revolution, in the last 400 years, forests, the original habitat of humans, have dwindled at an alarming rate; wild life has been threatened to extinction. Some wild animals have vanished. Pollution from industries has made the air impure and water bodies full of filth.

The association between primitive humans and the environment in which they lived was one of fear and respect. As humans became more and more 'civilized' and created innovative newer technology, the treasured natural resources such as the soil, the forest, the minerals, metals, the air, the water, plants and animals were increasingly overexploited. Coupled with the exploitation was the enormous increase in human population. In the last decade, environmentalists have made alarming discoveries.

- Environmental resources are limited and fast getting depleted due to over exploitation.
- Pollution of air, water and land caused by human activities is posing serious threat to human survival and well being.

The relationship between human and their environment has changed specially since the beginning of industrial revolution. It has become confrontational and the consequences have already started surfacing. You will learn more about environment degradation in the next lesson.

## INTEXT QUESTIONS 2.5

1. List some steps towards industrialization.

2. Which metals were discovered by the primitive humans.

3. List four factors those led to growth of industrialization.

4. What is the impact of industrialization upon nature.

## WHAT YOU HAVE LEARNT

- The earth bears several natural resources of which the non-living or abiotic resources are land, water, air, fossil fuels and minerals, and the living or biotic resources are plants, animals and microorganisms.
- Humans a part from food require, two major types of resources namely (1) materials and (2) energy for comfort and economic development.
- Ever since humans appeared on earth they have been drawing their food, clothing and other substances from nature.

- Humans were evolved more than 2 million years ago when they diverged from apes with whom they shared a common ancestor.
- The earliest bipedal humans were the **australopithecus** who evolved in Africa. They were ape like but had larger brains.
- The next stage in human evolution was **Homo erectus** with larger brain and erect posture. Their fossils have been found in Jawa and China.
- **Homo sapiens neanderthalensis** or neanderthal man arose from **Homo erectus**. Soon they became extinct but another line of humans the **Homo sapiens sapiens** evolved and they are considered to be the direct ancestors of the modern humans.
- Primitive humans lived in forests and used their hands to uproot edible plants roots, and pluck fruits and collect seeds. Since hands were not used for walking, they were used to make tools also.
- Primitive humans were hunters and gatherers and moved from place to place in search of food. (nomadic life)
- Along with human evolution, skills also improved progressively in tool making. Humans made simple tools with stones. The time period of their existence on earth is called "old stone age" or paleolithic age. Starting from crude pebble tools, as time passed, they made better and sharper tools. In the Neolithic or new stone age, the tools were polished and ground.
- Later human discovered fire and used it for cooking, driving away predators and capturing large animals.
- From a nomadic life, humans began to settle and make shelters.
- Around 12,000 years ago humans learnt to cultivate crops. Agricultural practices improved and humans grew enough food and their population increased.
- Surplus cultivated crops was transported to other places were bartered.
- Wheel was discovered and transportation became easier. They moved to newer places to raise new crops and also began to domesticate animals.
- While primitive humans were mining flint to make tools, they come across metal ores and mining and refining metals by heating began.
- They made lots of things with bronze, an alloy of copper and tin and later with iron.
- Soon they started manufacturing activity and thus began industrialization.
- Rapid expansion of industrialization has resulted in (i) depletion of natural resources and (ii) pollution of the environment
- The vary survival of humans is now threatened because of environmental degradation.

## TERMINAL EXERCISE

1. Name the abiotic and biotic natural resources.
2. Of what use are plants and animals to humans?
3. List 10 uses of water for human beings.
4. List the various sources of energy.
5. Trace the evolution of humans up to modern man.
6. What do you mean by the statement "early men were hunters and gatherers."
7. State the purposes for which primitive man made tools.
8. Primitive humans were thrilled to discover fire and why?
9. How did humans think of cultivating crops?
10. What changes took place in the behaviour and life style of primitive humans after they became agriculturists?
11. What do you mean by "bronze age" and "Iron age"?
12. State the factors which led to industrialization.
13. What impact did years of use by growing population of humans have on environmental resources?

## ANSWER TO INTEXT QUESTIONS

**2.1**

1. Air, water, substratum (any two)
2. (i) Land- to make shelter, for agriculture, pottery etc.

   (ii) Metals – to make tools, ornaments and other things
3. As food, transport

**2.2**

1. Australopithecus
2. 2 million years ago
3. Forage, plucks fruits and uproots plants and hunt animals

4. Caves
5. Hands became free to make tools and carry out many other activities.

**2.3**

1. Stone and metals
2. Uproot plants, kill animals
3. Cook food, heat up rooms, and scare away animals (any two)

**2.4**

1. In temporary oval hut shelter which often covered with plants.
2. About 10,000 years ago.
3. Dog
4. Bullock, camel, elephant.
5. Around 5000 years ago in Iraq and Syria.

**2.5**

1. Making wheels, constructing building, mining ore to make tools and ornaments.
2. Copper, iron and bronze
3. Technical development, economic development, invention of wheel, beginning of mining, agriculture etc. (any four)
4. Forest cut down, wild life has been threatened to extinction, and pollution from industries has made air impure and water bodies full of filth.

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# 3

# DEGRADATION OF NATURAL ENVIRONMENT

When humans evolved more than two millions years ago, the natural resources were over abundant as compared to human needs. As human population increased, more and more food and resources for shelter were required and these were drawn at an increasing rate from the environment. Even today, natural resources are being exploited by humans to meet their needs. In this lesson you shall learn how human activities degrade and deplete the natural resources of the environment.

## OBJECTIVES

After completing this lesson, you will be able to:

- *recall the concept of environmental degradation and factors that cause it;*
- *explain how exploitation of natural resources leads to environmental degradation;*
- *explain the relationship between population growth and environmental degradation;*
- *explain the relationship between urbanization and deterioration in environment;*
- *explain the causes and effects of deforestation;*
- *draw a relationship between excessive mining and environmental degradation;*
- *explain the meaning of fossil fuels and the impact of their use on the environment;*
- *discuss how modernization of agriculture has adversely affected the environment;*
- *discuss the impact of industrialization on abiotic (air, water and soil) and biotic resources (plants and animals) of the environment;*
- *list local, regional and global backlashes caused by environmental degradation;*
- *describe the impact of environmental degradation on life.*

## 3.1 CONCEPT OF ENVIRONMENTAL DEGRADATION

Increasing use of natural resources by rapidly increasing human population has resulted in overexploitation of natural resources. The consequences of such exploitation are clearly seen in soil erosion, loss of biodiversity and pollution of land, air and water bodies. The degradation of the environment from overexploitation has reached a level which is threatening human well-being and survival.

## 3.2 RECKLESS EXPLOITATION OF NATURAL RESOURCES LEADS TO ENVIRONMENTAL DEGRADATION

In nature, there exists an ecological balance. The activities of various organisms are balanced. The interaction between abiotic and biotic components are so fine tuned that there exists an equilibrium in nature.

As years passed by, human activities interfered with this equilibrium. Uncontrolled human activities caused damage to the environment.

Some of the human activities that have led to environmental degradation are mentioned below-

1. Forests are natural resources but they have been cut down for use by humans for converting them into the cultivable fields, for building houses and for taking away logs for making shelters and furniture or fuel. The rate at which trees are cut far exceeds the rate at which trees grow, so forests are getting denuded.
2. Trees lose lot of water through transpiration. This helps in forming rain clouds. Cutting of trees and clearing of forest reduced rainfall in the area. Also removal of plants and trees leads to soil erosion.
3. Forests are natural habitats of wild life. Extinction of wild life species is on the rise because their natural habitats are being destroyed due to deforestation.
4. Non-renewable energy resources such as coal, natural gas and petroleum are being used up speedily, leading to their depletion.

These are examples show the loss of natural resources due to the overuse by humans.

**On the other hand,**

1. Excessive burning of coal, wood, kerosene, petrol etc. release toxic gases such as $SO_2$ (sulphur dioxide), NOx (oxide of nitrogen),CO(carbon monoxide) and hydrocarbons in the air. These gases are also emitted by industries, power plants, automobiles and aircrafts. The toxic gases pollute air which adversely effects human health and plants.
2. Acid water from mines, toxic waste of industries, chemical fertilizers and pesticides from agricultural fields have polluted rivers and other water bodies.

3. The problem of soil pollution is increasing day by day in villages, cities and industrial areas due to faulty disposal of solid and liquid wastes generated from households and industries.

Thus humans have spoilt the environment by (i) depleting natural resources to a critical level and (ii) causing pollution to natural water bodies and land areas.

## 3.3 IMPACT OF POPULATION GROWTH ON ENVIRONMENT

The enormous increase in human population is making the future of humans insecure. It is estimated that 5 million people lived in the world at the time when agriculture begin about 12000 years ago. The population of our country alone is now well over one billion.

### 3.3.1 Factors leading to rise in population

Many factors have contributed to the enormous rise in human population. These are listed below:

1. Improved agricultural practices have helped in increasing food production, hence food became available.
2. Progress in medicine prevented deaths due to injury and epidemic diseases.
3. Average longevity of humans has increased since heart, lung and kidney disorders as well as other diseases can now be diagnosed and treated through modern medical technology.

### 3.3.2 Impact of population growth on environment

With growing population, requirement for space, shelter, and commodities have exerted enormous pressure on the environment. To provide for these, land use has change dramatically. It has already been seen that forests have been cleared for cultivation of grain and fruit crops.

#### 1. Clearing land for cultivation to grow more food

Forests and natural grasslands have been converted to farmlands. Wetlands have been drained and arid lands have been irrigated. These changes have been made to grow more food and more raw materials. But in doing so, the natural resources have been depleted and the landscapes have undergone drastic changes. For example, forests have been cleaned over large for cultivation of agriculture crops. Many mangrove forests known to reduce erosion and stabilize shorelines have been cleared use for growing food crops to meet the needs of the growing population.

#### 2. Water scarcity

Water received as rainfall, flows into rivers, lakes and other water bodies. Some of it seeps into the ground and reaches the ground water. At certain depth of the soil, all the pore spaces between soil particles are saturated with water. This depth is called **Water**

**Table**. The water table may remain stable if the drawn from the ground water is replenished by the seepage of the rain water. But if water withdrawal exceeds beyond the rate of replenishment of the ground water table keep on receding and resulting in drying out of wells. In many areas excessive withdrawl has depleted ground water resources causing acute water scarcity.

**3. Need for human settlements**

Apart from excessive land use changes for growing food, large population means greater requirement for shelter. To make houses for so many, stones and other building materials have to be quarried more rocks have to be blown off and more water to be used.

**4. Need for transport**

Elaborate network of transport is required to fulfill the growing need of teeming millions. Various modes of transports have been developed which consume growing quantities of fossil fuels such as coal, gas and petroleum, polluting the atmosphere.

**5. Need for various commodities**

Articles of everyday use such as plastic vessels, mugs, buckets etc., agricultural implements, machinery, chemicals, cosmetics etc are manufactured in factories. The raw materials and fossil fuels and water needed to run industries for manufacturing these products lead to their depletion. Rapid industrialization has also led to pollution from dumping of industrial effluents into rivers and other water bodies. Rapid industrialization has caused much damage to the environment. Mining activities have depleted stock of mineral resources particularly fossil fuels.

Present day industrial civilization is becoming a burden on nature and it is time for us to learn to live in harmony with nature.

**6. Slum development**

Over populated areas result in congested roads and slum formation which lack basic amenities like drinking water, drainage, waste disposal, lack of hygienic conditions and filthy environment create potential conditions for public health problems including spread of epidemic diseases. Discharge of untreated effluents and throwing of waste into water bodies have polluted most of the lakes and rivers.

**7. Pollution resulting from overpopulation**

Holy rivers Ganga, Yamuna and other are suffering from pollution due to discharge of effluents from industries, human settlements, bathing, washing of clothes and throwing of garbage into the river.

## INTEXT QUESTIONS 3.1

1. State any two types of environmental degradation caused by humans.

___

Notes

2. Give one reason for increase in human population.

3. Why rapid growth of world population is a cause for alarm?

## 3.4 DEFORESTATION AND ITS CONSEQUENCES

Forests are found all over the world except the polar regions. Originally forests covered one third of the land area. You have already learnt that since the beginning of human evolution, they have depended on the forest resources. Forests are nature's major processors of solar energy. They provide habitat for diverse kinds of organisms including large wild animals. Primitive humans too, lived in forest and were completely dependent on forests for survival till they took to farming; Cutting of trees in forests is called **deforestation.** Deforestation has taken place for various purposes at an alarming rate in different parts of the world resulting in severe loss of wild plants and animals. (Fig. 3.1)

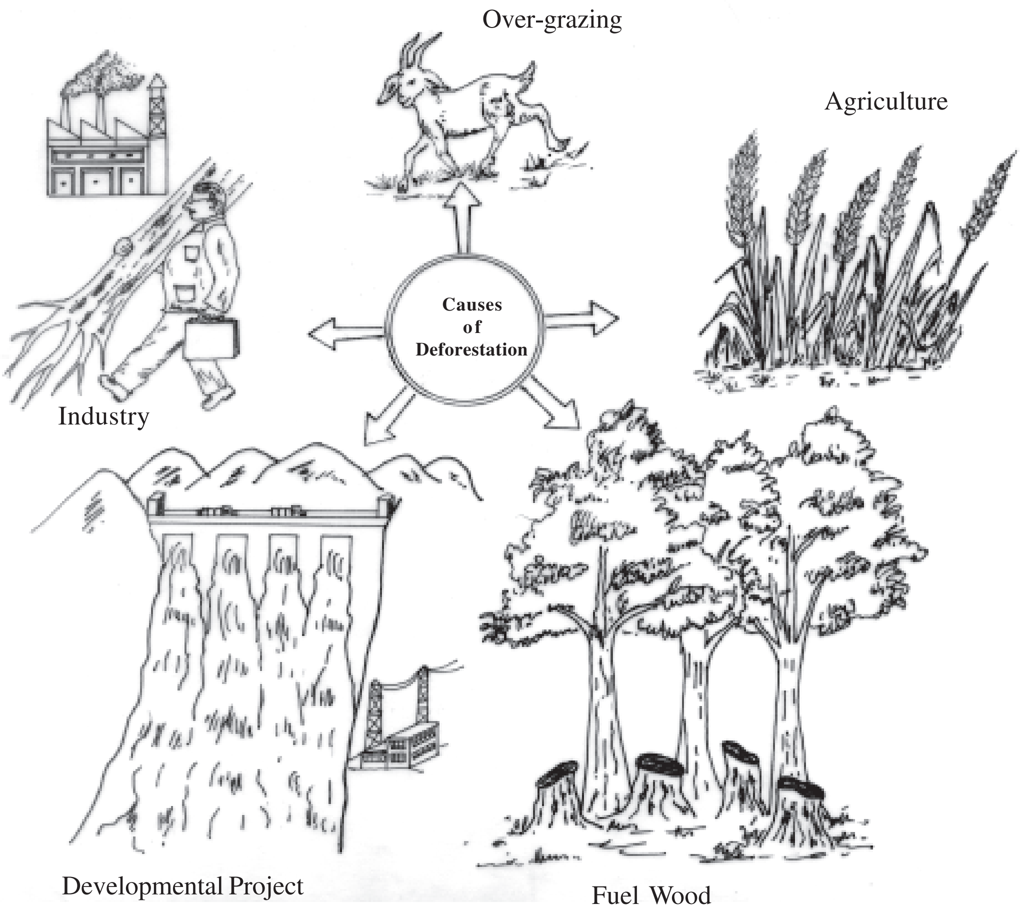


***Fig. 3.1:*** *Causes of deforestation*

Forests have been cleared for the various reasons-

**1. Developmental activities**

As humans began leading a settled life, crop fields, building, roads, industries, schools, hospitals, railway and irrigation canals etc. became necessary developmental activities. Forests were cleared to meet the need for land needs for the above developmental activities.

**2. For timber and wood**

Wood is used in buildings construction, making furniture and other articles for human use. Trees that yield wood grow in forests and were cut down for timber. Use of firewood for cooking and heating etc. also contribute to deforestation

**3. For pastures**

Forests are cleared to grow grasses and converted into grassland for grazing by cattle.

**4. Shifting cultivation**

Shifting cultivation is a system of crop cultivation involving cleaning of forest and burning the fallen trees to clear the land for raising crops. Crops are grown on the cleared area for few years and abandoned after few years as the land loses its fertility. Thereafter a new forest areas is cleared for cultivation and the same cycles is repeated

### 3.4.1 Consequences of deforestation

**• Soil erosion**

Trees intercepts rainfall and cutting of trees and removal of plants leads soil erosion. Plants roots hold the soil in place. With loss of protecting cover of plants, top soil, that is rich in organic matter, is washed away and the soil looses its fertility..

**• Landslides**

Removal of trees from forests leads to soil erosion. Ultimately cause landslides in hilly areas. This is because roots of trees hold the soil in position;

**• Silting**

The loss of trees from forests also causes silting of rivers and lakes as loose soil gets washed with rainwater and reaches water bodies;

**• Loss of wild habitat**

Wild animals live in forests. Cutting forests means loss of their habitat which in turn renders them endangered or even extinct.

- **Deforestation**

Deforestation results in change of climate since trees make the surroundings humid. Loss of trees leads to loss of humidity. Also transpiration from plants makes rain clouds and so rainfall is reduced due to deforestation.

- **Loss of $CO_2$ sink**

Pollutants released by industries take $CO_2$ are taken up by trees. When forests are denuded. This $CO_2$ sink is lost and $CO_2$ collects in the environment.

- **Pollution**

When trees are cut to use for making furniture or paper, the sawmills and paper mills pollute water in which they dump the waste.

- **Loss of medicinal and other useful plants**

Unique medicinal plants grow in certain forests. They are lost due to deforestation. Aromatic herbs, rubber trees and other useful plants are also lost due to deforestation

Thus forest destruction leads to large scale environmental degradation

## INTEXT QUESTIONS 3.2

1. What is deforestation?

2. Give two reasons why trees are cut down by humans.

3. State any two consequences of deforestation.

4. Why do wild animals become endangered due to deforestation?

5. Why does deforestation cause soil erosion?

## 3.5 ENVIRONMENTAL DEGRADATION FROM MINING

- **Loss of vegetation**

Vegetation and soil are removed to get access to mineral deposits. The flora and fauna present in the area is lost.

**• Depletion of minerals**

You have already learnt in the last lesson that earth is full of metals and mineral resources. They are very important non-renewable natural resource. India is very rich mineral resources. In last two hundred years advancement in mining technology has progressively intensified mining of mineral resources. Large amount of lead, aluminum, copper and iron ores have been used up. It is believed that in the next 20 years silver, tin, zinc and mercury will be depleted to an alarming level if their exploitation continues at the present rate.

**• Dumping of debris**

Extraction of minerals from the earth also produces significant amounts of over-burden or debris. Often it is much more as compared to the quantity of mineral obtained. The dug out loose waste material is dumped on the adjacent land. Dumping of mining waste not only occupies large land area but the waste dumps also become a source of soil erosion.

**• Land subsidence**

Excessive mining specially underground mining may lead to land subsidence and may also cause landslides. The landscape too is spoilt.

Unless care is taken, not only minerals will be alarmingly depleted but also a large land area, which could otherwise be used productively, is lost due to disposal of mining waste.

## 3.6 IMPACT OF INDUSTRIALIZATION ON THE ENVIRONMENT

To meet the growing requirement of the increasing human population large scale manufacture of essential goods is necessary. Small factories to big industries have come up for mass production of goods. Industrialization is important for the development of a country. But industrialization that disregards environmental concerns led to environmental degradation like the following reasons:

- Natural resources used as raw materials by industry are depleting rapidly.
- Industries generate lot of toxic gases, and liquid effluents leading to environmental degradation.
- Industries generate large amount of waste, which pile up in the environment. Disposal of waste not only needs land but also pollutes the environment and poses hazards to human health.
- Industries use up a lot of fossil fuels as source of energy. (Refer to lesson-2, Subsection 2.1.1 on energy to know how fossil fuels are formed). Accelerated consumption of fossils fuels is depleting their stock as they are limited and non-renewable. But burning of fossil fuels releases $CO_2$ in the atmosphere leading to global warming about which you shall learn later (lesson-14).

## 3.7 IMPACT OF MODERNIZED AGRICULTURE ON ENVIRONMENT

Increase in food production to achieve self sufficiency is an important objective. Intensive agriculture unfortunately, may lead to serious damage to environment. Some of these are listed below.

- Forests have been cleared transformed into farmlands for growing food crops.
- Excessive irrigation and poor drainage causes water logging and kill plants.
- **Pollution by agrochemicals**

Increased use of synthetic fertilizers causes to serious environmental problems. For example, unused fertilizers from agricultural fields are carried away by run off waters into lakes and rivers causing pollution. These agrochemicals may even seep through the soil and pollute ground water. Excessive nutrients enrichment of water bodies leads to 'eutrophication' (i.e. enrichment of water with nutrients particularly nitrates and phosphates triggers the explosive growth of green algae) may take place in water bodies and kill aquatic life.

Use of pesticides not only kills pests that destroy crop but may also kill many non pest organisms which may include even useful species of insects such as pollinators, birds and helpers in dispersal of plant seeds. Pesticides tend to accumulate and their concentration increases through the food chain and reach toxic levels in eggs, milk and other food items. (biomagnification)

- Agro- industrial wastes are generated. e.g. crop residues such as paddy, jawar, gram straws, cotton straws, sugarcane trash, and coconut shells etc. pile up causing environmental degradation.
- High yielding varieties (HYV) of food crops replaced various traditional crop varieties. Traditional agriculture was based on multicropping system, i.e. growing of food crops , fodder and firewood crops together. This practice had been replaced by monoculture i.e growing of only one kind of crop (such as wheat etc) in a field of specific set of nutrients making soil unfit for growing other crops but is being considered again.

## INTEXT QUESTIONS 3.3

Answer in one sentence:

1. Why are chemical pesticides considered harmful even though they kill insects' pests that damage crops?

______________________________________________

2. How do chemical fertilizers used in fields reach water bodies?

3. List any three degradational effects of modern agriculture on environment.

## 3.8 URBANIZATION AND ENVIRONMENT

Urban life is city life. More and more people are moving to cities from villages in search of jobs. The rural-urban migration is also partly due to population growth and poverty in the villages. Urbanization means permanent settlement of people in cities and this has resulted in degradation of the environment in various ways.

Industrialization opened up many new jobs.

Industries attracted rural youth to cities and their migration become easier with the improvement in communication and transport facilities.

Growth of cities lead to increasing demand of environmental resources leading to following changes -

- Cultivated land was lost forever for building houses, industries, roads and other facilities.
- A water supply system had to be developed to provide water for drinking and other domestic uses. Growing urban population created increasing demand for potable water. As a result, availability of water become more and more scarce.
- Industries, that were set up to provide the necessary goods for urban folk, generated industrial waste, leading to the pollution of the environment. In cities, black smoke emitted from industries, buses, truck etc. cause air pollution. Large amount of garbage is generated and not disposed properly. As a result garbage remains scattered and unattended. Domestic and industrial effluents are drained into rivers and lakes. High noise levels are a common feature of urban environment.
- An incessant influx of people into cities and shortage of housing result in development of slums and squatter areas. Inadequate facilities and lack of basic amenities in slums leads to unhygienic condition and social distortion and crime.

## INTEXT QUESTIONS 3.4

Answer in one sentence

1. Why there is water scarcity in cities?

2. Where do minerals and metals occur naturally?

_______________________________________________

3. Give one consequence of mining.

_______________________________________________

4. Name one natural resource that is getting depleted due to industrialization.

_______________________________________________

## 3.9 ENVIRONMENTAL BACKLASH

You are now very well familiar with the kind of environmental devastation caused by various human activities. Floods, drought, acid rain, oil spills are of common occurrence and they are largely due to the carelessness and callousness of humans towards the environment. Loss of wildlife and their habitat , disappearance of some of species such as cheetah from the country; Bhopal gas tragedy are examples of the environmental retort. At the global level, the problem of 'global warming' and 'ozone layer depletion' poses serious threat to human health and wellbeing.

### 3.9.1 Local environmental backlash

**(i) Salination of irrigated soils**

In several areas over irrigation resulted in salt accumulation in the soil as water is lost from evaporation but the salts dissolved in water remains in the soil and accumulate progressively making the soil saline and unfit for cultivation and infertile.

**(ii) Eutrophication**

Eutrophication of a water body occurs when plant nutrients such as nitrates and phosphates are released by the action of aerobic bacteria on organic wastes entering a water body. These nutrients promote growth of algae (algal bloom). Algae consume all the oxygen and aquatic organism die due to lack of oxygen.

**(iii) The Minamata disease**

Plastic, caustic soda, fungicide and pesticide manufacturing factories release mercury along with other effluents in the water body nearby. Mercury enters food chain through bacteria –algae-fish and finally the humans. Fish died due to consumption of Hg. Those who ate these fish were affected by mercury poisoning which proved fatal in certain cases. The high concentration of Hg in water and in tissues of fish resulted from formation of soluble mono methyl mercury ($CH_3Hg+$) and volatile dimethyl mercury [$(CH_3)_2Hg$] by the action of anaerobic bacteria.

### (iv)Extinction of wild life species

The numbers of tigers and lions have dwindled, the great Indian bustard is endangered and the list of the animals and plants threatened to extinction is long and growing. The Kalu River near Mumbai is severely polluted by industrial waste and the Bombay duck, a favorite edible fish which was once common in this river has been lost forever. Tigers and lions are being killed for sport and by poachers.

### 3.9.2 Regional Environmental backlash

### (i) Floods

Floods are a natural disaster and India is a flood prone country. Floods occur almost every year during the period monsoon, continuous heavy rainfall brings huge quantities of water into rivers which overflow and cause flood. The habitations close to the river get flooded resulting in loss of human life and property. This means heavy economic losses. The flood affected areas suffer from quite shortage of potable water often outbreak of epidemic diseases.

### (ii) Drought

Failure of monsoon and absence of rain leads to drought. Rise in the average global temperature due to global warming will increase water use and may create water shortage. It is estimated that a $3^0$C. Global warming may reduce as much as 10% precipitation and creating water scarcity leading to drought conditions. Shortage of water would adversely affect agriculture, industries and plants communities. Animals that are unable to move to greener pastures will perish; humans will suffer from health problems.

### (iii) Acid rain

Moisture laden air rises to higher altitudes and condenses to fall as rain or snow

Pure rain has a pH of 5.6 but in areas where industries burn oil and coal emit $SO_2$ (sulphur dioxide)into the atmosphere and motor vehicles release NOx (compound of nitrogen) into air, the rain becomes more acidic reaching pH of 2. This is because $SO_2$ and NOx dissolve in water vapour present in the atmosphere and forms $H_2SO_4$ and $HNO_3$.

When acidic snow melts acid rain drops reaches water bodies and making them acidic. Acidic water kills aquatic fauna and flora. Acidic rain is toxic to trees and corrodes buildings, marble structures and archaeological monuments.

### (iv) Oil spills

Sometimes there is accidental spill of crude oil and petroleum products into the sea by oil tankers and ships. A thin layer of oil covers sea surface depriving marine organisms of oxygen. Floating oil slicks kill marine life and severely affect ocean ecosystem.

### 3.9.3 Global backlash

**(i) Biodiversity loss**

Dwindled forests the natural habitat of various plants and animals has vanished and so have vanished forever many valuable trees and animals. Some are on the verge of extinction while others are on the borderline. See table 9.1 for the disappearing floral and faunal treasure of our country. (See lesson 9)

**(ii) Global warming and green house effect**

Green house is a glass chamber in which heat or solar radiations is trapped and plants grown in its closed warm environment.

Industrialization and urbanization have led to emission of large quantities of carbon dioxide into atmosphere from burning of fossil fuels. Increased $CO_2$ concentration in the atmosphere does not allow heat radiations given out by earth, to escape into the outer space. Increased atmospheric concentration of $CO_2$ has raised the average global temperature causing global warming. Consequences of global warming include melting of snow caps and rising of sea level, rising temperature of the earth will cause polar ice caps to melt leading rise in sea level. Excessive heat expands water. Sea level rise cause flooding of coastal cities and damage coastal ecosystems like marshes and swamps. Global warming may change rainfall pattern; lead to early maturation of crops and reduce grain size and yield of crop.

**(iii) Collapse of marine fisheries**

As already mentioned, acid rain has toxic effect on ecosytem. Global warming has driven marine fish towards cooler northern parts of the earth. Others are swimming to reach the cool deeper realms of ocean. The temperature of northern sea, it is estimated, to have increased by $1^0C$ in the last twenty-five years, several species of fish and other marine animals have permanently moved to cooler northern regions.

Smaller fish are able to move faster to cooler areas away and the elevated temperature is taking its toll no larger fish, some of which are likely to become extinct. This change in behaviour of fish has led to collapse of marine fisheries and loss of livelihood for many - many fisher folk.

Other reasons for collapse of marine fisheries is the dumping of massive amount waste into the sea. The waste dumped with the sea include sewage and garbage generated by people living in coastal areas and industrial waste from industries. Run off from agricultural fields carrying fertlilzers and pesticides are brought by rivers to the sea. Fertilizers cause "eutrophication." Oil spills and oil slicks also kill marine life.

**(iv) Ozone layer depletion**

The ozone layer in earth's atmosphere prevents harmful UV radiations of sun from reaching earth's surface. CFCs(Chloroflorocarbons) used in refrigeration, air conditioning, cleaning solvents, fire extinguishers and aerosols have damaged the ozone layer or ozone shield particularly over Artic and Antarctic. 30-40% reduction in the ozone layer may cause sunburn, fast ageing of skin, skin cancer, cataract, cancer of retina, genetic disorders, and reduced productivity in sea and forests.

## 3.10 ENVIRONMENTAL DEGRADATION- A THREAT TO SURVIVAL

You have now learnt how various human activities have caused irreparable damage to land, air and water and consequently to the organisms that inhabit them. Primitive humans struggled with nature for their survival as you have read in the earlier lessons. As human beings became more civilized and through the progress of science and technology they created various luxuries of comfortable living. But population explosion coupled with human greed for progressive prosperity and comfort has exploited and degraded the environment mercilessly to such a large extent that human survival itself is now threatened.

Contaminated food, water and air is taking its toll on human health. Toxic chemicals and harmful radiations have the potential of causing serious problems of human health.

Asthma, pulmonary fibrosis, pneumoconiosis are caused due to air pollution. Long exposure to pollutants in the working place such as mines, textile mills, poultry, crackers, sand blasting and chemical industries cause respiratory diseases. Carcinogenic chemicals and ionizing radiations in the environment have been responsible for cancer.

The enormously large population means reduced job opportunities, unemployment and related stress. Stress may also due to job pressure, money problems, uncomfortable living and dislike for work or workplace. Asthma, ulcers, diabetes, hypertension, depression, schizophrenia are **stress related** diseases and increasing rapidly.

Degraded quality of life and continuous health problems lead to mental problems. Environmental health and well being are the most valuable possessions of humans. These are fast getting lost due to the fast deterioration of the environment.

## INTEXT QUESTIONS 3.5

Answer in one or two words but not more than one sentence-

1. Name the chemical responsible for Minamata disease.

2. Why do herbivores increase in number in the forest where lions have been killed by poachers?

3. State one reason for excessive floods due to human activities.

4. What is the pH of pure rain water?

5. What combines with seawater to form oil slick?

6. Expand CFC.

## WHAT YOU HAVE LEARNT

- We depend on environment for survival as it gives us oxygen to breathe, food to eat and water to drink.
- We also get fibre, medicines, fuel etc. from environment.
- As growth of human population, spread of became agrarian culture and industrialization lead to the environmental degradation in two ways (i) depletion of natural resources (ii) pollution of the environment (air, water and soil)..
- Natural resources have been depleted through deforestation, excessive use of fossil fuels; mining etc. air has been polluted by toxic gases emitting from motor vehicles, toxic wastes discharged into water bodies.
- Better medical facilities and food for all has increased longevity and cut down infant mortality and death due to epidemics. This has resulted in increase in population.
- Demands of increased population like land for housing and cultivation of food crops, industrialization, fossil fuels as source of energy resource for industries and homes, ground water have been depleted and air, water and soil polluted.
- Humans have cut down trees and cleared forests to obtain firewood and timber and to get land for agriculture and human settlements. Deforestation has resulted in serious loss of biodiversity.
- Modernized agricultural practices have provided food for teeming millions but created problems of land erosion, environmental pollution from fertilizers and pesticides.
- Humans have moved from villages to cities in search of better employment opportunities, education and health facilities, resulted in formation of slums which suffer from unhygienic conditions.
- The consequences of depleting natural resources and environment pollution are looking the face of humans. Examples are: Bhopal Gas tragedy, Minamata disease in Japan at

the localized levels; floods, drought; oil spills and collapse of marine fisheries at the regional level. The backlash at the Global level is represented by global warming, ozone depletion and loss of biodiversity.

- In a nutshell, human survival itself is threatened due to the damage done to the environment by humans themselves.

## TERMINAL EXERCISE

1. How is the utilization of fossils fuels related to a harmful impact on the environment?
2. List three reasons for human population explosion.
3. In what way has increase in human population has degraded the environment?
4. State three reasons for deforestation.
5. Write an essay on “impact of deforestation”.
6. Why modern agriculture is held responsible for polluting air and water?
7. Why the modern influx of humans from villages to cities causing is serious concern to urban planners?
8. Why “green house gases” are considered dangerous?
9. Why do environmentalists think that “marine fisheries” may collapse, if we are not careful?
10. Write notes on:
    i. Mining and environmental degradation
    ii. Acid rain
    iii. Global warming and green house effect
    iv. Biodiversity loss

## ANSWER TO INTEXT QUESTIONS

**3.1**

1. Deforestation/depletion of fossil fuels/depletion of minerals/air, water or soil pollution etc.
2. Longevity due to better medical facilities/ availability of food..
3. Because natural resources are limited/degradation of environment is a threat to survival.

**3.2**

1. Cutting down trees to clear forests
2. For cultivation/timber/fuel wood/building houses etc.
3. Biodiversity loss/soil erosion/floods/loss of $CO_2$ sink etc.

4. Forest is natural habitat of wild animals
5. Roots hold soil in place.

**3.3**

1. They also kill useful insects.
2. The unused fertilizers from fields flow into water bodies during rains.
3. Conversion of forest into agricultural fields/water logging/use of agricultural/agroindustrial waste.(Any three)

**3.4**

1. Consumers than available water
2. Under the soil and inside it.
3. Depletion of useful metals/loss associated flora and fauna/land subsidence/landslides
4. Fossil fuels/water/metal ores.

**3.5**

1. Hg/Mercury
2. No lions to feed on them and reduce their number.
3. Rise in temperature due to green house gases/melting of ice caps.
4. 5- 6
5. Less volatile components of oil
6. Chlorofluorocarbons

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# 4

# PRINCIPLES OF ECOLOGY

In the previous module (module-1) you have learnt about the origin and evolution of the environment. You have also learnt how humans have been interacting with the environment. In this lesson, which is the first one in the module-2, you will learn some important concepts of ecology which is an established branch of science.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define the term ecology;*
- *explain the relationship between organism and its habitat with a special mention of the human species;*
- *recognize the levels of ecological organizations from organism (individual) to population, community, ecosystem, biome and biosphere;*
- *differentiate between habitat and niche;*
- *describe the concept of species and explain the basic idea of adaptation, evolution and extinction;*
- *explain the concept of population with reference to organisms;*
- *highlight the characteristics of size, growth, density and dispersion of population;*
- *analyze the demographic factors influencing the changes in population of organisms;*
- *explain community structure with reference to species diversity, interspecific interactions and ecological succession.*

## 4.1 DEFINITION OF ECOLOGY

**'Ecology may be defined as the scientific study of the relationship of living organisms with each other and with their environment.'**

The term ecology was first coined in 1869 by the German biologist Ernst Haeckel. It has been derived from two Greek words, 'oikos', meaning home or estate and 'logos' meaning study. The emphasis is on relationships between organisms and the components of the environment namely abiotic (non-living) and biotic (living).

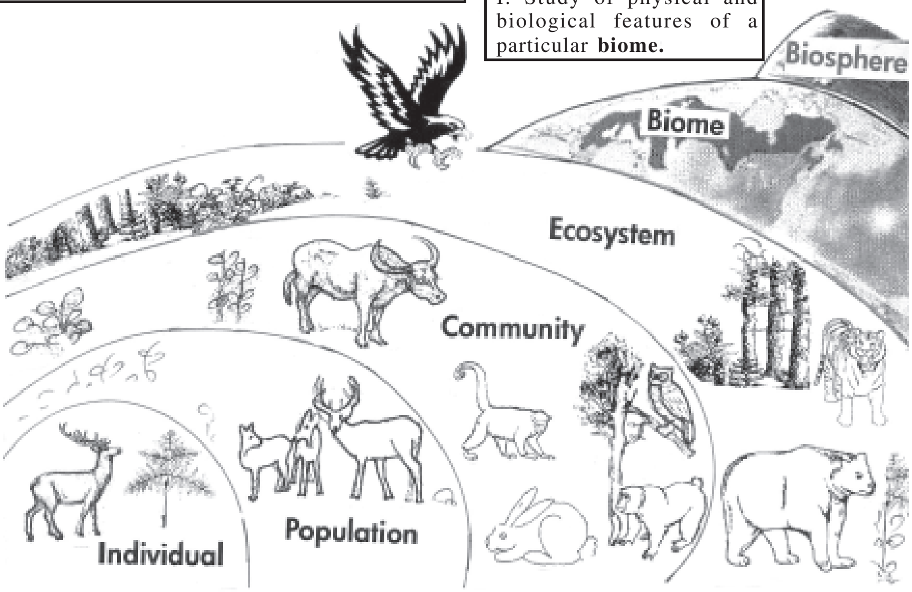
## 4.2 LEVELS OF ECOLOGICAL ORGANIZATION

Ecology not only deals with the study of the relationship of individual organisms with their environment, but also with the study of populations, communities, ecosystems, biomes, and biosphere as a whole (see Fig. 4.1)

A large community unit, characterized by a major vegetation type and associated fauna, found in a specific climatic region is a **biome**
Biomes refer basically to terrestrial areas. The aquatic systems like the seas, rivers etc. are also divided into distinct life zones on basis of salinity.

II. Study of human activities affecting the earth like global climate, ozone hole etc.

I. Study of physical and biological features of a particular **biome.**




| | | | | |
|---|---|---|---|---|
| **Study of Levels of ecological organization** | **1. Organisms** (individual) basic unit of study | **2. Population** A group of organisms consisting of a number of different populations that live in defind area and interact with each other. | **3. Community** A group of organisms consisting of a number of different species that live in an area and interact with each other | **4. Ecosystem** A communities of organisms and their physical environment, interacting as an ecological unit. |
| **Types of study** | Study of the form, physiology, behavior, distribution and adaptation of organism in relation to environment. | Study of interaction between populations and intraspecific relationships. | Study of structure and composition of community and interspecific interactions between members of community. | Study of the community in relation to the structure of its ecosystem-nutrients cycling, climate, energy flow etc. studied. |

***Fig. 4.1:*** *Levels of ecological organization and types of ecological studies*

## 4.3 HABITAT AND ORGANISM

Habitat is the physical environment in which an organism lives. Each organism has particular requirements for its survival and lives where the environment provides for those needs. The environmental requirement of an elephant would be a forest. You would not expect an elephant in the ocean nor would you expect a whale in the forest? A habitat may support many different species having similar requirements. For example, a single ocean habitat may support a whale, a sea-horse, seal, phytoplankton and many other kinds of organisms. The various species sharing a habitat thus have the same 'address'. Forest, ocean, river etc. are examples of habitat.

The features of the habitat can be represented by its structural components namely (1) space (2) food (3) water (4) and cover or shelter (Fig. 4.2).

Earth has four major habitats-(1) **Terrestrial** (2) **Freshwater** (3) **Estuarine** (Where rivers meet the ocean) and (4) **Ocean**. The human gut is the habitat of a tapeworm and the rotting log a habitat of a fungus.

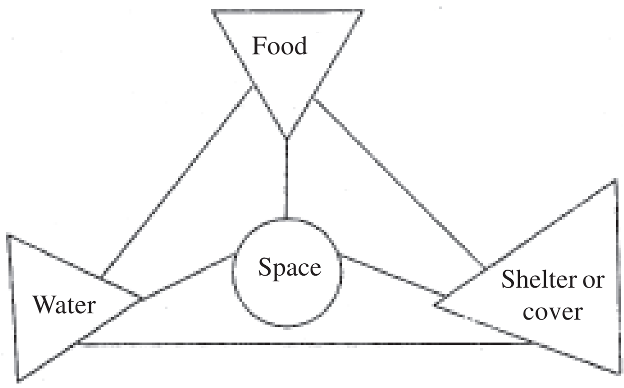



***Fig. 4.2:*** *Structural components of a habitat*

## 4.4 NICHE AND ORGANISM

In nature, many species occupy the same habitat but they perform different functions. The functional characteristics of a species in its habitat is referred to as "**niche**" in that common habitat. Habitat of a species is like its 'address' (i.e. where it lives) whereas niche can be thought of as its "profession" (i.e. activities and responses specific to the species). **The term niche means the sum of all the activities and relationships of a species by which it uses the resources in its habitat for its survival and reproduction.**

A niche is unique for a species while many species share the habitat. No two species in a habitat can have the same niche. This is because if two species occupy the same niche they will compete with one another until one is displaced. For example, a large number of different species of insects may be pests of the same plant but they can co-exist as they feed on different parts of the same plant. (Fig. 4.3).

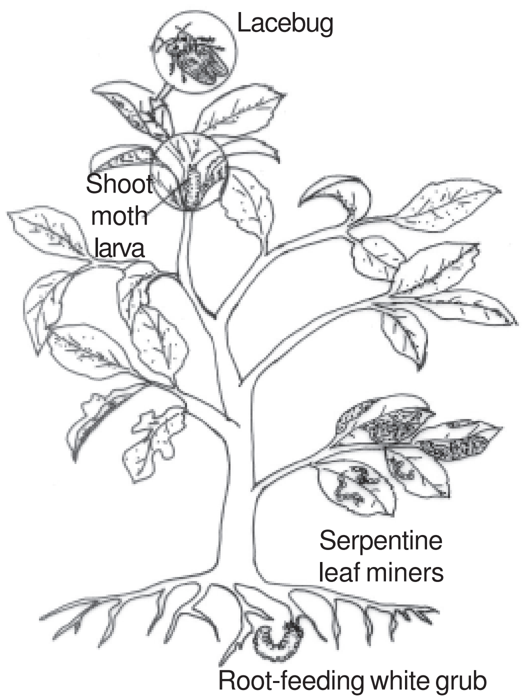



***Fig. 4.3:*** *Different species of insects feeding on different parts of the same plant*

Another example is the vegetation of the forest. The forest can support a large number of plant species as they occupy different niches: the tall trees, the short trees, shrubs, bushes and grasses are all part of the forest but because of varying heights they differ in their requirements for sunlight and nutrients and so can survive together (Fig. 4.4)

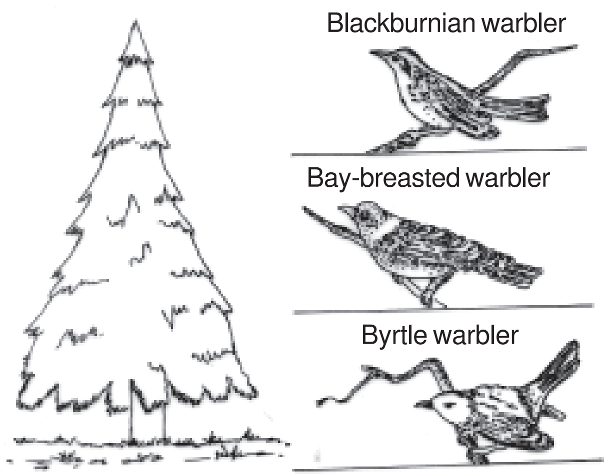



***Fig. 4.4:*** *The three species of warbler birds search for insects as food in the forest at different levels in the tree and so occupy different niches*

The most important resources in the niches of animals are food and shelter while in case of plants, they are moisture and nutrients (phosphorous and nitrogen).Fig. 4.5 shows the niche of human beings.

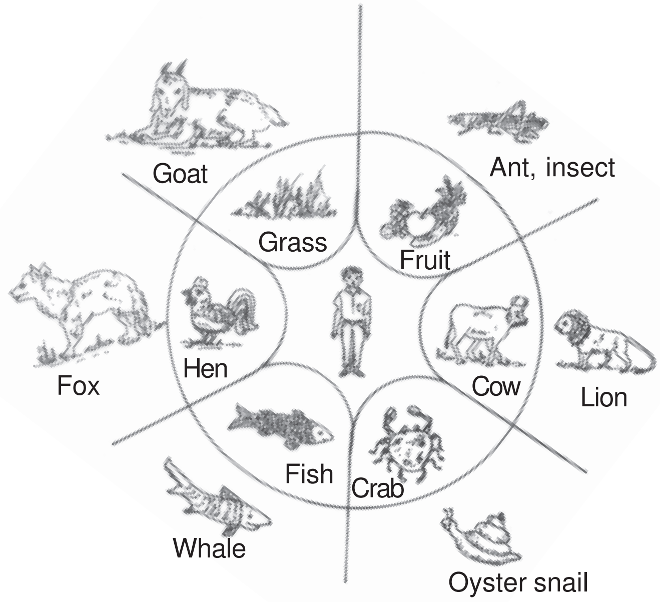



***Fig. 4.5:** The ecological niche of human being*

## INTEXT QUESTIONS 4.1

1. What does the term ecology mean?

_______________________________________________

2. Define the term niche.

_______________________________________________

3. Give one point of difference between habitat and niche.

_______________________________________________

## 4.5 ADAPTATION

Every organism is suited to live in its particular habitat. You know that the coconuts cannot grow in a desert while a camel cannot survive in an ocean. Each organism is adapted to its particular environment. **An adaptation is thus, "the appearance or behaviour or structure or mode of life of an organism that allows it to survive in a particular environment".** Presence of gills and fins are examples of adaptation in fishes to aquatic habitat. In aquatic flowering plants absence of wood formation and highly reduced root system are adaptations to aquatic environment. Adaptations that can be observed in structure (Fig. 4.6) or behaviour or physiology of an organism. Adaptations have genetic basis and have been produced and perfected through evolution. This means that the adaptions have developed over many generations to help a species survive successfully in its environment.

Examples of basic adaptations that help animals and plants to survive in their respective environments.

- Shape of bird's beak.
- The thickness or thinness of fur.
- Presence of feathers and wings in birds.
- Evergreen and deciduous nature of trees.
- Presence and absence of thorns on leaves and stems.

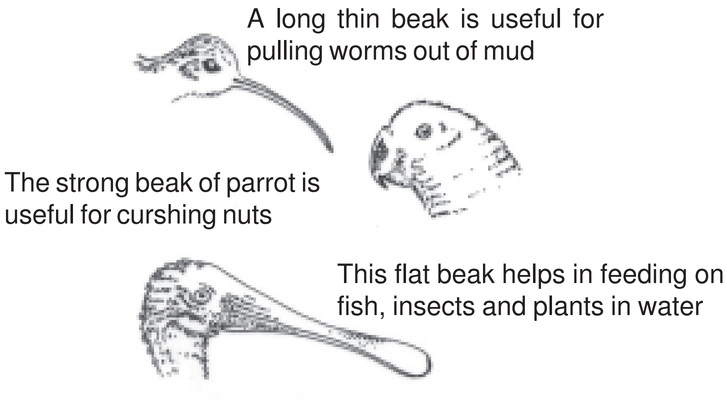



***Fig. 4.6:*** *Adaptation in the types of beaks in birds: The beaks of different birds are adopted for feeding on different kinds of food*

**• What is a Species**

A species is defined as; "a group of similar populations of organisms whose members are capable of interbreeding, and to produce fertile offspring (children)". A tiger, a lion, a lotus and a rose are examples of different species. Every species has a scientific name, understood by people of all over the world. Humans belong to species of *Homo sapiens*. Only members of the same species can interbreed to produce fertile offspring. Every species has its own set of genetic characteristics that makes the species unique and different from other species.

**• Variation**

However, species are generally composed of a number of distinct populations which freely interbreed even though they appear to be different in appearance.

Difference in colour of skin, type of hair; curly or straight, eye colour, blood type among different ethnic groups represent variation within human species. Similarly, different shape and size of cows, dogs and cats etc. are examples of variation with in each of these species (Fig. 4.7). In plants, tall and short pea varieties, various shape and size of brinjals exhibit variation among these plant species. Variations are produced as a result of chance mutation. Competition and natural selection determines as to which variation will succeed and survive. Those variations that enable a species to survive in the struggle for existence are encouraged and promoted.

In plants one can observe wide variation in size and shapes of mangoes, brinjals etc.

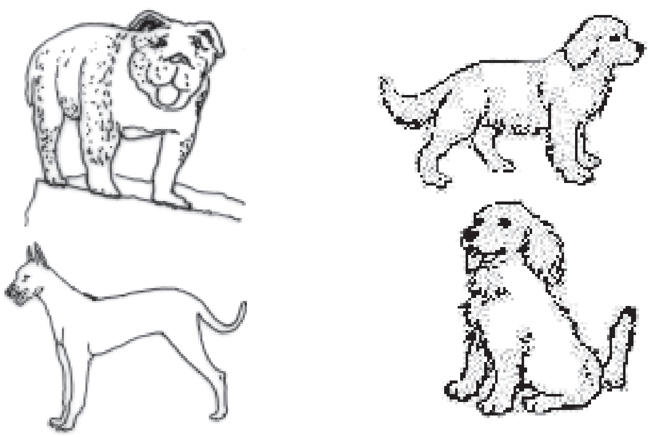


***Fig 4.7:** The populations of these four types of dogs look different but all are capable of breeding among themselves and capable of producing fertile offspring. All four belong to same species Canis lupus.*

**Evolution**

A valid theory of evolution was propounded by Charles Darwin and Alfred Wallace in 1859. This theory has been extended in the light of progress in genetics and is known as **Neo-Darwinism**. It has the following features:

1. Organisms tend to produce more off springs that can be supported by the environment.
2. **Mutation** (a change in genetic material that results from an error in replication of DNA) causes new genes to arise in a population. Further, in a sexually reproducing population, meiosis and fertilization produce new combination of genes every generation, which is termed **recombination.** Thus members of the same species show 'variation' and are not exactly identical. Variations are heritable.
3. An evolutionary force which Darwin termed **natural selection**, selects among variations i.e. genes that help the organism to adopt to its environment. Such genes are reproduced more in a population due to natural selection.

4. Those offspring which are suited to their immediate environment have a better chance of surviving, reaching reproductive age and passing on the suitable **adaptations** to their progeny.

5. Evolution thus results in **adaptation** and **diversity of the species**.

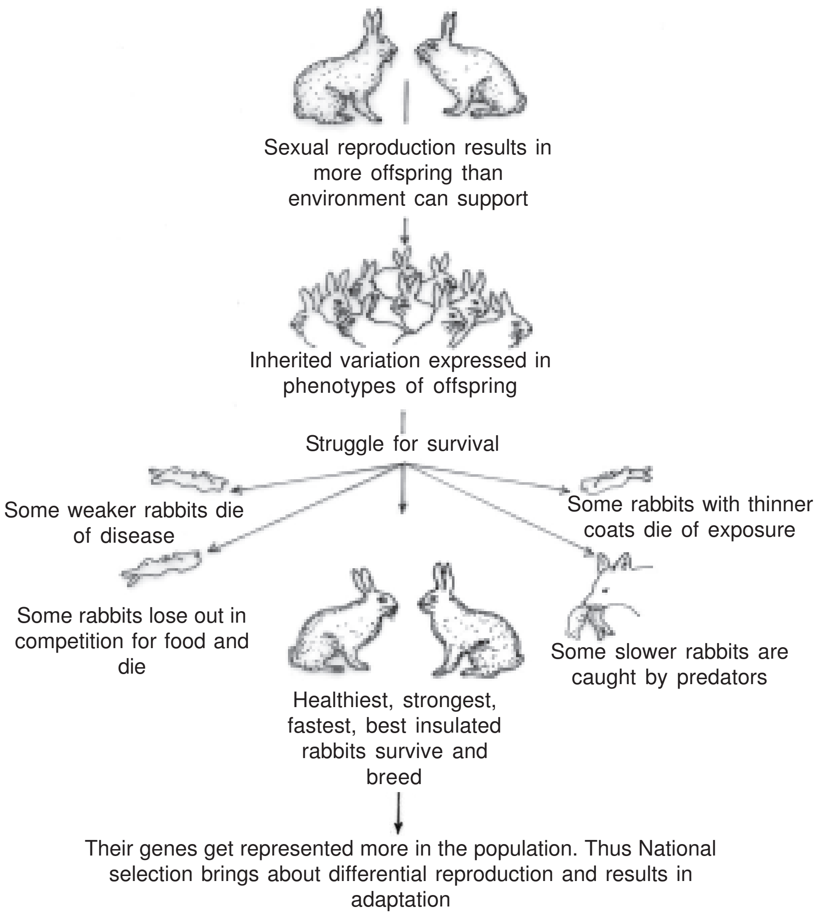



***Fig 4.8:*** *Process of natural selection*

## 4.6 SPECIES FORMATION: SPECIATION

The number of species surviving in the world today is the outcome of two processes- speciation and extinction.

**Speciation** is the process by which new species are formed and evolution is the mechanism by which speciation is brought about.

A species comprises of many populations. Often different populations of a species remain isolated due to some geographic barrier such as mountain, ocean, river, etc. Geographic isolation occurs when a physical barrier develops between two populations of a species as you can see in fig. 4.8**.** The most common way a population undergoes speciation is by geographic isolation.

- The members of a population of a species live in a particular environment and are capable of breeding with the member of another population of the same species.
- The population then becomes separated into two completely isolated populations by a barrier which prevents their interbreeding and gene exchange. The isolating mechanism may be a physical barrier like water, mountain, ocean represent geographical isolation. (Fig. 4.9)

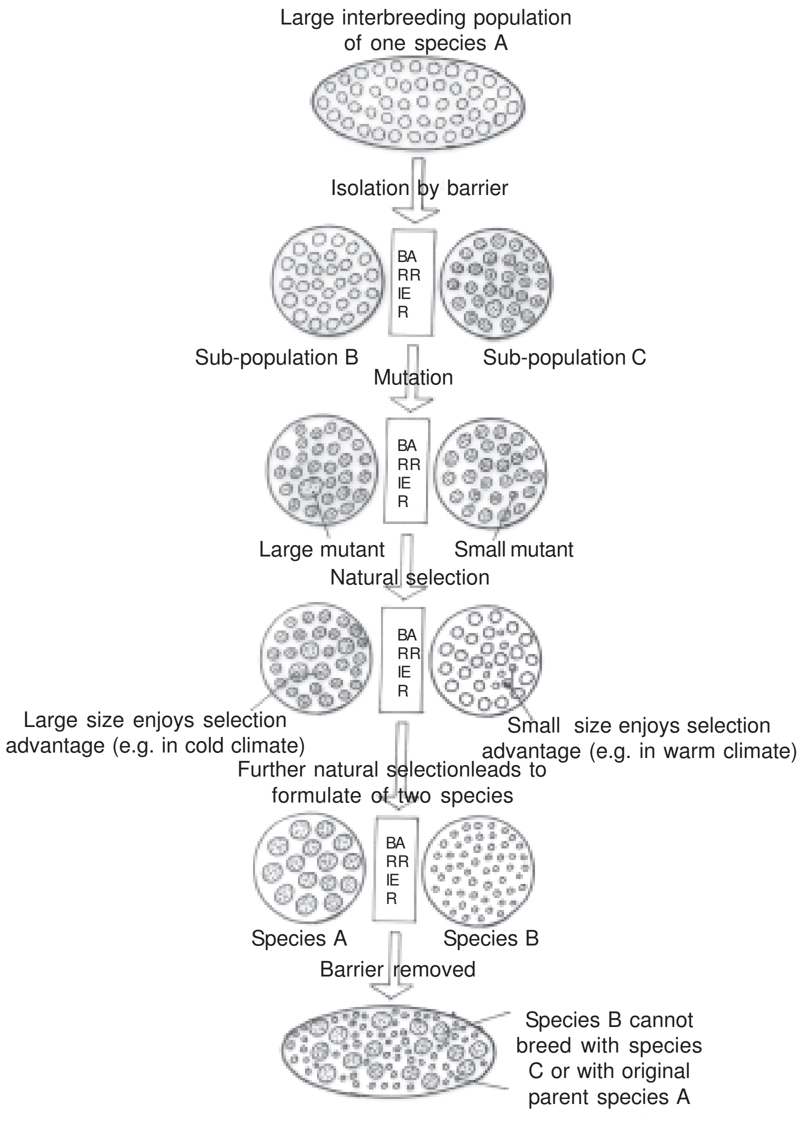



***Fig. 4.9:*** *Geographical isolation*

- Ecological isolation caused by differences in temperature, humidity, pH etc. in the environment of the two populations.
- Reproductive isolation caused by interference in interbreeding between members of different populations of species i.e. species. When two populations of a species are unable to interbreed due to reproductive barrier.
- Reproductive isolation may occurs due to any one or more of the following reasons:
  (i) When two different populations become sexually receptive at different times of the year. For example a population of frogs that breeds in May is effectively isolated from one that breeds in July, though both populations may occur in the same area.
  (ii) Members of different populations are not attracted by courtship behaviour towards one another.
  (iii) Pollination mechanism fails, between flowers of two populations.
  (iv) Cross fertilization is prevented as sex organs of different populations of a species do not match.
- Mutations occur randomly in isolated populations giving rise to new variation within each sub-population of these mutations those that help to adapt to the environment are reproduced in greater numbers in the next generation due to natural selection.
- In other words since no two environments are identical, natural selection pressures that occur on each separate sub-population are different, depending on local conditions such as climate, disease, predators etc. Natural selection affects each sub-population differently and so different 'variations' caused by nutrition or recombination in different subpopulations get established. With the passage of time, the sub populations become more and more different from each other.
- After a long period of time, the sub-populations become very different and get isolated, reproductively, i.e. they no longer interbreed.
- Later even when the barrier is removed the sub-populations are unable to interbreed and thus subsequently the sub-populations become two different species.

**An example of formation of new species**

A current example of speciation can be seen in the two species of squirrels Kaibab squirrels and Abert squirrels that live on opposite sides of the Grand Canyon. Biologists assume that the two squirrel populations became separate species when about one million years ago, the Colorado river changed its course, splitting the original population of squirrels into two. Since the environment on opposite sides of the canyon is different, different characteristics were favoured on each side of the canyon, by natural selection. After many years of separation, the genetic differences between the populations became so large that the two squirrel populations became two separate species. They look different and can no longer interbreed (Fig 4.10).

Kaibab Squirrel (North Rim)
*Sciurus kaibabensis*

Aberr Squirrel (South Rim)
*Sciurus aberti*

***Fig. 4.10:** The Kaibab squirrel of the north rim and the Abert squirrel of the south rim had common ancestors*

### 4.6.1 Extinction

Ever since life evolved on earth, new species better suited or adapted to the environment have appeared and older less successful forms have died or become extinct. Extinction is generally a natural occurrence. It means the dying out of a variety of or a species. The primary reason for these extinctions is environmental change or biological competition. Extinction occurs when species cannot evolve fast enough to cope with the changes taking place in their environment. (Fig. 4.11). Many species have gone extinct during geological history of the earth. Fossils are, the preserved remains of animals, plants, and other organisms that lived in the geological past.

(a)

(b)

***Fig. 4.11:** (a) Fossil of fern plant. (b) Fossil fish*

Extinction may take place due to catastrophic natural phenomena such as tsunami, volcanoes etc. In recent time, human activities such as deporation, over exploitation, environmental pollution and environmental change are other factors responsible for extinction. Deforestation for expansion of industries and human settlements has promoted economic growth but at the same time it has resulted in habitat loss for many wild plants and animals. Pollution has killed many an aquatic species.

## INTEXT QUESTIONS 4.2

1. What is meant by the term adaptation? Answer in one sentence.

______________________________________________

2. Define : (i) species (ii) variation

______________________________________________

3. Name two sources of variation.

______________________________________________

4. Name the evolutionary force which brings about greater reproduction of adaptive variation.

______________________________________________

5. Explain the term (i) speciation and (ii) extinction.

______________________________________________

## 4.7 POPULATION

'Population' is defined as a group of freely interbreeding individuals of the same species present in a specific area at a given time. For example, when we say that the population of a city is 50,000, we mean that there are 50,000 humans in that city. However, all populations of humans living in any part of the world constitute the species ***Homo sapiens.***

A population has traits of its own which are different from those of the individuals forming the population. An individual is born and dies but a population continues. It may change in size depending on birth and death rates of the population. An individual is either female or male, young or old but a population has a sex ratio and age structure, which means, the ratio of male to female in the population and the various age groups into which the population may be divided.

The characteristics of any population depends on:

(i) density of the population, (ii) natality (birth rate), (iii) mortality (death rate), (iv) dispersal, (v) biotic potential (vi) age distribution (vii) dispersion and (viii) growth form.

**Density:** The number of individuals per unit area at a given time is termed as **population density**. The density of species varies from time to time and from one place to another. For example, you may notice more plant and animal species in the garden during the monsoon season. Density of a particular organism in a region is determined by selecting random samples of a particular dimension size called quadrat from that region.

In case of large, mobile animals like tigers, leopards, lions, deer etc, the density may be determined by counting individual animals directly or by the pugmarks (foot imprints) left by the animals in a defined area (Fig. 4.12). Pugmarks of each individual animals are unique and different from one others. Study of pug marks can provide the following information reliably if analyzed skillfully:

- Presence of different species in the area of study.
- Identification of individual animals.
- Population of large cats (tigers, lions etc.).
- Sex ratio and age (young or adult) of large cats

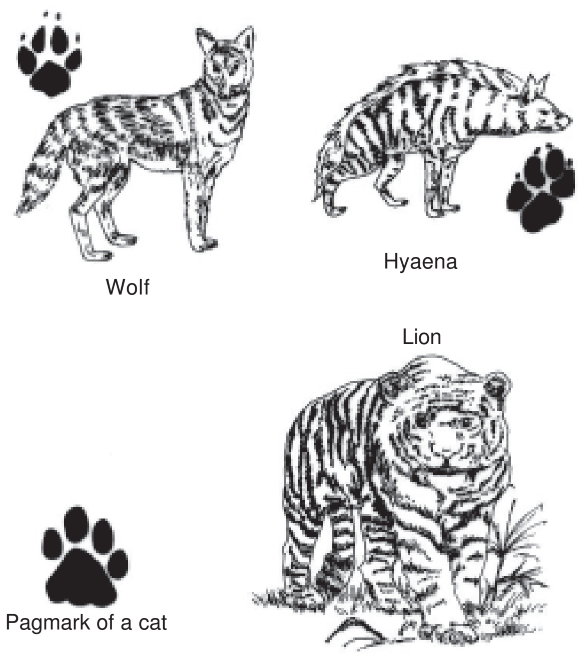



***Fig. 4.12:*** *Pugmark of a lion/cat (Foot prints) of soft padded wild animals*

Counting of human population is called **census** and is carried out by the Indian government every 10 years. In census however each individual is physically counted.

- **Natality:** The rate at which new individuals are born and added to a population under given environmental conditions is called **natality**. Birth, hatching, germination and vegetative propagation cause an increase in the number of individuals in a population.

In case of humans, natality or birth rate is usually expressed in terms of births per thousand per year.

- **Mortality:** Loss of individuals from a population due to death under given environmental conditions is called **mortality**. The number of individuals dead in a year is calculated for obtaining the mortality rate or death rate. Mortality rate in human population may be expressed in terms of number of persons dead per thousand per year.
- **Dispersal:** The movement of individuals of a population out of a region on a permanent basis is termed emigration while immigration refers to the movement of individuals into a new area where dispersal includes both emigration and immigration of individuals. The population of a region is affected by dispersal. Active migration is not possible in plants though seeds may be dispersed over long distance by wind, water and animals.

The density of a population thus basically depends on four factors: i) natality, ii) mortality, iii) immigration and iv) emigration (Fig. 4.13)

Immigration
↓ (+)
(+) (-)
Natality Density Mortality
(-) ↓
Emigration

***Fig. 4.13:*** *Parameters of population*

**Age distribution**

Natural populations include individuals of all age groups. It, therefore, becomes necessary for us to consider age distribution of a population. Age distribution refers to the proportions of individuals of different age groups in a population.The population may be broadly divided into three age groups:-

- pre-reproductive group: comprising of juvenile individuals or children,
- reproductive group: consisting of individuals capable of reproduction ,
- post-reproductive group: contains aged individuals who are incapable of reproduction.

A rapidly growing population will usually contain a large proportion of individuals in the reproductive age group; a stationary population (where there is no increase or decrease in population) contains an even distribution of all age groups, and a declining population contains a large proportion of old or post-reproductive age of an individuals.

**• Sex ratio**

Sex ratio is an important aspect of population. It refers to the ratio between female and male individuals in a population

## 4.8 POPULATION GROWTH

The growth, stability or decline in number of individuals in a population is influenced by its relation with the environment.

Populations have characteristic patterns of growth with time, which is depicted by population growth curves. Two basic forms of population growth curves can be identified. (i) 'J' shaped growth curve and the (ii) 'S' shaped or sigmoid growth curve.

**Density independent population growth**

A forest fire may reduce a dense or scanty population drastically. Extreme weather conditions like drought, rains, floods, storms and sudden rise or fall in temperatures all act as density independent factors as they tend to cause sudden reduction in population numbers. The population growth that is depicted by a 'J' shaped growth curve is called density independent growth.

Generally the 'J' shaped growth curve is typical of the species which reproduce rapidly and which are greatly affected by seasonally fluctuating environmental factors such as light, temperature and rainfall. In this type of curve, population density increases rapidly in exponential (geometric) progression (total number doubles at regular intervals of time) like this:

$$8 \xrightarrow{\times 2} 16 \xrightarrow{\times 2} 32 \xrightarrow{\times 2} 64 \xrightarrow{\times 2} 128 \xrightarrow{\times 2} \text{till a peak is reached.}$$

This type of exponential growth occurs in nature when a population has abundant supply of resources. After reaching a peak there is a sudden crash or decline due to environmental or other factors. Such type of growth may be exhibited by insect populations which show explosive growth during the monsoon season and then abruptly disappear at the end of the season.

## INTEXT QUESTIONS 4.3

1. Define population.

   ______________________________

2. Name at least three characteristics of population.

   ______________________________

3. What are the factors on which density of a population depends?

   ______________________________

## 4.9 COMMUNITIES AND THEIR CHARACTERISTICS

In ecology the term community, or more appropriately 'biotic community, refers to the populations of different kinds of organisms living together and sharing the same habitat.

### 4.9.1 Organization of a biotic community

The characteristic pattern of the community is termed as structure of the community and is determined by:

- the roles played by its various populations;
- the range of its various populations;
- the type of area that is inhabited by the populations of the community;
- the diversity of species in the community;
- the interactions between various populations of the community inhabiting the area.

Members of a community also actively interact with their environment. In a community only those plants and animals survive which are adapted to a particular environment. The climate determines the type of environment, hence, the type of organisms in a community. For example, it is the climate of the area which determines whether a given area becomes a desert or a forest.

Communities created by human such as lawns or crop communities are such man made communication are crop communities are relatively simple and consists of only one species as opposed to a natural community characterized by a large number of species. Man made communities are very unstable and require great deal of care and constant manipulation and maintenance.

### 4.9.2 Stratification

Stratification of a community refers to the vertical layers of the vegetation. Tropical forests represent a good example of vertical stratification. In moist tropical rain forests up to five distinct strata or layers of vegetation can be formed. These include from the forest floor to the top (Fig. 4.14):

| | |
|---|---|
| (i) Ground layer of mosses and liverworts associated with dead leaves and other substances rich in organic matter. | **The bottom layer** |
| (i) Herb or grass layer, } | **The lower layer** |
| (ii) Short shrub layer | **The middle layer** |
| (iii) Tall shrub layer | |
| (iv) Layer of under storey of short trees, | |
| (v) Layer of canopy of lower tress and | **The upper layer** |
| (vi) Over storey or emergent tree layer formed by tall trees. | |


***Fig. 4.14:*** *Stratification in a biotic community*

As you can see in the fig. 4.14 the tropical forest the **canopy** dominates the area. They modify the light and moisture conditions for the shorter trees growing under them, which in turn determine the conditions for the ground vegetation. The vertical stratification of the plant community determines the structure of the community. The vegetation provides a number of habitats for the various organisms. Different layers of the community are occupied by different species of plants and animals. Plants and animals of each layer differ in size, behaviour and adaptation from those of other layers. The different layers of organisms minimize competition and conflict among the members of the community. The various species in the community compete with each other for nutrients, space, light and other resources. (refer again to Fig 4.4). Stratification is a practical strategy to minimize interspecific competition.

- **Community Characteristics**

**Species diversity**

An important attribute of a community is its species diversity.

The different kinds of organisms present in a community represent its species diversity. The species composition or diversity differs from one community to another. Even in the same community, there may be seasonal variation in species composition.

Species diversity also influences the stability of the community. A stable community is one which is able to return to its original condition after being disturbed in some way. Communities with high species diversity have been found to be comparatively more stable.

The diversity is calculated both by the number of species (richness) and the relative abundance of each species (evenness). Relative abundance is measure of relative proportion of different species occurring in a community. The greater the number of species and more even their distribution the greater is the species diversity.

## 4.10 ECOLOGICAL SUCCESSION

Biotic communities are dynamic in nature and change over a period of time. The process by which communities of plant and animal species in an area are replaced or changed into another over a period of time is known as **ecological succession**. Both the biotic and abiotic components are involved in this change. This change is brought about both by the activities of the communities as well as by the physical environment in that particular area. The physical environment often influences the nature, direction, rate and optimal limit of changes. During succession both the plant and animal communities undergo change. There are two types of successions (i) Primary succession and (ii) Secondary succession.

### 4.10.1 Primary succession

Primary succession takes place an over a bare or unoccupied areas such as rocks outcrop, newly formed deltas and sand dunes, emerging volcano islands and lava flows as well as glacial moraines (muddy area exposed by a retreating glacier). where no community has existed previously. The plants that invade first bare land, where soil is initially absent are called pioneer species. The assemblage of pioneer plants is collectively called pioneer community. A pioneer species generally show high growth rate but short life span (Fig 4.15)

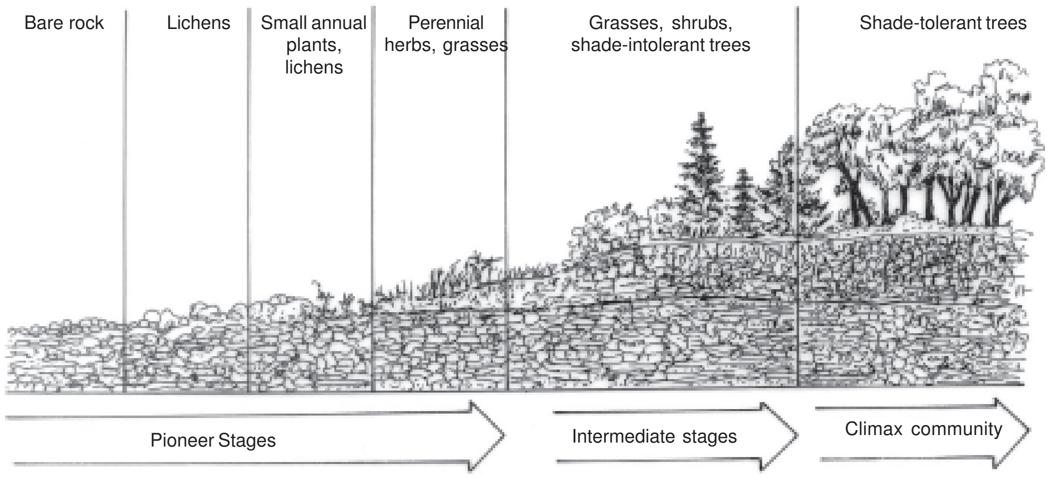



***Fig 4.15:** The orderly sequence of primary succession*

Primary succession is much more difficult to observe than secondary succession because there are relatively very few places on earth that do not already have communities of organisms. Furthermore, primary succession takes a very long time as compared to secondary succession as the soil is to be formed during primary succession while secondary succession starts in an area where soil is already present.

The community that initially inhabits a bare area is called **pioneer community**. The pioneer community after some time gets replaced by another community with different species combination. This second community gets replaced by a third community. This process continues sequence-wise in which a community replaced previous by another community. Each transitional (temporary) community that is formed and replaced during succession is called a stage in succession or a seral community (Fig. 4.16). The terminal (final) stage of succession forms the community which is called as **climax community**. A climax community is stable, mature, more complex and long lasting. The entire sequence of communities in a given area, succeeding each other, during the course of succession is termed **sere** (Fig 4.16).

The animals of such a community also exhibit succession which to a great extent is determined by plant succession. However animals of such successional stages are also influenced by the types of animals that are able to migrate from neighbouring communities. A climax community as long as it is undisturbed, remains relatively stable in dynamic equilibrium with the prevailing climate and habitat factors.

Succession that occurs on land where moisture content is low for e.g. on bare rock is known as **xerarch**. Succession that takes place in a water body, like ponds or lake is called **hydrarch**.

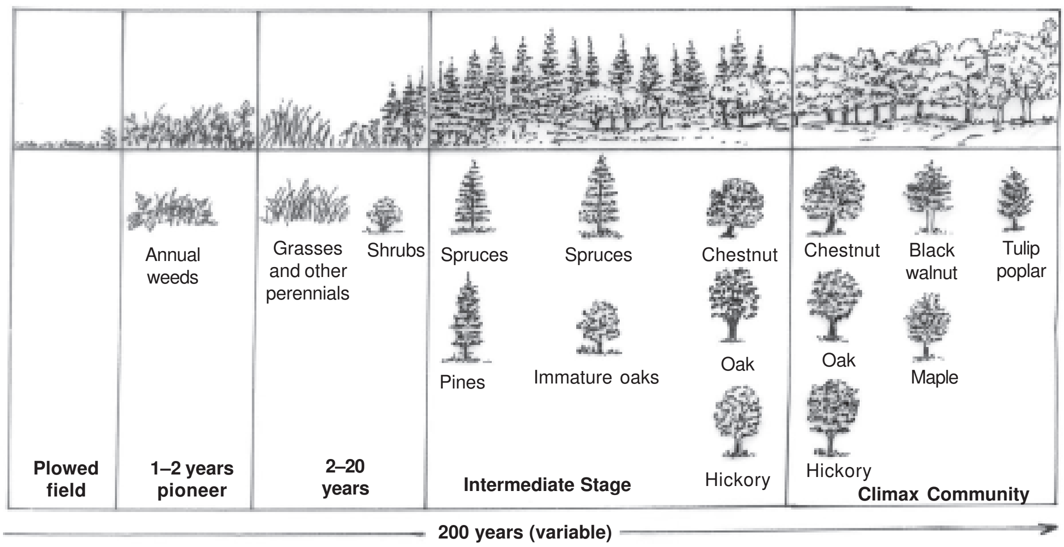



***Fig. 4.16:*** *Secondary succession on land*

### 4.10.2 Secondary succession

Secondary succession is the development of a community which forms after the existing natural vegetation that constitutes a community is removed, disturbed or destroyed by a natural event like hurricane or forest fire or by human related events like tilling or harvesting land.

A secondary succession is relatively fast as, the soil has the necessary nutrients as well as a large pool of seeds and other dormant stages of organisms.

## INTEXT QUESTIONS 4.4

1.Explain in brief (one to two sentences) the following ecological terms:

(i) Succession.____________________________

(ii) Pioneer species. ____________________________

(iii) Climax community ____________________________

(iv) Secondary succession ____________________________

## 4.11 BIOTIC INTERACTION

The biological community of an area or ecosystem is a complex network of interactions. The interaction that occurs among different individuals of the same species is called **intraspecific interaction** while the interaction among individuals of different species in a community is termed as **interspecific interaction**.

Interactions between organisms belonging to the same trophic level often involve competition. Individuals of population may compete for food, space and mates. For example if a mouse has been eaten by a cat, other cats competing for this resource would have one less mouse to prey on. The snake another predator of the mice would also have fewer mice to eat during the night if the cat has succeeded. Direct competition though, between the cat and snake is not much as they prey at different times. They also eat a variety of different foods. So competition may be intraspecific as well as interspecific.

Interspecific relationship may be direct and close as between a lion and deer or indirect and remote as between an elephant and a beetle. This is because interactions between two species need not be through direct contact. Due to the connected nature of ecosystems, species may affect each other through intermediaries such as shared resources or common enemies. Specific terms are applied to interspecific interactions depending upon whether the interaction is beneficial, harmful or neutral to individuals of the species. The various possible interactions between two species are given in Table 4.1.

**Table 4.1:** Possible biological interactions between two species.

| S. No. | Type of interaction | 1 Result of species 2 | Effects of interaction |
|---|---|---|---|
| **I.** | **NEGATIVE INTERACTIONS** | | |
| i. | Amensalism | 0 | one species is inhibited while the other species is unaffected |
| ii. | Predation | + | Predator–prey relationship: one species (predator) benefits while the second species (prey) is harmed and inhibited. |
| iii. | Parasitism | + | Beneficial to one species (parasite) and harmful to the other species (host). |
| iv. | Competition | 0 | Adversely affects both species |
| **II.** | **POSITIVE ASSOCIATIONS** | | |
| i. | Commensalism | + 0 | One species (the commensal) benefits, while the other species (the host) is neither harmed nor inhibited |
| ii. | Mutualism | + + | Interaction is favourable to both species |
| **III.** | **NEUTRAL INTERACTIONS** | | |
| i. | Neutralism | 0 0 | Neither species affects the other |

+ =beneficial; – = harmful, 0 =unaffected or neutral

- Some types of interactions listed by the effects they have on each partner. 'O' is no effect, – is detrimental and + is beneficial.

### 4.11.1 Types of Interactions

From the table you can see that in certain types of interspecific associations at least one of the species is harmed by the other. Such associations are termed as negative, in case where both the associated species are benefited is a positive association and when the associated species are neither benefited nor harmed represents a neutral interaction and include:

1. **Amensalism**: This is a negative association between two species in which one species harms or restricts the other species without itself being adversely affected or harmed by the presence of the other species. Organisms that secrete antibiotics and the species that get inhibited by the antibiotics are examples of **amensalism**. For example the bread mould fungi *Pencillium* produce penicillin an antibiotic substance which inhibits the growth of a variety of bacteria. *Pencillium* benefits apparently by having greater availability of food when the competition because of the bacteria is removed.

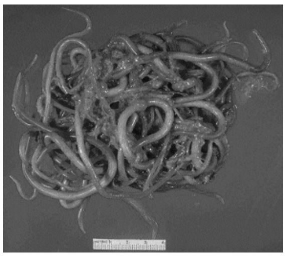
2. **Predation:** In this type of interaction **predator** captures, kills and eats an animal of another species called the **prey**. The predator naturally benefits from this relationship;

while the prey is harmed. Predators like leopards, tigers and cheetahs use speed, teeth and claws to hunt and kill their prey.

3. **Parasitism:** In this type of interaction, one species is harmed and the other benefits. Parasitism involves parasite usually a small size organism living in or on another living species called the **host** from which the parasite gets its nourishment and often shelter. The parasite is benefited and the host is harmed. Many organisms like animal, bacteria and viruses are parasites of plants (Fig. 4.18a) and animals (Fig. 4.18b). Plants like dodder plant (*Cuscuta*) (Refer again to fig. 4.18a) and mistletoe (*Loranthus* ) are parasites that live on flowering plants. Tap worm, round worm, malarial parasite, many bacteria, fungi, and viruses are common parasites of humans.

(a) (i)
Dodder, a parasitic plant is eating up a bush

(ii)
Dodder, a leafless parasitic plant, growing on the leaf of a grass tree



(b) *Ascaris lumbricoides* infections. A mass of large round worms from a human infestation.

***Fig. 4.17:** Parasite-host relationship (a) Plant parasite: Dodder (Cuscuta) plant is a parasitic weed that obtains moisture and nourishment by attaching to a green, living plant. (b) Animal parasite: Ascaris or round worms are internal parasites found in the human intestines*

4. **Competition**: This is an interaction between two populations in which both species are harmed to some extent. Competition occurs when two populations or species, both need a vital resource that is in short supply. The vital resource could be food, water, shelter, nesting site, mates or space. Such competition can be: (i) interspecific competition-occurring between individuals of two different species occurring in a habitat and (ii) intraspecific competition-occurs between individuals of same species.

Intraspecific competition occurs between members of the same species and so it is very intense.

5. **Commensalism:** In this relationship one of the species benefits while the other is neither harmed nor benefited. Some species obtain the benefit of shelter or transport from another species. For example sucker fish, remora often attaches to a shark by means of its sucker which is present on the top side of its head. This helps the remora get protection, a free ride as well as meal from the left over of the shark's meal (Fig. 4.18). The shark does not however get any benefit nor is it adversely affected by this association. Another example of commensalisms is the relationship between trees and epiphytic plants. Epiphytes live on the surface of other plants like ferns, mosses and orchids and use the surface of trees for support and for obtaining sunlight and moisture. The tree gets no benefit from this relationship nor are they harmed.

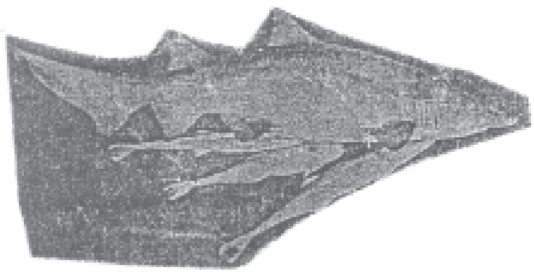


**Fig. 4.18:** *Commensalism: A shark with suckerfish*

6. **Mutualism:** This is a close association between two species in which both the species benefit. For example of protocorporation the sea anemone, a cnidarian gets attached to the shell of hermit crabs for benefit of transport and obtaining new food while the anemone provides camouflage and protection by means of its stinging cells to the hermit crab (Fig. 4.19).

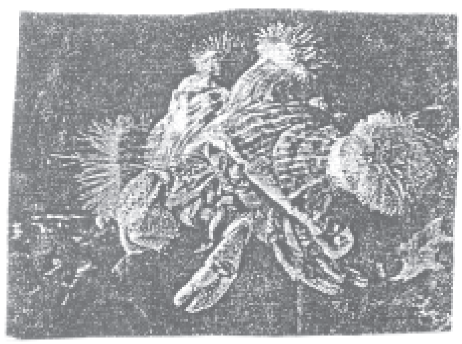


***Fig. 4.19:*** *Sea anemone, attached to a shell inhabited by a hermit crab*

However, some mutualisms are so intimate that the interacting species can no longer live without each other as they depend totally on each other to survive. Such close associations

Notes

are called **symbiosis**. An example of such close mutualistic association is that of termite and their intestinal flagellates. Termites can eat wood but have no enzymes to digest it. However, their intestine contains certain flagellate protists (protozoans) that have the necessary enzymes to digest the cellulose of the wood eaten by termites and convert it into sugar. The flagellates use some of this sugar for their own metabolism while enough is left for the termite. Both termite and flagellates cannot survive without each other. Another familiar example of symbiosis is seen in pollination of flowers where flowering plants are cross pollinated by the bees which benefit by getting nectar from the plants and both cannot survive without the other.

7. **Neutralism:** Neutralism describes the relationship between two species which do interact but do not affect each other. It is to describe interactions where the fitness of one species has absolutely no effect what so ever on that of other. True neutralism is extremely unlikely and impossible to prove. When dealing with the complex networks of interactions presented by ecosystems, one can not assert positively that there is absolutely no competition between or benefit to either species. Since true neutralism is rare or non-existent, its usage is often extended to situations where interaction are merely insignificant or neglible.

## INTEXT QUESTIONS 4.5

1. Define (a) ecological succession, (b) symbiosis

   ______________________________

2. What type of competition exists between members of a deer herd in an area?

   ______________________________

3. What type of relationship is represented by a garden spider feeding on a grasshopper?

   ______________________________

4. What type of relationship is represented by a flower being pollinated by a butterfly?

   ______________________________

5. Which term best fits the relationship of a person who has a lice feeding on his scalp?

   ______________________________

6. Which term means two species live together with each providing a benefit to the other through the relationship?

   ______________________________

## WHAT YOU HAVE LEARNT

- Ecology may be defined as the scientific study of the relationships between each other and with their environment. The term ecology was coined by Ernst Harckel in 1869 .
- Ecology encompasses study of individual, organisms, population, community, ecosystem, biome and biosphere which form the various levels of ecological organization.
- Habitat is the physical environment in which an organism lives (it corresponds to address of an organism).
- Niche refers to the functional position of a species in its habitat.
- Species is a group of populations whose individual members are capable of interbreeding with each other to produce a fertile offspring.
- Evolution is the change which gives rise to new species. Mutation and recombination are sources of 'variation' or differences in the genetic make up or gene pool of a species. Natural Selection is the mechanism proposed by Darwin and Wallace which interacts with variation to cause greater reproduction of these genes which help in adaptive to the environment.
- Thus Evolution results in adaptation.
- Evolution leads to speciation or formation of new species. Isolation is the factor which supports specimen. Isolation is of two major types (i) geographical isolation (ii) reproductive isolation.
- Many species, however, have been lost forever and not a single individual belonging to these species which once existed are now present. Extinction may occur due to catastrophic events in nature or due to human activities.
- Population is a group of interbreeding individuals found in a specific time in a particular geographical area. The characteristics of a population become evident through the (i) population density (ii) birth rate or natality (iii) death rate or mortality (iv) dispersion (immigration and migration) (v) age distribution (vi) sex ratio.
- Ecological succession is the successive growth of primary succession occurs in an area where there is no previous community. Secondary succession forms on existing natural vegetation.
- Biotic interaction refers to the interaction taking place between individuals belonging to the same species (intra specific) or different species (interspecific). Examples are (i) competition (ii) predation (iii) parasitism (iv) mutualism (v) symbiosis (vi) commensalism (vii) neutralism

## TERMINAL EXERCISE

1. Define the terms : Ecology, niche, species, extinction.
2. What do you understand by 'Variation and Natural Selection'? In what way do they interact to cause evolution?
3. What is the role of isolation in the formation of new species and keeping them distinct.
4. In what ways have humans caused the extinction of species?
5. What do you understand by (i) natality (ii) speciation (iii) mutation (iv) extinction
6. Explain 'ecological succession'.
7. State and explain community characteristics.
8. What are (i) climax community and (ii) pioneer species?
9. Write an essay on biotic interaction.
10. Define biotic Interaction. Describe any one type of positive, negative and neutral quotation.

## ANSWER TO INTEXT QUESTIONS

**4.1**

1. Ecology means the scientific study of the relationship of living organisms with each other and with their environment.
2. The term niche means the sum of all activities and relationship a species has while obtaining and using the resources it needs to survives and reproduce.
3. Habitat is the physical environment where an organism lives while niche is the sum of all activities and relationship of a species

**4.2**

1. The appearance or behaviour or structure or mode of life of an organism that allows it to survive in particular environment.
2. Species – a group of similar populations of organisms whose members are capable of inter breeding to produce fertile offspring.

   Variation- differences in structure due to differences in gene combinations.
3. (i) Gene combination (ii) Mutation

4. Natural selection
5. Speciation- is the process by which new species are formed and extinction is dying out of a variety of or a species.

**4.3**

1. A Group of freely interbreeding individuals of the same species present in a specific area at a given time.
2. i) Density of the population

   ii) Natality

   iii) Mortality (any other)
3. Mortality, natility, immigration, emigration

**4.4**

1. (i) Succession is the orderly change of organisms in an environment over time.

   (ii) Pioneer species is the name use for the first time assemblage of plants that inhabit as area undergoing changes during succession. They are the first species in successional process.

   (iii) Climax community is the final stage of succession. It is a relatively stable, long lasting community.

   (iv) Secondary succession is the term used for the orderly series of change s that begins with the disturbance of an existing community and leads to a climax community

**4.5**

1. The interacting species can no longer time without each other as they depend totally on each other to survive.
2. Intraspecific competition
3. Predation as it is preying upon or eating the grasshopper.
4. Mutualism as both are helped by the relationship.
5. Host
6. Mutualism

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# 5

# ECOSYSTEM

You know that earth is perhaps the only planet in the solar system that supports life. The portion of the earth which sustains life is called biosphere. Biosphere is very huge and can not be studied as a single entity. It is divided into many distinct functional units called ecosystem. In this lesson you will study about the structure and functions of ecosystem.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the concept of ecosystem;*
- *recognize the two major components of ecosystem;*
- *describe ecosystem components by giving example of a pond;.*
- *list a few natural and human modified ecosystems;*
- *explain energy flow through food chain;*
- *differentiate between the various trophic levels- producers, consumers and decomposers;*
- *construct a food chain and represents–terrestrial and aquatic ecosystem;*
- *define food web;*
- *define ecological pyramid, pyramid of number, biomass and energy;*
- *explain ecological efficiency;*
- *explain ecosystem growth or evolution of ecosystem;*
- *explain importance of maintaining balanced ecosystem.*

## 5.1 ECOSYSTEM

In the previous lesson, you learnt that in nature several communities of organisms live together and interact with each other as well as with their physical environment as an ecological unit. We call it an **ecosystem**. The term ‘ecosystem’ was coined by A.G. Tansley in 1935. An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- a pond is a good example of ecosystem.

### 5.1.1 Components of an ecosystem

**Components of ecosystem:** They are broadly grouped into:-

(a) Abiotic and (b) Biotic components

**Components of Ecosystem**

- **Abiotic components**
  - **Physical factors**
    - Temperature
    - Humidity
    - Light
    - Atmospheric pressure
  - **Inorganic substances**
    - Water
    - Oxygen
    - Carbon dioxide
    - Nitrogen
  - **Organic substances**
    - Proteins
    - Carbohydrates
    - Lipids
- **Biotic components**
  - Producers (Green plants)
  - Consumers (Animals)
  - Decomposers (Microorganisms)

**(a) Abiotic components (Nonliving):** The abiotic component can be grouped into following three categories:-

**(i) Physical factors:** Sun light, temperature, rainfall, humidity and pressure. They sustain and limit the growth of organisms in an ecosystem.

**(ii) Inorganic substances:** Carbon dioxide, nitrogen, oxygen, phosphorus, sulphur, water, rock, soil and other minerals.

**(iii) Organic compounds:** Carbohydrates, proteins, lipids and humic substances. They are the building blocks of living systems and therefore, make a link between the biotic and abiotic components.

**(b) Biotic components (Living)**

**(i) Producers**: The green plants manufacture food for the entire ecosystem through the process of photosynthesis. Green plants are called autotrophs, as they absorb water and nutrients from the soil, carbon dioxide from the air, and capture solar energy for this process.

**(ii) Consumers:** They are called heterotrophs and they consume food synthesized by the autotrophs. Based on food preferences they can be grouped into three broad categories. **Herbivores** (e.g. cow, deer and rabbit etc.) feed directly on plants, **carnivores** are animals which eat other animals (eg. lion, cat, dog etc.) and **omnivores** organisms feeding upon both plants and animals e.g. human, pigs and sparrow.

(iii) **Decomposers:** Also called **saprotrophs.** These are mostly bacteria and fungi that feed on dead decomposed and the dead organic matter of plants and animals by secreting enzymes outside their body on the decaying matter. They play a very important role in recycling of nutrients. They are also called **detrivores or detritus feeders**.

### 5.1.2 Functions of ecosystem

Ecosystems are complex dynamic system. They perform certain functions. These are:-

(i) Energy flow through food chain

(ii) Nutrient cycling (biogeochemical cycles)

(iii) Ecological succession or ecosystem development

(iv) Homeostasis (or cybernetic) or feedback control mechanisms

Ponds, lakes, meadows, marshlands, grasslands, deserts and forests are examples of natural ecosystem. Many of you have seen an aquarium; a garden or a lawn etc. in your neighbourhood. These are man made ecosystem.

### 5.1.3 Types of ecosystems

Ecosystems are classified as follows:

(i) Natural ecosystems (ii) Man made ecosystems

**(i) Natural ecosystems**

(a) Totally dependent on solar radiation e.g. forests, grasslands, oceans, lakes, rivers and deserts. They provide food, fuel, fodder and medicines.

(b) Ecosystems dependent on solar radiation and energy subsidies (alternative sources) such as wind, rain and tides. e.g tropical rain forests, tidal estuaries and coral reefs.

**(ii) Man made ecosystems**

(a) Dependent on solar energy-e.g. Agricultural fields and aquaculture ponds.

(b) Dependent on fossil fuel e.g. urban and industrial ecosystems.

You will study the details of natural and human made ecosystems in lesson 6 and lesson 7 respectively.

## INTEXT QUESTIONS 5.1

1. List the abiotic components of ecosystem.

2. List the biotic components of ecosystem.

______________________________________________

3. What role do decomposers play in an ecosystem?

______________________________________________

4. Mention two examples of (i) natural ecosystem (ii) man made ecosystem.

______________________________________________

## 5.2 POND AS AN EXAMPLE OF AN ECOSYSTEM

A pond is an example of a complete, closed and an independent ecosystem. It is convenient to study its basic structure and functions. It works on solar energy and maintains its biotic community in equilibrium. If you collect a glass full of pond water or a scoop full of pond bottom mud, it consists of a mixture of plants, animals, inorganic and organic materials. Following components are found in a pond ecosystem.

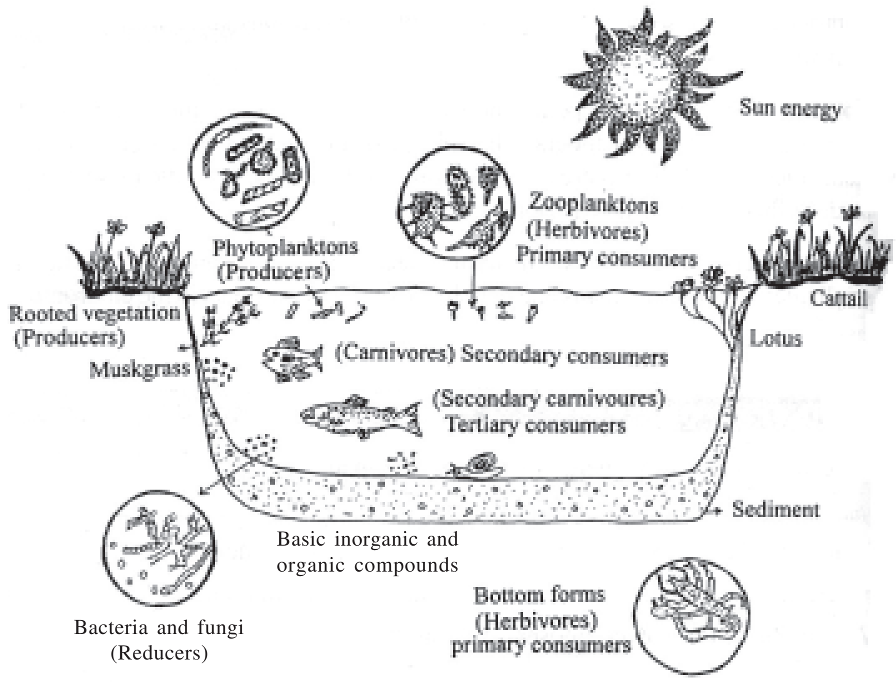



*Fig. 5.1: Pond ecosystem*

### (a) Abiotic components

(i) **Light**: Solar radiation provides energy that controls the entire system. Penetration of light depends on transparency of water, amount of dissolved or suspended particles in water and the number of plankton. On the basis of extent of penetration of light a pond can be divided into **euphotic** (eu=true,photic=light), **mesophotic** and **aphotic** zones. Plenty of light is available to plants and animals in euphotic zone. No light is available in the aphotic zone.

(ii) **Inorganic substances**: These are water, carbon, nitrogen, phosphorus, calcium and a few other elements like sulphur depending on the location of the pond. The inorganic substances like $O_2$ and $CO_2$ are in dissolved state in water. All plants and animals depend on water for their food and exchange of gases- nitrogen, phosphorus, sulphur and other inorganic salts are held in reserve in bottom sediment and inside the living organisms. A very small fraction may be in the dissolved state.

(iii) **Organic compounds**: The commonly found organic matter in the pond are amino acids and humic acids and the breakdown products of dead animals and plants. They are partly dissolved in water and partly suspended in water.

**(b) Biotic components**

(i) **Producers or autotrophs:** synthesize food for all the heterotrophs of the pond. They can be categorized into two groups:-

(a) Floating microorganisms and plants

(b) Rooted plants

(a) Floating microorganisms (green) and plants are called **phytoplankton** ("phyto"- plants, "plankton" –floating). They are microscopic organisms. Sometimes they are so abundant in pond that they make it look green in colour e.g. *Spirogyra, Ulothrix, Cladophora,* Diatoms, *Volvox.*

(b) Rooted plants: These are arranged in concentric zones from periphery to the deeper layers. Three distinct zones of aquatic plants can be seen with increasing deapth of water in the following order:

i) **Zone of emergent vegetation:** . eg. *Typha*, Bulrushes and *Sagittaria*

ii) **Zone of rooted vegetation with floating leaves** . eg. *Nymphaea*

iii) **Zone of submergent vegetation:** eg. All pond weeds like *Hydrilla* , *Rupia*, musk grass etc.

(ii) **Consumers/Heterotrophs** are animals which feed directly or indirectly on autotrophs eg. Tadpole, snails, sunfish, bass etc.

Pond animals can be classified into the following groups

(a) **Zooplanktons** are floating animals. Cyclops, Cypris

(b) **Nektons** are the animals that can swim and navigate at will. Eg. fishes

(c) **Benthic animals** are the bottom dwellers: beetle, mites, mollusks and some crustaceans.

(iii) **Decomposers:** They are distributed through out the entire in the whole pond but in the sediment most abundant. There are bacteria and fungi. (*Rhizopus, Penicillium, Curvularia ,Cladosporium)* found at the bottom of the pond.

## INTEXT QUESTIONS 5.2

1. What are phytoplanktons?

2. Where will you search for the decomposers in a pond?

3. How do nektons differ from zooplanktons?

4. From where do the fishes living at bottom of the pond get their food?

## 5.3 ECOSYSTEM FUNCTION–ENERGY FLOW THROUGH ECOSYSTEM

Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and abiotic components of an ecosystem are linked through them.

### 5.3.1 Food Chain

Transfer of food energy from green plants (producers) through a series of organisms with repeated eating and being eaten is called a food chain. e.g.

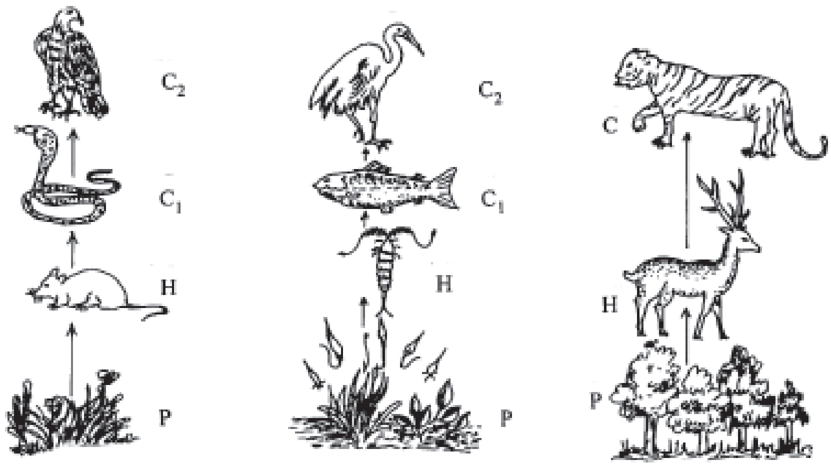
Grasses → Grasshopper → Frog → Snake → Hawk/Eagle

Each step in the food chain is called **trophic level**. In the above example grasses are 1$^{st}$, and eagle represents the 5$^{th}$ trophic level.

Some more example of food chain are given in fig**.** 5.2.

During this process of transfer of energy some energy is lost into the system as heat energy and is not available to the next trophic level. Therefore, the number of steps are limited in a chain to 4 or 5. Following trophic levels can be identified in a food chain.

(1) **Autotrophs:** They are the producers of food for all other organisms of the ecosystem. They are largely green plants and convert inorganic material in the presence of solar energy by the process of photosynthesis into the chemical energy (food). The total rate at which the radiant energy is stored by the process of photosynthesis in the green plants is called **Gross Primary Production** (GPP). This is also known as total photosynthesis or total assimilation. From the gross primary productivity a part is utilized by the plants for its own metabolism. The remaining amount is stored by the plant as **Net Primary Production** (NPP) which is available to consumers.




P = Producer, H = Herbivore, C = Carnivore, $C_1$ = First level carnivore, $C_2$ = Top Carnivore

***Fig. 5.2:*** *Some examples of food chain*

(2) **Herbivores:** The animals which eat the plants directly are called primary consumers or herbivores e.g. insects, birds, rodents and ruminants.

(3) **Carnivores:** They are secondary consumers if they feed on herbivores and tertiary consumers if they use carnivores as their food. e.g. frog, dog, cat and tiger.

(4) **Omnivores:** Animals that eat both plant and animals e.g. pig, bear and man

(5) **Decomposers:** They take care of the dead remains of organisms at each trophic level and help in recycling of the nutrients e.g. bacteria and fungi.

There are two types of food chains:

(i) **Grazing food chains:** which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores.

(ii) **Detritus food chains:** start from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc.

In an ecosystem the two chains are interconnected and make y-shaped food chain. These two types of food chains are:-

(i) Producers $\rightarrow$ Herbivores $\rightarrow$ Carnivores

(ii) Producers $\rightarrow$ Detritus Feeders $\rightarrow$ Carnivores

### 5.3.2 Food web

Trophic levels in an ecosystem are not linear rather they are interconnected and make a food web. Thus food web is a network interconnected food chains existing in an ecosystem. One animal may be a member of several different food chains. Food webs are more realistic models of energy flow through an ecosystem (Fig. 5.3).

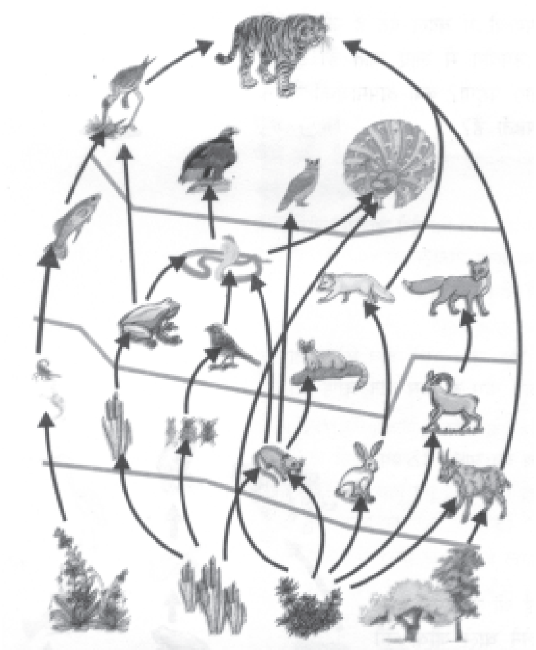


***Fig. 5.3:*** *Simple food web*

The flow of energy in an ecosystem is always linear or one way. The quantity of energy flowing through the successive trophic levels decreases as shown by the reduced sizes of boxes in fig. 5.4. At every step in a food chain or web the energy received by the organism is used to sustain itself and the left over is passed on to the next trophic level.

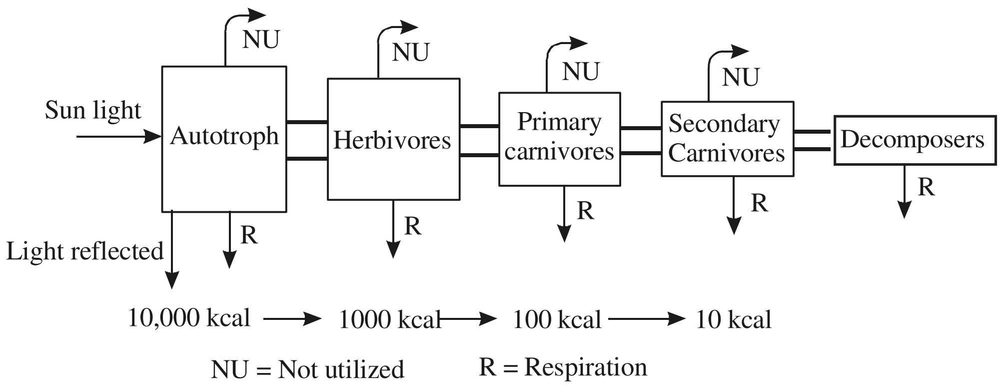



***Fig. 5.4:*** *Model of energy flow through an ecosystem. Boxes indicate the standing crop biomass and pipes indicate the energy flowing. (NU = Not utilized, R = Respiration)*

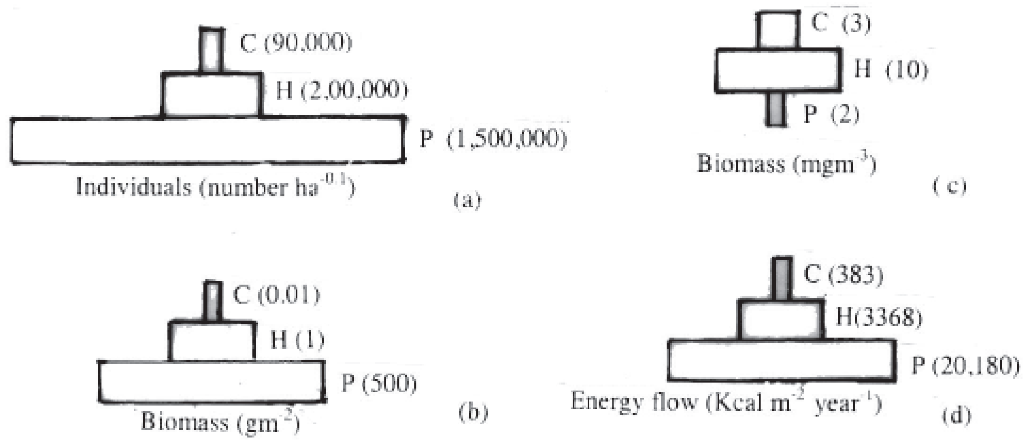
### 5.3.3 Ecological pyramid

Ecological pyramids are the graphic representations of trophic levels in an ecosystem. They are pyramidal in shape and they are of three types: The producers make the base of the pyramid and the subsequent tiers of the pyramid represent herbivore, carnivore and top carnivore levels.

(1) **Pyramid of number:** This represents the number of organisms at each trophic level. For example in a grassland the number of grasses is more than the number of herbivores that feed on them and the number of herbivores is more than the number of carnivores. In some instances the pyramid of number may be inverted, i.e herbivores are more than primary producers as you may observe that many caterpillars and insects feed on a single tree. (see fig. 5.5a)

(2) **Pyramid of biomass:** This represents the total standing crop biomass at each trophic level. **Standing crop biomass** is the amount of the living matter at any given time. It is expressed as gm/unit area or kilo cal/unit area. In most of the terrestrial ecosystems the pyramid of biomass is upright. However, in case of aquatic ecosystems the pyramid of biomass may be inverted e.g. in a pond phytoplankton are the main producers, they have very short life cycles and a rapid turn over rate (i.e. they are rapidly replaced by new plants). Therefore, their total biomass at any given time is less than the biomass of herbivores supported by them. (see fig. 5.5b)

(3) **Pyramid of energy:** This pyramid represents the total amount of energy at each trophic level. Energy is expressed in terms of rate such as kcal/unit area /unit time or cal/unit area/unit time.eg. in a lake autotroph energy is 20810 kcal/m/year (see fig. 5.5c). Energy pyramids are never inverted.




Pyramid of Number Grassland

Pyramid of biomass grassland

Pyramids of energy forest

***Fig. 5.5:** Ecological pyramids*

Note : P = Producer; $C_1$ = herbivore; $C_1$ = Carnivore ; $C_2$ = Top carnivore

## INTEXT QUESTIONS 5.3

1. Draw a simple food chain.

2. What is a food web?

3. Give examples of an inverted pyramids

4. Which type of pyramid gives the true picture of trophic structure of an ecosystem?

## 5.4 ECOLOGICAL EFFICIENCY

It is clear from the trophic structure of an ecosystem that the amount of energy decreases at each subsequent trophic level. This is due to two reasons:

1. At each trophic a part of the available energy is lost in respiration or used up in metabolism.
2. A part of energy is lost at each transformation, i.e. when it moves from lower to higer trophic level as heat.

It is the ratio between the amount of energy acquired from the lower trophic level and the amount of energy transferred from higher trophic level is called **ecological efficiency**. Lindman in 1942 defined these ecological efficiencies for the 1st time and proposed 10% rule e.g. if autotrophs produce 100 cal, herbivores will be able to store 10 cal. and carnivores 1cal. However, there may be slight variations in different ecosystems and ecological efficiencies may range from 5 to 35%. Ecological efficiency (also called Lindman's efficiency) can be represented as

$$\frac{I_t \times 100}{I_t - 1} = \frac{\text{Ingestion at trophic level}_t \times 100}{\text{Ingestion at previous trophic level} - 1}$$

### 5.4.1 Significance of studying food chains

1. It helps in understanding the feeding relations and interactions among different organisms of an ecosystem.
2. It explain the flow of energy and circulation of materials in ecosystems.
3. It help in understanding the concept of biomagnification in ecosystems.

## INTEXT QUESTIONS 5.4

1. What is the 10% rule of energy transfer in a food chain?

2. Give formula of Lindman's efficiency.

3. What is the significance of studying food chains?

## 5.5 BIOGEOCHEMICAL CYCLES

In ecosystems flow of energy is linear but that of nutrients is cyclical. This is because energy flows down hill i.e. it is utilized or lost as heat as it flows forward The nutrients on the other hand cycle from dead remains of organisms released back into the soil by detrivores which are absorbed again i.e. nutrient absorbed from soil by the root of green plants are passed on to herbivores and then carnivores. The nutrients locked in the dead remains of organisms and released back into the soil by detrivores and decomposers. This recycling of the nutrients is called **biogeochemical or nutrient cycle** (Bio = living, geo = rock chemical = element). There are more than 40 elements required for the various life processes by plants and animals. The entire earth or biosphere is a closed system i.e. nutrients are neither imported nor exported from the biosphere.

There are two important components of a biogeochemical cycle

(1) **Reservoir pool** - atmosphere or rock, which stores large amounts of nutrients.

(2) **Cycling pool or compartments of cycle**-They are relatively short storages of carbon in the form of plants and animals.

You shall now learn about the bio-geo chemical cycles carbon, nitrogen and water.

### 5.5.1 Carbon cycle

The source of all carbon is carbon dioxide present in the atmosphere. It is highly soluble in water; therefore, oceans also contain large quantities of dissolved carbon dioxide.

The global carbon cycle consists of following steps-

- **Photosynthesis**

Green plants in the presence of sunlight utilize $CO_2$ in the process of photosynthesis and convert the inorganic carbon into organic matter (food) and release oxygen. A part of the food made through photosynthesis is used by plants for their own metabolism and the rest is stored as their biomass which is available to various herbivores, heterotrophs, including human beings and microorganisms as food. Annually 4-9 x$10^{13}$ kg of $CO_2$ is fixed by green plants of the entire biosphere. Forests acts as reservoirs of $CO_2$ as carbon fixed by the trees remain stored in them for long due to their long life cycles. A very large amount of $CO_2$ is released through forest fires.

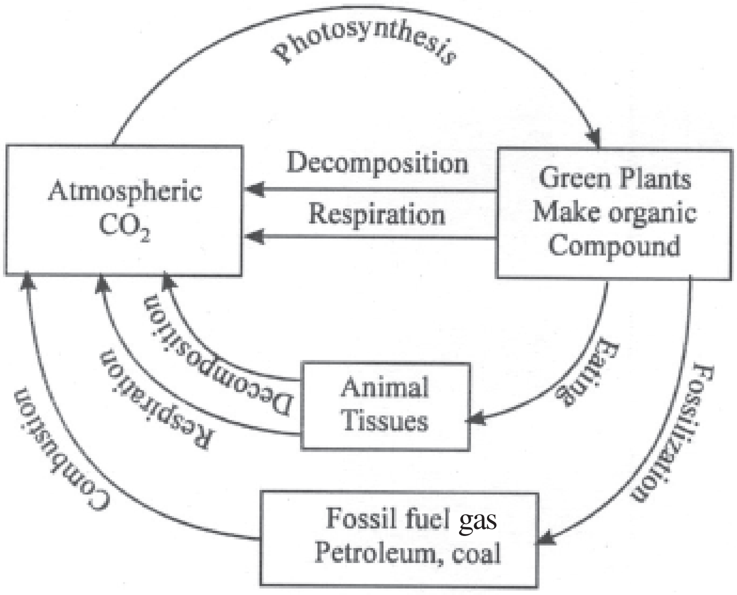



***Fig. 5.6:*** *Carbon cycle*

**• Respiration**

Respiration is carried out by all living organisms. It is a metabolic process where food is oxidized to liberate energy, $CO_2$ and water. The energy released from respiration is used for carrying out life processes by living organism (plants, animals, decomposers etc.). Thus $CO_2$ is released into of the atmosphere through this process.

**• Decomposition**

All the food assimilated by animals or synthesized by plant is not metabolized by them completely. A major part is retained by them as their own biomass which becomes available to decomposers on their death. The dead organic matter is decomposed by microorganisms and $CO_2$ is released into the atmosphere by decomposers.

**• Combustion**

Burning of biomass releases carbon dioxide into the atmosphere.

**• Impact of human activities**

The global carbon cycle has been increasingly disturbed by human activities particularly since the beginning of industrial era. Large scale deforestation and ever growing consumption of fossil fuels by growing numbers of industries, power plants and automobiles are primarily responsible for increasing emission of carbon dioxide.

Carbon dioxide has been continuously increasing in the atmosphere due to human activities such as industrialization, urbanization and increasing use and number of automobiles. This is leading to increase concentration of $CO_2$ in the atmosphere, which is a major cause of global warming.

### 5.5.2 Nitrogen cycle

Nitrogen is an essential component of protein and required by all living organisms including human beings.

Our atmosphere contains nearly 79% of nitrogen but it can not be used directly by the majority of living organisms. Broadly like corbondioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below.

(a) **Nitrogen fixation:** This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods:-

   (i) **Atmospheric fixation**: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

   (ii) **Industrial fixation**: At high temperature (400$^o$C) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

   (iii) **Bacterial fixation**: There are two types of bacteria-

      **(i) Symbiotic bacteria** e.g. Rhizobium in the root nodules of leguminous plants.

      **(ii) Freeliving or symbiotic** e.g. 1. *Nostoc* 2. *Azobacter* 3. Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(b) **Nitrification:** It is a process by which ammonia is converted into nitrates or nitrites by *Nitrosomonas* and *Nitrococcus* bacteria respectively. Another soil bacteria *Nitrobacter* can covert nitrate into nitrite.

(c) **Assimilation:** In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

(d) **Ammonification** : Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria This process is called ammonification. Ammonifying bacteria help in this process.

(e) **Denitrification:** Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.

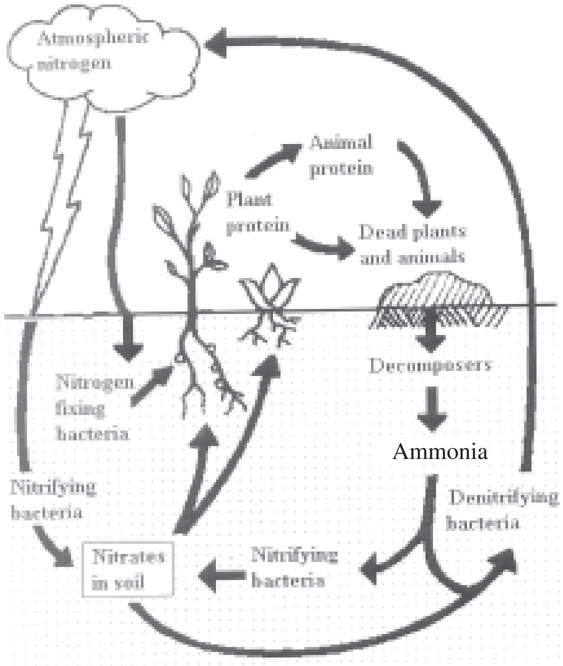



***Fig. 5.7:*** *Nitrogen Cycle*

### 5.5.3 Water Cycle

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). You have already studied that earth is a watery planet of the solar system, about 2/3$^{rd}$ of earth surface is covered with water. However a very small fraction of this is available to animals and plants.

Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water.

The driving forces for water cycle are 1) solar radiation 2) gravity .

Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other

Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy. Plants also transpire huge amounts of water. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the mountainous regions above the forests and condense to form rain precipitate which comes down due to gravity.

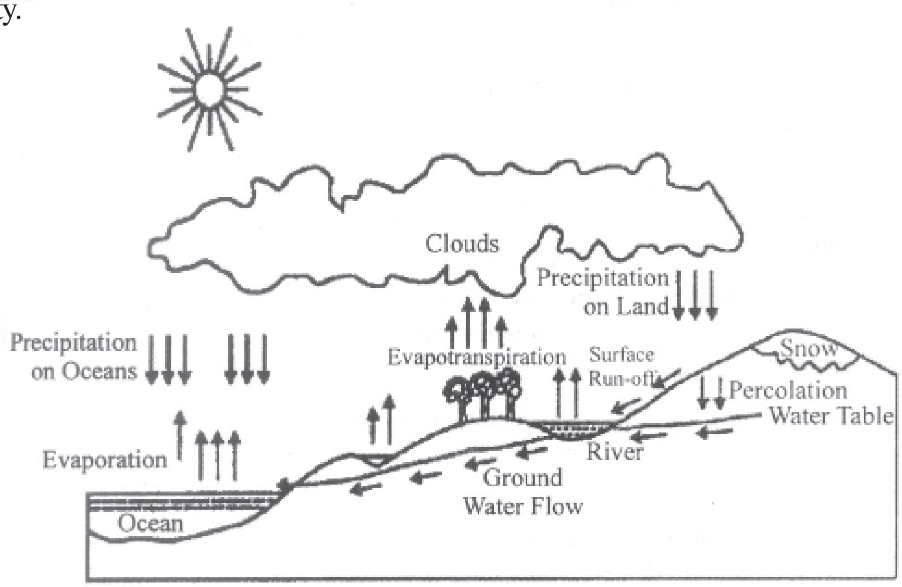



*Fig. 5.8:* Water Cycle

On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water run off from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.

## 5.7 HOMEOSTASIS OF ECOSYSTEM

Ecosystems are capable of maintaining their state of equilibrium. They can regulate their own species structure and functional processes. This capacity of ecosystem of self regulation is known as **homeostasis**. In ecology the term applies to the tendency for a biological systems to resist changes. For example, in a pond ecosystem if the population of zooplankton increased, they would consume large number of the phytoplankton and as a result soon zooplankton would be short supply of food for them. As the number zooplankton is reduced because of starvation, phytoplankton population start increasing. After some time the population size of zooplankton also increases and this process continues at all the trophic levels of the food chain.

Note that in a homeostatic system, negative feed back mechanism is responsible for maintaining stability in a ecosystem.

However, homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated. You will learn about the scope and limitations homeostatic mechanisms when you gain more knowledge about ecosystems. Humans are the greatest source of disturbance to ecosystems.

Large number of phytoplankton

↓

Increase population of zooplankton due to excess food available

↓

Reduction in phytoplankton

↓

Population of zooplanktons decrease
due to starvation

↓

Population of phytoplankton starts increasing due to less consumption

***Fig. 5.9:*** *Homeostasis in ecosystem*

## INTEXT QUESTIONS 5.5

1. What is a sedimentary cycle?

   ______________________________________________

2. Give an example of gaseous cycle.

   ______________________________________________

3. Why do forest acts as reservoir?

   ______________________________________________

4. Name a symbiotic nitrogen fixing bacteria.

   ______________________________________________

5. What is precipitation?

   ______________________________________________

## WHAT YOU HAVE LEARNT

- An ecosystem is a functionally independent unit of abiotic and biotic components of the biosphere.
- Climatic regime, inorganic substances, organic compounds, producers, macroconsumers and microconsumers are of structural components of the ecosystem.
- Functional processes an ecosystem are energy flow, food chains, nutrient cycles, ecosystem development and homeostasis.
- All the abiotic factors such as light, temperature, pressure, humidity, salinity, topography and various nutrients limit the growth and distribution of animals and plants.

- All the living organisms of an ecosystem are interdependent through food chains and food webs. Removal of any single species of the community causes ecological imbalance.
- Source of energy for all the ecosystems is solar radiations which is absorbed by autotrophs and passed on to the consumers in the form of food (organic substances). Energy flow is always down hill and unidirectional.
- Gross primary productivity (GPP) is the total amount of solar energy captured and stored in the form of organic substances by the green plants. Net primary productivity is the amount of organic substances left in the plant after its own metabolism i.e. GPP = NPP + plant respiration.
- Trophic relationships of the organisms in an ecosystem can be represented graphically in the form of ecological pyramids the base of the pyramid represents the producers and successive tiers represent subsequent higher levels.
- The nutrients move from the nonliving to the living and back to the nonliving component of the ecosystem in a more or less circular manner. These nutrient cycles are known as biogeochemical cycles.
- The main components of all the biogeochemical cycles are:-
  a) the reservoir pool that contains the major bulk of the nutrients soil or atmosphere.
  b) cycling pool which are the living organisms (producers, consumers and decomposers), soil, water and air in which it stays temporarily.

## TERMINAL EXERCISE

1. Define the following terms.
   (i) Autotrophs
   (ii) Heterotrophs
   (iii) Primary carnivores
   (iv) Saprotophs
   (v) Omnivores
2. Give reasons whether the following statements are true or false.
   (i) Food chains are more stable than food webs.
   (ii) Pyramids of energy are never inverted where as pyramid of biomass may be inverted.

(iii) A detritus food chain begins with autotrophs.

(iv) Phytoplankton is the term applied to floating organisms in a pond.

(v) Aphotic is the upper zone of a pond.

3. Give reasons for the following statements:

   (i) We see more wall lizards near the tube light during summer.

   (ii) Energy pyramids are never inverted.

   (iii) We can not directly use atmospheric nitrogen.

   (iv) There is higher concentration of cabon dioxide in the aphotic zone.

   (v) Food chains have a limited number of steps

4. What is an ecosystem? Explain its structural components.

5. Define decomposers and give their role in sustaining an ecosystem.

6. Why are ecosystems dynamic in nature? Give the various functional components of an ecosystem.

7. What is an ecological pyramid? Define and differentiate between different pyramid of energy and pyramid of numbers.

8. List the various steps of nitrogen cycle in a sequence.

9. The following organisms were identified in a pond ecosystem-*Spirogyra*, *Euglena, Hydra, Daphnia*, arthropod larvae, bass and sunfish. Make a food web and identify the trophic level of each one of them.

## ACTIVITIES

1) Visit a pond near your house and make the following observations:

   (a) note the colour of water

   (b) transparency (tie a white stone to a thread ,insert it into pond and measure the depth upto which you can see it)

   (c) check its pH with litmus paper

   (d) count the number of different types of plants in it (looking at the shape of the leaves)

   (e) Take a small amount of pond water in a petri dish and observe it under the binocular for different phytoplanktons and zooplanktons.

   Make sketches of these organisms that you observed.

2) Observe a park in your locality before and after the rains for one month and record your observations (count the number of different plant, insects, birds and rodents).

3) Collect a bowl full of mud from an open space near your house during rainy season and observe different types of worms in it. bernetic or homeostasis

## ANSWER TO INTEXT QUESTIONS

**5.1**

1. Physical, inorganic and organic substance.
2. Producer, consumer and decomposers.
3. They help in decomposing dead organic material and dead plants and animals therefore they are important for recycling of nutrients.
4. (i) Pond, lake, forests, ocean (any two)
   (ii) Agriculture, aquaculture

**5.2**

1. Microscopic floating vegetation in an aquatic ecosystem.
2. At the bottom of pond.
3. Zooplanktons are free floating and whereas nektons can aquatic animal can surim and narrgate.
4. Bentic animals like bettle, mites, mollusks and Crustrceans formed are by these fission.

**5.3**

1. Grass $\rightarrow$ rat $\rightarrow$ snake $\rightarrow$ eagle $\rightarrow$ forest $\rightarrow$ deer $\rightarrow$ tiger
2. Food web – Inter connected food chains of an area form a food web.
3. Pyramid of number in case of a tree or in a pond.
4. Pyramid of energy.

**5.4**

1. 10% rule is i.e. related to ecological efficiency and states that the amount of energy transferred at each tropic level is only 10% of the energy of the previous tropic level.
2. $\dfrac{\text{Ingestion at tropic level t}}{\text{Ingestion at previous level}} \times 100$
3. Biomagnifications is the concentration of non-degradable pollutants in the successive tropic level in a food chain.

**5.5**

1. Sedimentary cycle It is a type of biogeochemical cycle where the main reservoir is lithosphere.
2. Nitrogen ($N_2$) and carbon
3. Forests trees have long life and therefore the carbon fixed by them cycles very slowly.
4. *Rhizobium*
5. Condensation of water vapours to form clouds.

# 6

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# NATURAL ECOSYSTEM

Whenever you travel long distance you come across changing patterns of landscape. As you move out from your city or village, you see croplands, grasslands, or in some areas a forests, desert or a mountainous region. These distinct landscapes are differentiated primarily due to the type of vegetation in these areas. Physical and geographical factors such as rainfall, temperature, elevation, soil type etc. determine the nature of the vegetation. In this lesson you will learn about the natural ecosystems with their varied vegetation and associated wildlife.

## OBJECTIVES

After completing this lesson, you will be able to:

- *list the various natural ecosystems;*
- *describe the various terrestrial ecosystems;*
- *describe the various aquatic ecosystems (fresh water, marine and estuarine);*
- *recognize ecotones, their significance and the edge effect.*
- *list the major Indian ecosystems;*
- *list the threatened ecosystems-mangrove, wetlands, coastal ecosystems and islands;*
- *explain the need and methods of conservation of natural ecosystems.*

## 6.1 WHAT ARE NATURAL ECOSYSTEMS

A **natural ecosystem** is an assemblage of plants and animals which functions as a unit and is capable of maintaining its identity such as forest, grassland, an estuary, human intervention is an example of a natural ecosystem. A natural ecosystem is totally dependent on solar energy. There are two main categories of ecosystems.

**(1) Terrestrial ecosystem:** Ecosystems found on land e.g. forest, grasslands, deserts, tundra.

**(2) Aquatic ecosystem:** Plants and animal community found in water bodies. These can be further classified into two sub groups.

(i) Fresh water ecosystems, such as rivers, lakes and ponds.

(ii) Marine ecosystems, such as oceans, estuary.

## INTEXT QUESTIONS 6.1

1. What is a natural ecosystem?

___

2. Which are the main categories of natural ecosystems?

___

3. Give examples of terrestrial ecosystems.

___

4. Give examples of fresh water ecosystems.

___

## 6.2 TERRESTRIAL ECOSYSTEMS

Terrestrial ecosystems are (a) forests (b) grasslands, (c) deserts and (d) tundra

### (a) Forests

Forests are large areas supporting rich growth of trees. Depending on the climate and type of trees they are generally grouped into:

(i) Tropical rain forests

(ii) Temperate deciduous forests

(iii) Boreal or north coniferous forests

**(i) Tropical rain forest**

- **Distribution:** These are found in the high rain fall areas on either side of the equator. Such forests are found in the western coast of India, scattered in south east Asia, some parts of Africa and south America.
- **Flora and fauna:** Tropical rainforests occur in areas by having high temperature and high humidity and receives above 200 cm of rainfall per year. Soil is rich in humus.

These forests have a very rich biodiversity e.g. Brazilian tropical rain forests have more than 300 species of trees in an area of 200 square kilometer. Trees are tall growing upto 50 to 60 m. These forests also support epiphytes, like vines, creepers, woody creepers and orchid etc. These forests are rich in tree dwelling animals such as monkeys, flying squirrels, snails, centipedes, millipedes, and many insect species are common on the forest floor.

**(ii) Temperate deciduous forests**

- **Distribution:** They occur mostly in northwest, central and eastern Europe, eastern north America, north China, Korea, Japan, far eastern Russia and Australia. Trees of deciduous forests shed their leaves in autumn and a new foliage grows in spring.
- **Climate:** These forests occur in the areas of moderate climatic conditions such as temperature ranging but 10 to 20$^oC$ with a 6 month long winter and an annual rainfall between 75 to 150 cm. They have its brown soils which are rich in nutrients.
- **Flora and fauna:** Common trees are oak, beach, heath, chest nut, birch, pine. These forests also show stratification and have a under storey of saplings shrubs and tall herbs. Prominent grazers include deer, bison and rodents. Rodents play a very important role in these forests. They feed on seeds, fruits and tree leaves. Black bear, raccoons, wild cat, wolves, fox and skunks are the omnivores found in these forests. Hibernation or winter sleep during winter is a common feature of animals found in these forests. Invertebrate fauna comprises green flies, aphids, certain moths and butterflies.

**(iii) Boreal or north coniferous forests:**

- **Distribution:** Coniferous forests are also known as 'Taiga'. They extend as a continuous belt across north America and north Eurasia below the arctic tundra. There is no counterpart of these forests in southern hemisphere as there is no land at this latitude. Climate is cold with long, harsh winter, with mean annual temperature below 0$^0$C. The soils are acidic and poor in nutrients.
- **Flora and fauna:** Coniferous forests are characterized by evergreen, drought resistant and woody. Conifers (gymnosprerms) e.g. spruce, fir and pine trees which bear naked seeds in cones. The animals found in these forests, are red squirrel, deer, goat, mule, moose etc. The carnivores which feed upon them are timber wolves, lynxes, bear. Some common birds are crossbill, thrushes, warblers, flycatchers, robin and sparrow.

**(b) Grasslands**

- **Distribution:** Grasslands are areas dominated by grasses. They occupy about 20% of the land on the earth surface. Grasslands occur in both in tropical and temperate regions where rainfall is not enough to support the growth of trees. Grasslands are known by various names in different parts of the world.

| Place | Name of the grassland |
|---|---|
| North America | Prairies |
| Eurasia (Europe and Asia) | Steppes |
| Africa | Savanna |
| South America | Pampas |
| India | Grassland, Savanna |

Grasslands are found in areas having well defined hot and dry, warm and rainy seasons.

Tropical grasslands are commonly called Savannas. They occur in eastern Africa, South America, Australia and India. Savannas form a complex ecosystem with scattered medium size trees in grass lands.

- **Flora and fauna:** Grasses are the dominating plants with scattered drought resistant thorny trees in the tropical grasslands. Badgers, fox, ass, zebra, antelope are found grazing on grasslands support the dairy and leather industries. Grasslands also support large population of rodents, reptiles and insects.

**(c) Deserts**

- **Distribution:** Deserts are hot and low rain areas suffering from water shortage and high wind velocity. They show extremes of temperature. Globally deserts occupy about $1/7^{th}$ of the earth's surface.
- **Flora and fauna:** *Cacti*, *Acacia, Euphorbia* and prickly pears are some of the common desert plants. Desert animals include shrew, fox, wood rats, rabbits, camels and goat are common mammals in desert. Other prominent desert animals are, reptiles, and burrowing rodents insects.
- **Adaptations:** Desert plants are hot and dry conditions.

(i) These plants conserve water by following methods:

- They are mostly shrubs.
- Leaves absent or reduced in size.
- Leaves and stem are succulent and water storing.
- In some plants even the stem contains chlorophyll for photosynthesis.
- Root system well developed spread over large area.

(ii) The animals are physiologically and behaviorally adapted to desert conditions.

- They are fast runners.
- They are nocturnal in habit to avoid the sun's heat during day time.

- They conserve water by excreting concentrated urine.
- Animals and birds usually have long legs to keep the body away from the hot ground.
- Lizards are mostly insectivorous and can live without drinking water for several days.
- Herbivorous animals get sufficient water from the seeds which they eat.

Camel is known as the ship of the desert as it can travel long distances without drinking water for several days.

**(d) Tundra**

The word tundra means a "barren land" since they are found in those regions of the world where environmental conditions are very severe. There are two types of tundra- **arctic** and **alpine.**

- **Distribution: Arctic tundra** extends as a continuous belt below the polar ice cap and above the tree line in the northern hemisphere. It occupies the northern fringe of Canada, Alaska, European Russia, Siberia and island group of arctic ocean. On the south pole **Anatarctica tundra** in the south pole is very small since most of it is covered by ocean .

  **Alpine tundra** occurs at high mountains above the tree line. Since mountains are found at all latitudes therefore alpine tundra shows day and night temperature variations.

- **Flora and fauna:** Typical vegetation of arctic tundra is cotton grass, sedges, dwarf heath, willows, birches and lichens. Animals of tundra are reindeer, musk ox, arctic hare, caribous, lemmings and squirrel.

Most of them have long life e.g. *Salix arctica* that is arctic willow has a life span of 150 to 300 years. They are protected from chill by the presence of thick cuticle and epidermal hair. Mammals of the tundra region have large body size and small tail and ear to avoid the loss of heat from the surface. The body is covered with fur for insulation. Insects have short life cycles which are completed during favourable period of the year.

## INTEXT QUESTIONS 6.2

1. What are deciduous trees?

   ______________________________________________

2. Explain two common characteristics of the desert.

   ______________________________________________

3. How are the animals and plants of deserts adapted to heat and drought?

______________________________________________

4. Where are Prairies and Steppes are found?

______________________________________________

## 6.3 AQUATIC ECOSYSTEMS

Aquatic ecosystems refers to plant and animal communities ocuring in water bodies. Aquatic ecosystems are classified on the basis of salinity into following two types:

(i) Freshwater

(ii) Marine

**(i) Fresh water ecosystem**

Water on land which is continuously cycling and has low salt content is known as fresh water and its study is called limnology.

(i) Static or still water (Lentic) e.g. pond, lake, bogs and swamps.

(ii) Running water (Lotic) e.g. springs, mountain brooks, streams and rivers.

**Physical characteristics:** Fresh waters have a low concentration of dissolved salts. The temperature shows diurnal and seasonal variations. In tropical lakes, surface temperature never goes below $40^0C$, in temperate fresh waters, never goes above or below $4^0C$ and in polar lakes never above $4^0C$.

- In temperate regions, the surface layer of water freezes but the organisms survive below the frozen surface.
- Light has a great influence on fresh water ecosystems. A large number of suspended materials obstruct penetration of light in water.
- Certain animals float upto water surface to take up oxygen for respiration Aquatic plants use carbon dioxide dissolved in water for photosynthesis.
- Lakes and ponds are inland depressions containing standing water. The largest lake in the world is lake Superior in North America. Lake Baikal in Siberia is the deepest. Chilka lake of Orissa is largest lake in India.

Three main zones can be differentiated in a lake:-

- Peripheral zone (littoral zone) with shallow water.
- Open water beyond the littoral zone where water is quite deep.
- Bentic zone (bottom) or the floor of the lake.

Aquatic organisms can be floating in water or free swimming or sedentary (fixed), depending on their size and habit. Microscopic floating organisms such as algae, diatoms, protozoans and larval forms are called **plankton.** Rooted aquatic plants, fish, mollusk and echinoderms are bottom dwellers. (Recall from lesson-5, Fig. 5.1)

**Wetlands** are areas that periodically get inundated with water and support a flourishing community of aquatic organisms including frog and other amphibians. Swamps, marshes and mangroves are examples of wetlands.

**(ii) Marine ecosystem:** Pertains to the seas and oceans including marine organisms.

• **Distribution:** Marine ecosystem covers nearly 71% of the earth's surface with an average depth of about 4000 m. Fresh water rivers eventually empty into ocean. Different kinds of organisms live at different depths of the sea or ocean.

Salinity of open sea is 3.6% and is quite constant.

The range of temperature variation is much less in the sea than on the land. Hydrostatic pressure due to water column increases with depth in oceans. It is 1 atm near the surface and 1000 atm at greatest depth. Animals in the deeper layers are adapted to the high pressure. Some marine organisms such as sperm whales and certain seals can dive to the great depths and swim back to the surface without difficulty. Tides, due to gravitational pull of the moon are a common feature of marine ecosystems.

• **Flora and fauna:** Biodiversity of the marine ecosystems is very high as compared to terrestrial ecosystems. Almost every major group of animals occurs in the sea. Insects and vascular plant are completely absent in marine ecosystem. Maximum diversity of marine organisms is found in the tidal zone that is near the shore. Diatoms, algae, dinoflagellates and jelly fishes are some of the free floating life forms in oceans. Large crustaceans, molluscs, turtles and mammals like seals, porpoises, dolphins and whales are free swimming animals that can navigate. Bottom dwellers are generally sessile (fixed) organisms like sponges, corals, crabs and starfish.

• **Adaptations:**

- Light weight animals and plants float in water and move with the water currents.
- Animals and plants in ocean are tolerant to high concentration of salts (osmoregulation). Osmoregulation is the process by which a constant osmotic pressure is maintained in blood.
- Swimming animals have streamlined body. Their body is laterally compressed.
- Deep sea forms show bioluminescence (they emit light).
- They are dependent for their food on the upper sea zones.

## INTEXT QUESTIONS 6.3

1. What is plankton?

2. What is aquatic ecosystem?

3. Name two plants and two animals which found in marine ecosystem.

## 6.4 ECOSYSTEMS OF INDIA

India is a vast country and possess many types of natural ecosystems.

**(a) Terrestrial**

1. Forests
   - (i) Tropical rain forests
   - (ii) Tropical deciduous forests
   - (iii) Temperate broad leaf forests
   - (iv) Temperate needle – leaf or coniferous forests
   - (v) Alpine and tundra forests
2. Grasslands
3. Deserts
   - (i) Thar deserts
   - (ii) Rann of Kutch
4. Mountains — The Himalayas
5. Ghats

**(b) Aquatic**

1. Fresh water ecosystem
2. Marine ecosystem

### 6.4.1 Terrestrial ecosystem in India

**Forests**

Forests in India can be classified in different ways, according to their position, atmosphere, weather condition etc. Some of the common characteristics of various types of natural vegetation in India includes:

- tropical rain forests,
- tropical deciduous forests,
- temperate broad leaf forests.
- temperate needle leaf or coniferous forests
- alpine and tundra forests, etc.

Apart from these, there are also some other types of forests are found in India like **tidal forests, Himalayan vegetation, rain forests of southern India, desert region,** etc.

**(i) Tropical rain forests**

The tropical rain forests are playing an important role in natural vegetation in India. These types of forests include the tropical evergreen forests and tropical semi-evergreen forests and they are mostly found in places where there is plenty of rainfall and sunshine throughout the year. Growth of the trees is usually at its best where rainfall is in surplus of 200 cm, with a short dry season. Such types of forests are found within rainy slopes of the Western Ghats, plains of West Bengal and Orissa and north-eastern India. Trees grow very briskly in these forests and attain heights of about 60 m and above. The number of species in these forests is too vast and too assorted to utilise each one of them commercially. Ebony, mahogany and rosewood are the main trees of these forests.

**(ii) Tropical deciduous forests**

Tropical deciduous forests are also known as deciduous (whether it is moist or dry)forests because they cast leaves for about six to eight weeks in summer. They are also called the monsoon forests with all their grandeur and beauty. This is so because they form a natural cover approximately all over India, especially within regions having 200 and 75 cm of annual rainfall. Most of the tropical deciduous forests are found in the state of Kerala in India. Apart from Kerala, these forests can be found in the eastern slopes of Western Ghats and also in the north eastern parts of the peninsular plateau and in the valleys of the Himalayas. The tropical deciduous forests are pretty substantial, cost- effective and they demand a lot of maintenance, as they are less resistant to fire. These forests can be divided into moist and dry deciduous forests. The moist deciduous forests are most commonly found on the eastern slopes of the Western Ghats. They are also found in the region of Chhotanagpur plateau, covering east Madhya Pradesh, south Bihar, and west Orissa, Shiwaliks in the northern India. Important trees of these forests are teak, sal, and sandalwood.

**(iii) Temperate broad leaf forests**

It mainly occur between 1500-2400 m altitudes in western Himalayas. Several species of Oak (Quercus) are found in these forests. Oak species are ever green in the Himalayan region. These species show peak leaf fall during summer but never become leafless. Height of the trees may be 25-30 m. Trees canopy is dense, herbaceaus layer is least developed and grasses are generally lacking. The Oak forests are often rich in epiphytic flora.

**(iv) Temperate needle leaf or coniferous forests**

This type of forests are found in the Himalaya over 1700 to 3000 m altitude. These forests contain economically valuable gymnospermous trees like pine (Pinus wallichiana) deodar (Cedrus deodara), Cypress (Cypressus torulosa), Spruce (Picea simthiana) and siver fir (Abies pindrow). Coniferous forests are taller 30-35 m and possess evergreen canopy of long needle like leaves. Canopy of these trees always remains green. In many species, it is cone-shaped.

**(v) Alpine and Tundra forests**

The alpine and tundra forests is another kind of natural vegetation in India. Vegetation growing at altitudes above 3600 m is usually known as alpine vegetation and it can be noticed that with the increment of the altitude, the plants show stunted growth. The trees like silver fir, pine, juniper and birch belong to this category. The alpine grasslands are mainly found at higher altitudes in this region. The people belonging to the tribal groups like Gujjar and Bakarwal make extensive use of this region. The vegetations like lichen and mosses are also found in high altitudinal regions.

• The **tidal forests** provide another variety of natural vegetation in India. They can be found along the coasts and rivers and they are enshrouded by mangrove trees that can live in both fresh and salt water. Sundari is a renowned mangrove tree, mainly found in the tidal forests and it is after this tree that the name Sundarban has been entitled to the forested parts of the Ganga-Brahmaputra delta.

• The **Himalayan vegetation** is one of the major kinds of natural vegetation in India. The thick tropical forests in the eastern region of India have a sharp distinction with the pine and coniferous woodlands of the western Himalayas. Chir pine (*Pinus roxburghii*) grows throughout the northwest Himalayas, with the exception of Kashmir. Chilgoza (pine nut), oak, maple, ash (*Fraxinus xanthoxyloides*), etc also grow abundantly in the eastern Himalayas.

• The **rain forests of Southern India** are contributing hugely to the natural vegetation in India. The most luxuriant rain forests lie on the southwestern coast, in the state of Kerala. Here the lagoons are canopied by coconut trees and lead to the longest uninterrupted stretch of rain forests in the country. The Andaman and Nicobar Islands and the state of Arunachal Pradesh are some of the other regions with well preserved rain forests in India. Apart from that, dense sandal, teak and sisoo (*Dalbergia sissoo*) forests also flourish on the wet Karnataka plateau.

• The **Thar Desert** presents a wonderful picture of natural vegetation in India. The trees in this desert are short and stout, and stunted by the scorching sun. Cacti, *reunjha* (Acacia leucophloea), khejra (*Prosopis spicigera*), kanju (*Holoptelia integrifolia*), Oak (*Calotropis gigantea*) etc are common plants in this region. All the above mentioned varieties of forests and areas are contributing hugely to the natural vegetation in India (Fig. 6.1).

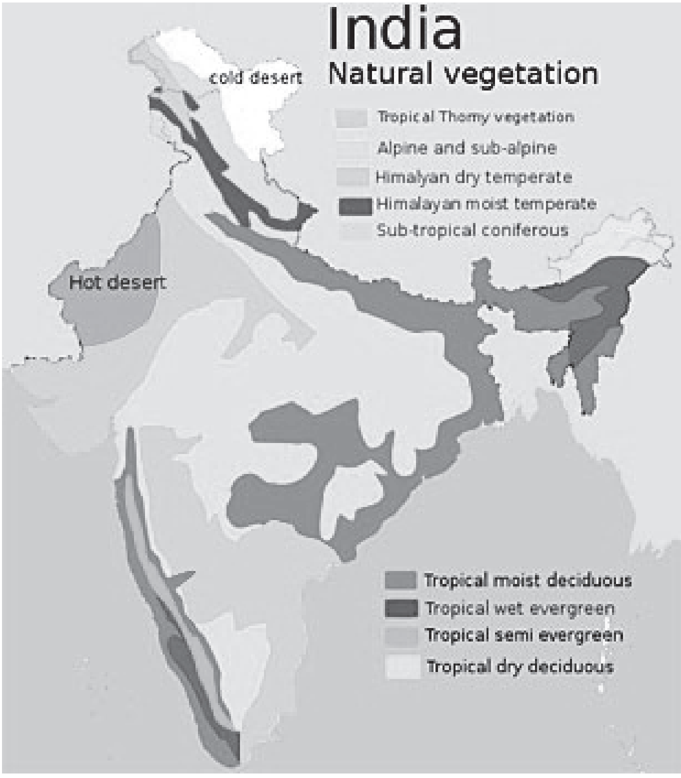


***Fig. 6.1*** *Natural Vegetation*

### (2) Grasslands

Grasslands are one of the intermediate stage in ecological succession and cover a part of the land on all the altitudes and latitudes at which climatic and soil conditions do not allow the growth of trees. In India, grasslands are found as village grazing grounds (Gauchar) and extensive low pastures of dry regions of western part of the country an also in Alpine Himalayas . Perennial grasses are the dominant plant community. In some regions grasslands also support a variety of other herbaceous plants like sedges, legumes and members of the sunflower family

Grasslands support a large number of herbivores from minute insects to very large mammals. Rats, mice, rodents, deer, elephant, dog, buffalo, tiger, lion, ferrets are some common mammals of grasslands. In the north east India, one horned rhinoceros is amongst the threatened animal of grassland is this region. A large number of avian fauna makes the grassland colourful.

### (3) Deserts

The Thar desert in Rajasthan is an extension of the Sahara deserts through Arabian and Persian deserts. They extend from Punjab, Haryana, Rajasthan to Gujarat state.

Indian deserts are divided into four main types:

- hills,
- plains with hills,
- marshes and
- plains with sand dunes.

The distinct Rann of Kutchch–Bhuj in Gujarat forms a separate zone with in Thar deserts due to its different climatic conditions. It represents vast saline flats. The region of sand dunes is most spectacular and covers an area of 100,000 sq. km nearly. It extends into Pakistan. The dunes are highly sandy and contain 0.12–0.18 mm size grain, 1.8 to 4.5 % of clay and 0.4–1.3% of silt.

Since heat and light intensity are very high and sand dunes are shifting, these deserts can not support vegetation. There are only some thorn forests and dry open grasslands. Indira Gandhi canal which carries water through Punjab and Haryana enters into Rajasthan supports some vegetation. The main crops of desert are bajra, millet, wheat, barley, maize, jowar, guwar. Medicinal plants found here are mehndi, hak, isabgole and gugal.

Indian deserts support many threatened species of birds and mammals, such as Asiatic lion, wild ass, bats, scaly ant eater, desert fox, Indian gazzel, four horned antelope , white browed Bushchat, Great Indian Bustard, Cranes and Sandgrouse. Gulf of Kuchch is distinguished by the presence of living corals, pearl oyster, sea turtles and a large number of migratory birds like kingfisher, cranes ibis and herons.

### (4) Mountains – The Himalayas

**Distribution:** The Himalaya is a great range of mountains that spreads over a west-northwest to east- southeast over a distance of about 2500 km covering Afganistan , Pakistan, India, Nepal, Bhutan and China. In India, it extends from the Indus trench below Nangaparbat in the west to Yarlungtsangpo- Brahmputra George below Namchebarwa peak in east.

The Himalayas lying within India occupy nearly 5,31,250 sq. km area

They cover about 16.6% of India's total geographical area and are spread partially or completely over 12 states namely: Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, West Bengal, Arunachal Pradesh, Assam, Nagaland, Manipur, Tripura, Mizoram and Meghalaya.

Himalayas are geographically divided into:

(i) the Eastern Himalayas or the Assam Himalayas: Out of the above the Eastern Himalaya has a greater diversity of ecosystems like, forests, grasslands, marshes, swamps, lakes streams and rivers Eastern Himalayas consists of nearly 8000 species of the flowering plants. It has many primitive as well as many endemic plant species. Eastern Himalayas is known as centre of origin of cultivated plants . Many cereals, fruits and vegetables are cultivated here. E.g. Orchids, *Aster, Accasia, Albizzia, Delbergia* species (timber) and many legumes etc.

(ii) the Central Himalayas or the Nepal Himalayas

(iii) the Western Himalayas: On the western Himalayas cold deserts of Ladakh support drought and cold resistant varieties of plants and animals e.g. Yak.

(iv) the North-West Himalayas or the Punjab Himalayas

Eastern Himalayas are one of the of the world and has large no animals because of its varied ecological conditions e.g. Pangolins elephants macaque languor civet.

**(5) Ghats**

Western and eastern ghats are also important ecosystems of India

**Western ghats** also known as Sahyadri extend from Tapti river in north to Kanyakumari in south covering nearly 1,40,000 sq km parallel to the west coast of peninsular India. They pass through the states of Gujarat, Maharashtra, Goa, Karnatka, Tamilnadu and Kerala. These ghats are one of the richest biological resources and form distinct ecological and biogeographical region of India. Western ghats are one of 25 hot spots of the world. *Hot spots are the regions which show maximum biodiversity, richness of species and endemic forms.* These ecosystems are the threatened due to human interference. June- September are rainy months. The rainfall may vary from 100 to 500 cm. Soil is mainly red or black in most of the regions and rich in nutrients. 3500 species of flowering plants have been recorded from western ghats of which nearly1500 are endemic species.

Nearly 209 species of fresh water fishes occur in these ghats of which 120 are endemic. Similarly out of 219 species of amphibians found here 106 are endemic.

**Eastern ghats** extend in north south-west strike in Indian peninnsula covering an area of about 75000 sq. km They are spread through the states of Orissa, Andhra Pradesh and Tamilnadu. The eastern ghats do not form a continuous range because the great rivers Mahanadi,Godavari and Krishna cut across them. They are an assemblage of discontinuous ranges of hills, plateaus and basins. The climate of these ghats may be semiarid to semihumid with a rainfall ranging from 60 to 160 cm. The vegetation ranges from evergreen trees to that of dry savannas. The eastern ghats are affected by the human activity. Conservation of biodiversity here is a big issue today. Special measures are taken to protect this floristic zone. United Nations Conference on Environment held in Rio de Janerio in 1992 discussed the issue of conservation of this region.

### 6.4.2 Aquatic ecosystem in India

**Freshwater ecosystem**

Freshwater are terrestrial aquatic ecosystems. Lakes, flood ponds, reservoirs and rivers are its important components. The total freshwater area of India is about 7.6 million hectare.

- **Lake***s* are naturally formed deep water bodies e.g. Sultanpur lake, Batkal lake (Haryana).
- **Flood points** are the places that undergo periodic flooding as a river channel overflows with flood water i.e. natural areas constituting shallow and seasonal water bodies. Bank of large rivers have flood points.
- **Reservoir** is man made areas holding water irrigation and human use. e.g, reservoirs formed by dams used for irrigation.
- **Rivers** are the flowing water bodies as you have studied in this lesson. For example river Yamuna, Ganga and Tapti, Krishna, Kawari, Narmada etc.

**Marine ecosystem**

India has a long coastline of about 8000 km stretching along nine states and two island chains. At the coast a number of rivers form estuaries at their confluence with the sea. There are three gulfs - one on the east coast that is gulf of Mannar and two on the west coast i.e. gulf of Kutchch and gulf of Khambhat.

The continental shelf (extension of land into the sea) is 200 m in depth but variable in width along the coast. The Indian ocean is the smallest of the three great oceans.

The tides are very important in determining the marine life. Nearly 14 species of sea grasses and 120 species of sea weeds are found along the coast. Representatives of almost all the invertebrate and vertebrate groups are found in the marine ecosystem. Corals are the most abundant and play a very important role. 199 Species of corals are known from Indian Ocean. They make coral reefs which are home to a large number of other sedentary species like many molluscs, crustaceans and coelenterates. The biodiversity in a coral reef is comparable to that of a tropical rain forest. Sea shore provides feeding and breeding ground to a number of birds also. Sea crows, whales and dolphins are the mammals that have secondarily invaded the sea .

Marine fisheries constitute a highly productive sector in India It is a source of food and employment to the coastal population.

## INTEXT QUESTIONS 6.4

1. Name the various zones of the Himalayas.

2. Where are deserts found in India?

______________________________________________

3. Give two differences between western and eastern ghats?

______________________________________________

4. Give two Plants and two animals which found in grassland.

______________________________________________

5. Name three gulf which are found in India.

______________________________________________

## 6.5 THE THREATENED ECOSYSTEMS

Some of the natural ecosystems are very sensitive to misuse by humans and to natural disasters or calamities. About such activities you will be study in lesson 12. *Natural disasters are sudden natural accidents or events that cause a lot of damage to natural ecosystems and human life*. Some of the important natural disasters are like tsunamies, earthquakes, landslides, volcanic eruptions and cyclones.

### 6.5.1 Estuaries

An estuary is a place where a river or a stream opens into the sea. It is a partially enclosed coastal area at the mouth of the river where its fresh water carrying fertile silt and runoff from the land mixes with the salty sea water. It represents an ecotone between fresh water and marine ecosystem and shows a variation of salinity due to mixing of sea water with fresh water.

**Estuaries** are very dynamic and productive ecosystems since the river flow, tidal range and sediment distribution is continuously changing in them. Examples of estuaries are river mouths, coastal bays, tidal marshes, lagoons and deltas.

**Deltas** are triangular areas bordering the river valley towards the mouth. They are associated with the land projecting into the sea in the form of protuberances.

Estuaries are richer in nutrients than fresh waters or marine waters therefore; they are highly productive and support abundant fauna. In general the phytoplanktons of estuaries are diatoms, dinoflagellates, green algae, blue-green algae. Towards the sea coast of the estuaries there are large algae and sea grasses. Near the mouth of the rivers and deltas there are mangrove forests.

The vast mangrove forests act as barriers for the costal habitat to check the wind speed during cyclones and high velocity landward winds.

All the plants and animals in the estuaries are subjected to variations in salinity to which they are adapted (osmoregulation).

Estuaries have been damaged due to urbanization, industrialization and population growth. Aquaculture activities such as prawn seed harvesting has caused considerable damage. Further, pollution due to industrial effluents and always remains have caused eutrophication.

### 6.5.2 Mangroves

Mangroves represent a characteristic littoral (near the sea shore) forest ecosystem. These forests grow in sheltered low lying coasts, estuaries, mudflats, tidal creeks backwaters (current less, coastal waters held back on land), marshes and lagoons of tropical and subtropical regions. They are distributed over the east and west coast and island of Andaman and Nicobar. Since mangroves are located between the land and sea they represent the best example of ecotone.

**Characteristics of mangrove ecosystem:-**

(1) The mangrove forests include a diverse composition of trees and shrubs.

(2) Plants are well adapted to high salinity(halophytic).

(3) Resistant to tidal effect.

(4) Tolerant to high temperature.

(5) Roots bear pneumatophore ( or aerial roots ), which is an aerating system.

Mangroves are highly productive ecosystems and the trees may vary in height from 8 to 20 m. They protect the shoreline from the effect of cyclones and tsunamies.

Indian mangroves are distributed along the east and the west coasts and Andaman and Nicobar islands. Mangroves along the east coast are more luxuriant and considerably diverse due to the presence of nutrient rich deltas formed by the rivers Ganga, Mahanadi, Godavari, Krishna and Cauvery.

The animal communities are of two types:

1. Permanent fauna mainly bentic are molluscs, crustaceans, polychaetes, insects and birds like kingfishers.
2. Visiting fauna includes mollusks, echinomerms, crustaceans and birds which come from adjacent terrestrial ecosystems and rivers . Tree frogs, crocodiles, turtles and snakes are also found in these forests. They are breeding and spawning ground for many commercially important fishes. *Sunderban mangroves are the only mangroves where tiger population is found.*

Mangroves in India have been reduced to more than 50% during the last forty years. They are subjected to both natural as well as anthropogenic threats. Natural calamities such as cyclones, tsunamies and anthropogenic activities such as construction of houses and markets causing soil erosion and soil sedimentation has lead to their destruction. For example in Sunderbans collection of tiger prawn seeds for trade has greatly affected the other animals found in these forests.

### 6.5.3 Islands

Islands are land masses surrounded by sea water from all sides They may be far away from the continent (oceanic island )or may be very close to it (continental island). India has two main island groups: 1) Andaman and Nicobar islands in Bay of Bengal and 2) Lakshadweep in Arabian sea. These ecosystems are threatened mainly due to habitat destruction for resources and tourism. Although industrial pollution is much less on these islands, oil spills in oceans have greatly affected their fauna and flora. Many endemic species of turtles and birds have been threatened to extinction. The Government is taking special measures to protect them.

## INTEXT QUESTIONS 6.5

1. Name two threatened ecosystems.

   (i) ______________________ (ii)______________________

2. Where are mangrove ecosystem found in India.

   ______________________________________________________

3. Why is estuary a more productive ecosystem than ocean or fresh water?

   ______________________________________________________

4. What are islands?

   ______________________________________________________

## 6.6 ECOTONE

Ecotone is a zone of junction between two or more diverse ecosystems e.g. the mangrove forests. They represent an ecotone between marine and terrestrial ecosystem.Some more examples of ecotone are – grassland, estuary and river bank

Characteristics of ecotone:

(1) It may be very narrow or quite wide.

(2) It has the conditions intermediate to the adjacent ecosystems. Hence ecotone is a zone of tension.

(3) It is linear as shows progressive increase in species composition of one in coming community and a simultaneous decrease in species of the other out going adjoining community.

(4) A well developed ecotones contain some organisms which are entirely different from that of the adjoining communities.

(5) Sometimes the number of species and the population density of some of the species is much greater in this zone than either community. This is called **edge effect.** The organisms which occur primarily or most abundantly in this zone are known as **edge species.** In the terrestrial ecosystems edge effect is especially applicable to birds. For example the density of song birds is greater in the mixed habitat of the ecotone between the forest and the desert.

## 6.7 PROTECTION OF NATURAL ECOSYSTEMS

Natural ecosystems have been misused by the human being as a result of which the biodiversity and wild life has been threatened. Increasing human population, its increasing needs and greed are the root causes of destruction of natural ecosystems. Destruction and loss of any of the natural ecosystem will result in ecological imbalance and the human being (the destroyer) himself will become an endangered species. Hence natural ecosystems need protection

Protection of natural ecosystem demands management of human use of the biosphere resources such that they give maximum benefits to the present human generation while maintaining its potential to meet the needs of future human generations. Protection of natural ecosystems to an environmentalist means to protect animals and plants in their natural habitat in totality and not the protection of any one species . It can be achieved by the following methods:-

- Humans should reduce their needs.
- Introduction of the species from the other parts of the world and the human interference should be reduced to minimum into natural ecosystems.
- Some of the areas should be earmarked as **protected** or **reserve zones**. This can be achieved by making **buffer or transitional zones** around the protected area. (Buffer zone and transitional zones are where only a few humans are permitted to enter)
- Species in the detrimental habitats should be shifted to their unexploited natural habitat. Delhi Development Authority along with Delhi University has jointly established a Yamuna Biodiversity park in Delhi to protect and restore natural biodiversity lost from the Yamuna river bank. The same natural habitat is created for the plants and aquatic birds. Within a span of one year after the establishment of wetland the number of migratory birds has increased remarkably.

- Zones of megadiversity and hot spots of biodiversity should be protected. Megadiversity zones are those regions of the world which have largest number of species. 200 global megadiversities have been identified. India is one of the megadiversity countries**.** Hot spots are the richest and most threatened reservoirs of plant and animal life of the earth. They have maximum number of endemic species. 25 terrestrial hot spots have been identified for the conservation of biodiversity. They occupy 1.4% of the earth's surface and 20% of worlds the human population lives in these areas. Western ghats and Eastern Himalayas are two hot spots of India.
- International and national level efforts should be made for conserving natural ecosystems e.g. Earth Summit held in June 1992 at Rio di Janerio , Brazil, it was resolved to make efforts to protect and conserve biodiversity.
- Sacred forests and sacred lakes are protected by the tribal communities due to the religious sanctity accorded to these forests. They are most undisturbed by human activity and are known as **pristine forests.** Chipko movement to protect the forests of Mandal villages a good example of local people's effort to conserve natural ecosystems.

## INTEXT QUESTIONS 6.6

1. Define ecotone.
2. Give four examples of ecotone.
3. Define edge species.
4. Why there are more number of species of song birds in Mangrove forests?
5. What is meant protection of natural ecosystem for an environmentalist.

## WHAT YOU HAVE LEARNT

- Natural ecosystems are formed as a result of interaction of regional climate with the regional substrate without the interference by man.
- Natural ecosystems can be classified into two types: 1) terrestrial and 2) aquatic.

- Terrestrial ecosystems are forests, grasslands, deserts and tundra.
- Aquatic ecosystems are fresh waters bodies such as rever, lake and marine habitat such as seas and ocean.
- Similar altitudinal and latitudinal variations in the climatic conditions result in nearly identical.
- Distribution patterns of natural ecosystems from sea level to high mountain peaks and equator to poles.
- Tundra biome occurs in the region where the environmental conditions are very severe and there is very little vegetation below the poles and at high mountain peaks
- Forests are the regions densely packed with tall trees.
- Deserts like tundra form an extreme condition in the sequence of biomes. They occur in dry barren regions of the earth.
- Wetlands are ecotones between terrestrial and aquatic ecosystems like marshes, swamps and mangroves.
- Ecotone is a zone of junction between two adjoining communities e.g. estuaries, mangroves and grassland.
- We the human beings are responsible for the reduction of natural ecosystems. To protect our own species it is essential for us to protect them. Therefore to prevent the further destruction people should be educated and the various methods should be adopted for the protection of natural environment and ecosystem balance.

## TERMINAL EXERCISE

1. What do you understand by natural ecosystem ? Give examples.
2. Give differences between the following:
   a. Alpine and arctic tundra
   b. Savanna and prairie
   c. Tropical and temperate forests
3. What do you understand by biodiversity? Explain its significance.
4. Give two desert adaptations of plants and animals.
5. Describe the various types of forest found in India (in brief).
6. Explain various zones of Himalayas.

7. Write short note on grassland and deserts found in India.
8. Explain how deforestation has resulted in ecological imbalance.
9. What is an ecotone? Explain its significance for the edge species.
10. Give two methods of protecting natural ecosystems.

## ANSWER TO INTEXT QUESTIONS

**6.1**

1. Is an assemblage of plants and animals functions as a unit and is capable of maintaining its identity.
2. Terrestrial and Aquatic.
3. Forest, grasslands, deserts and tundra
4. Rivers, lakes and ponds

**6.2**

1. The leaves of these trees shed in autumn and new foliage grows in spring
2. Hot and low ration areas, suffering from water shortage (any other).
3. Animals– are fast runners, nocturnal habit conserve water by excreting concentrated urine.

   Plants – are mostly shrubs, leaves absent or reduced in size leaves and stems are succulent, root system well developed.
4. North America and Eurasia

**6.3**

1. Microscopic floating organisms such as diatoms, protozoan and larval forms re called plankton.
2. Refers to plant and animal communities occurring in water bodies. Flora and Fauna of marine ecosystem
3. Vascular plants are completely absent. Diatoms, algae, dinoflagellates and jelly fishes are free floating forms. Large crustaceans mollusks, turtles and mammals like seals, porpoises, dolphins and whales are free floating animals. Bottom dwellers are generally sessile (fixed) organisms like sponges, corals, crabs and starfish.

**6.4**

1. The Eastern Himalayas, the Central Himalayas, the Western Himalayas and the North-West Himalayas.
2. From Punjab, Haryana, Rajasthan to Gujarat state.
3.

| Eastern Ghats | Western Ghats |
|---|---|
| Extended in north-south-west strike in Indian peninsula. Rainfall may vary from 60-160 m vegetation ranpees from evergreen trees to that of dry savannas. | Extended from Tapti river to Kanyakumari. Rainfall may vary from 100 to 500 cm. 3500 species of flowering plants and has been recorded. |

4. Plants - Sedges, legumes and sunflower (Any two)

   Animals - Rat, mice, deer, elephant, dog, tiger (Any two)
5. Gulf of Mannar, gulf of Kutchch and gulf of Khambhat.

**6.5**

1. Estuaries, mangroves and islands (any two).
2. East and west coast and islands of Andaman and Nicobar.
3. Estuaries are very dynamic and productive ecosystems since the river flow, tidal range and sediment distribution is continuously changing in them. They are richer in nutrients than fresh waters or marine waters therefore; they are highly productive and support abundant fauna.
4. Island is land masses surrounded by sea water from all sides.

**6.6**

1. Ecotone is a zone of function between two or more diverse ecosystems. e.g. the mangrove forest.
2. Mangrove, grasslands, estuary and river bank.
3. The organisms which occur primarily or most abundantly in this zone are known as edge species.
4. Because of their mixed habitat of ecotone between the forest and the desert.
5. Protection of natural ecosystems to an environmentalist means to protect animals and plants in their natural habitat in totality and not the protection of any one species.

# 7

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# HUMAN MODIFIED ECOSYSTEMS

The greed and need of human being has modified and changed the natural ecosystems greatly. The main reasons for the modification of natural ecosystems are and 1) increasing human population 2) increasing human needs and 3) changing life styles. In this lesson you will learn about different types of human modified ecosystems, the modifications brought about for their optimum utilization.

## OBJECTIVES

After completing this lesson, you will be able to:

- *list the various human modified ecosystems;*
- *describe the overall changes in the environment due to rapid growth of human population and industrialization in India;*
- *explain formation of agro-ecosystems and impact of agricultural practices on natural environment;*
- *mention the impact of human practices - plantation of forests;*
- *analyze the effect of construction of dams and diversion of rivers on ecological balance;*
- *list merits and demerits of fish culture pond;*
- *describe the features of urban areas as human modified ecosystems and explain the environmental consequences;*
- *relate industrialization with environmental degradation;*
- *suggest methods to minimize human impact on ecosystems.*

## 7.1 HUMAN MODIFIED ECOSYSTEMS

Human modified ecosystems may or may not depend on solar energy e.g. in an industry energy is provided in the form of fossil fuel or electricity or both.

Some examples of human modified ecosystems are:

(1) Agro-ecosystems

(2) Plantation forests

(3) Urban ecosystems

(4) Rural ecosystems

(5) Aquaculture

(6) Industrial areas

(7) Laboratory cultures

### 7.1.1 Characteristics of human modified ecosystems

(1) Highly simplified.

(2) Species diversity is very low.

(3) Food chains are simple and small.

(4) Depend on human (anthropogenic) support for survival; need for fossil fuel energy, fertilizers, irrigation etc.

(5) Attract large number of weeds.

(6) More susceptible to epidemic diseases.

(7) Suffer from soil erosion.

(8) Highly unstable.

### INTEXT QUESTIONS 7.1

1 Name two human modified ecosystems.

______________________________

2 Give two characteristics of human modified ecosystems.

______________________________

## 7.2 IMPACT OF INCREASING HUMAN POPULATION AND INDUSTRIALIZATION ON ENVIRONMENT IN INDIA

Human population is rapidly increasing in India consequently our demand for natural resources is also increasing. The industrialization in India is also increasing at a rapid pace. The increasing population and growing industrialization are severely affecting the environment in various ways: Some important impacts are briefly described below:

- **Pollution:** Development of Science and Technology is a boon to mankind in fulfilling growing human needs, but on the other hand they have caused environmental pollution. Pollution refers to the addition of any substance in the environment that has direct or indirect adverse effect on humans (Lesson 10). The consequences of pollution are many. Industrial accidents that have taken away several lives e.g. in Bhopal, accidental leakage of MIC (methyl isocyanate) gas from Union Carbide Company killed more than 2000 people within 12 to72 hours. Many people lost their eyesight and suffered from serious medical complications.

- **Global warming:** Increasing use of fossil fuels is a leading cause of increasing levels of $CO_2$ and other green house gases in the atmosphere. Atmospheric build up of green house gases have caused considerable heating of the earth leading to global warming. Global warming is causing melting of glaciers and rise in the sea level. Rising sea level poses a serious threat to low lying coastal areas and specially to thickly populated coastal cities like Mumbai, Chennai and Kolkata etc.

- **Human health and disease:** An increase in the population is leading to increasing incidences of epidemic diseases such as AIDS (Aquired Immuno Deficiency Syndrome), Hepatitis, T.B. (tuberculosis), bird flu, swine flu, Syphilis, Gonorrhoea,cancer and many more diseases These diseases are caused by environmental pollution or over crowding.

- **Over exploitation of natural resources:** Rapidly growing population results in over exploitation of resources. Over exploitation and introduction of a new or genetically modified species reduce the productivity of natural ecosystems. For example- introduction of new (genetically modified) high yielding variety or non- native species in any natural ecosystem reduces the population of native species. Over harvesting of edible fishes reduces their reproductive rate and their population start reducing in number and may become completely extinct after some time.

- Deforestation, over grazing, intensive cultivation, over irrigation etc. results in the loss of top soil and fertility of the land. Prolonged degradation of land leads to desertification.

- **Water bodies:** Rivers, lakes, ponds, estuaries and oceans are being increasing abused. Rivers and other water bodies are being used for disposal of all liquid effluents and all other kinds of wastes. Today most of the water bodies suffer from growing pollution. Pollution of river Yamuna is one such example.

## INTEXT QUESTIONS 7.2

1. Name any gas that contributes global warming.

_______________________________________________

2. Write the full form of MIC and AIDS.

3. What causes soil erosion?

## 7.3 AGROECOSYSTEMS AND AGRICULTURAL PRACTICES

Agroecosystems are large areas where commercial crops are cultivated. Crop plants are sown and harvested by humans for economic purposes. They are also known as crop ecosystems and mostly cultivated as monoculture (growing only one type of crop) on the entire field or some times growing two or more crop species in the same field at the same time.

### 7.3.1 Characteristics of agro-ecosystems

(1) They are highly simplified ecosystems supporting monoculture of a crop species.

(2) Species diversity is lowest

(3) Highly unstable and not self sustaining.

(4) Attract weeds and susceptible to plant diseases.

(5) Soil are poor, deficient in nutrients, require supplement of chemical or fertilizers.

(6) Need artificial irrigation and water management.

(7) Dependent on human care and management.

### 7.3.2 Economic importance

(i) Agroecosystems fulfill the basic requirementsof food, fruits, edible oil etc.

(ii) Good quality grains can be produced with high yield.

(iii) Provides livelihood to a large number of people .More than 70 % of Indian population depends on agriculture.

### 7.3.3 Disadvantages of agro-ecosystem

- Large scale monoculture of agricultural crops results in severe loss of native biodiversity including genetic diversity of crop plants.
- High yielding varieties of crop plants are more susceptible to disease e.g. smut of sugarcane, maize and sorghum and rust of wheat and bajra are common plants diseases. To protect crop from pests and diseases requires large scale use of pesticides and chemicals which pollute the environment.
- Deplete ground water in many areas due to well irrigation.

- Run off water from agricultural field laden with fertilizers and pesticides pollute river, lakes and ponds.

## 7.4 PLANTATION FOREST

It is a man made ecosystem consisting of individuals of a particular tree species . Trees planted on barren land, private land, village panchayat land, roadsides, canal banks, along with railway line and on land not suitable for agriculture. The aim is to grow fast growing trees which are commercially valuable.

### 7.4.1 Characteristics of plantation forests

(1) Plantation forests are generally monoculture, like oil palm plantation, rubber plantation, coffee plantation.

(2) Plantation forests have trees of approximately same age.

(3) Plantation forests are highly susceptible to pathogens are pests.

(4) Poor in species diversity.

(5) Requires constant human care and management.

(6) Recently plantations of *Jatropa curcare* have become very popular for obtaining biodiesel.

### 7.4.2 Economic importance

(1) Tree plantation are raised for fruits, oil, rubber, coffee, timber, fire wood, pulp wood for making rayon and paper industries.

(2) Trees are also planted to serve as wind breaks or shelter belts.

(3) Tree plantations are also raised for controlling soil erosion and for increasing soil fertility.

(4) Tree plantation provides job opportunities and generate income.

## INTEXT QUESTIONS 7.3

1. Name five types of plantations.

______________________________

2. Which type of trees are preferred for plantation forests?

______________________________

3. List any two common features of agro ecosystem and plantation forests.

______________________________

4. Which plant you would recommend to raise a plantation for obtaining bio diesel?

______________________________

## 7.5 URBAN ECOSYSTEMS

Urban life is the life in a city where many people live close together. Presently there seems to be an urban revolution as people all over the world are moving into towns and cities. In year 1800, only 5% of the world population was urban-dwelling (50 million people) and in 1985 it increased to 2 billion. At present 45% of the world population is urban population and by 2030 there will be more than 60% people living in cities.

### 7.5.1 Characteristics of urban ecosystems

(1) High population density: The maximum population density is observed in Malta Africa. It is 1100 persons/sq km. Next ranking is Bangladesh with 888persons/sq. km., Bahrin 759 persons/sq km, Netherland 441 persons/sq km and Japan 328 persons/sq km.

(2) Conjestion, shortage of housing and growth of slum areas.

(3) Urban areas import increasing quantity of energy, food and various other materials from outside to survive.

(4) Generate large quantities of solid and liquid wastes and air pollutants causing problems of environmental pollution.

(5) More employment opportunities as well as tough competiton.

(6) Better education facilities.

(7) Better medical facilities and health care is provided.

(8) More and diverse sources of entertainment.

### 7.5.2 Advantages of urban ecosystems

(1) Economically well developed.

(2) Hub of industrial growth.

(3) Centre of commerce.

(4) Multicultural social environment.

(5) Reduced infantile mortality.

(6) Centres of political activity.

### 7.5.3 Disadvantages of urban ecosystems

(1) Urban areas consume 75% of the earth's resources and produce 75% of the waste.

(2) Urban areas are highly polluted since growing number of vehicles and industries emit large quantities of pollutants.

(3) Suffer from problem of noise pollution is caused by industries and transport.

(4) Urban ecosystems suffer from serious shortage of water availability.

(5) High crime rate,unrest and unemployment .

(6) Increasing population density in cities of the world compels some people to live in slums e.g. in Mumbai 3 million people live in slums pavement and squalter settlements which lack basic civic facilities like safe drinking water, waste disposed, health care etc.

Urban revolution is taking place more rapidly in developing countries like India. The average growth rate of population twice as fast as the average growth of population. Currently rate of increase in the population of city dwellers in developing countries is much faster as compared to the cities of industrialized countries.

## 7.6 RURAL ECOSYSTEMS

Rural ecosystems are midway between natural and urban ecosystems since the exploitation of nature and natural resources by humans is relatively much less. Rural people live relatively close to nature and follow a simple life style.

### 7.6.1 Characteristics of rural ecosystems

- Many villages belong to a single family.
- In rural areas people live in small clusters in thatched, mud houses surrounded by farm lands. In rural areas people are directly or indirectly dependent on agriculture and consume locally available resources.
- Drinking water is largely obtained from wells, canals, lakes or rivers.
- Education, healthcare, drainage, sanitation, hygiene, and transport etc. are inadequate or lacking.
- Rural areas are mostly free from air and noise pollution.

The government policies to reduce the migration of people from villages to cities are to increase the cost of land in the cities and reduce it in the villages. More employment opportunities should be created in the villages. Some incentives should be given to the people working in the villages.

## INTEXT QUESTIONS 7.4

1. List any two advantages of rural ecosystems.

2. Why do people tend to migrate from villages to cities?

3. List any two disadvantages of urban ecosystem.

4. Why do you like to go to a hill station during vacations?

## 7.7 AQUACULTURE—MERITS AND DEMERITS

Aquaculture is the artificial cultivation of aquatic plants or animals. It is primarily carried out for cultivating certain commercially important edible species of fresh and marine water fishes, molluscs, crustaceans and aquatic plants. Generally natural water bodies support a rich biodiversity, very few species are harvested by man. 20,000 species of fish are known of which only 22 of them are taken largely by man. **Fisheries** include the extraction of food from the sea and the fresh water where as **aquaculture** is rearing of the aquatic organisms in artificially made water bodies (Fig. 7.1) e.g. culture of fish like carps, tilapia.

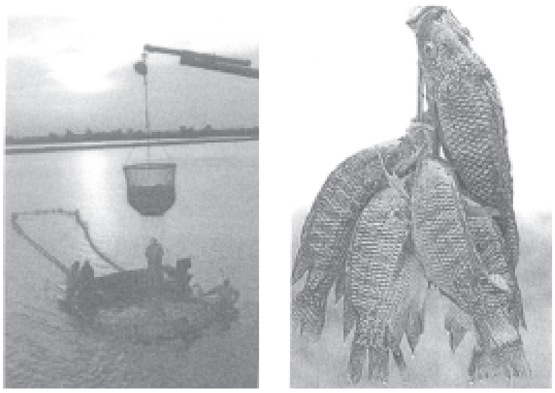

***Fig. 7.1:*** *Aqualture*

There are two types of aquaculture:

1. **Fish farming** is cultivation of fish in a controlled environment often a coastal or inland pond, lake, reservoir or rice field (paddy) and harvesting when they reach the desired size.

2. **Fish ranching** is a practice of keeping which fishes in captivity for the first few years in floating cages in coastal lagoons and releasing them from captivity into water bodies. Adults are harvested when they return for spawning to the lagoons.(for laying eggs) e.g. Salmon and Hilsa which migrate to rivers to spawn are cultivated by fish ranching method.

Notes

### 7.7.1 Fisheries and aquaculture in India

India has a very long coast line for trapping sea food. Marine resources include Bay of Bengal, Arabian Sea, Indian Ocean, numerous gulfs, coral reefs, mangroves and brackish waters like lagoons and Chilka lakes in Orissa. India's inland waters occupy about 1.6 mha (million hectares). They are in the form of major river systems such as Ganges, Yamuna, Brahmaputra, Narmada, Mahanadi, Cauvery and Krishna and others. Further, there are canals, ponds, lakes, and irrigation channels where culture fishery can be practised. The fresh cultured fishes are mostly various species of carps (*Labeo, rohita, Catla catla*) Chinese carp, green carp, mirror carps, cat fish etc.

Tilapia, trouts, salmons and some more species of fishes are cultured in net pens. Milk fish and mullets are cultured in enclosures or bamboo fences. Tilapia is a very favourite fish of many. It is also known as aquatic chicken. They are also grown through small scale aquaculture by many poor farmers. This fish can grow well even on a low protein diet , and resistant to many diseases and parasites It can breed rapidly under captivity.

### 7.7.2 Merit of aquaculture

(1) Ecological efficiency is high. 2 kg. of grains are required to add 1 kg live weight.

(2) High yield in small volume of water.

(3) Improved qualities of fish obtained by selection and breeding and genetic engineering.

(4) Aquaculture reduces over harvesting of fisheries.

(5) High profit.

### 7.7.3 Demerit of aquaculture

(1) Large inputs of feed, water and land are required.

(2) Loss of native aquatic biodiversity. As it replaced by monoculture of a commercially important fish species.

(3) Produces large amounts of fish wastes that pollute water bodies.

(4) Destroys mangrove forests or coastal vegetation.

(5) Aquaculture fishes are very sensitive to pesticide runoff from croplands.

(6) In aquaculture ponds high population density is maintained that makes them highly vulnerable to diseases leading to total collapse of the crop.

(7) Aquaculture tanks or reservoirs are often get contaminated after a few years.

## INTEXT QUESTIONS 7.5

1. What is the difference between fisheries and aquaculture?

______________________________

2. Name any two fresh water fishes that are being grown in pond culture.

______________________________

3. Name the fish that is commonly known as aquatic chicken.

______________________________

4. In what way aquacultures affect the mangrove forests?

______________________________

## 7.8 DAMS, RESERVOIRS AND DIVERSIONS

A dam is a structure built in order to store river or tidal water. Dams, reservoirs and diversions capture and store runoff water and release it as needed. They are used for:

(1) controlling or moderating floods,

(2) producing hydroelectric power, and

(3) supply water for irrigation, industry and other uses to rural, suburban and urban areas. Support recreational activities such as swimming and boating.

### 7.8.1 Advantages of dams

(1) Water released from dams to generate electricity.

(2) Reduce the use of coal and thereby reduce $CO_2$ emission.

(3) Reduce downstream flooding.

(4) Reduce river silting below the dam.

(5) Supply irrigation water for croplands.

### 7.8.2 Disadvantages of dams

(1) Permanently submerge large areas of forests and crop lands.

(2) Displace large number of native people.

(3) Increase water pollution on account of reduced water flow.

(4) Reduce nutrients replishment of down stream flood plains.

(5) Disrupt spawning and migration of some fish species.

(6) High cost.

(7) Large dams i.e. more than 15 meters high (492 feet) increase the risk of inducing earthquakes specially in earthquake prone areas.

(8) Change physico-chemical quality of water.

## 7.9 INDUSTRIALIZATION AND ENVIRONMENTAL DEGRADATION

A rapid increase in urbanization is resulting in a simultaneous growth of industrialization. The industrial processes involve mining, manufacturing, metallurgical processing, welding, grinding and synthesis of chemicals.Industries which are being made by man to make better use of the primary raw materials produced under natural environmental conditions cause environmental degradation in the following manner:

**Pollution:** All these industries discharge several waste gases and particulate pollutants into the atmosphere. Some of them are as follows:-

(i) Gaseous pollutants: Oxides of carbon, nitrogen and sulphur.

(ii) Particulate matter: Fine metal dust, fly ash, soot, cotton dust and radioactive substances.

(iii) Burning of plastics: Emit poly chlorinated biphenyles (PCBs) which are harmfull for lungs and vision.

(iv) Accidental release of some poisonous gases like phosgene ($COCl_2$) and methyl isocynate (as it happened in Bhopal) are fatal.

(v) Secondary air pollutants formed from complex reactions between primary pollutants, such as smog and acid rain, which are harmful all living organisms, buildings and monuments.

**Land use and habitat destruction**: The natural ecosystems are modified to fulfill the increasing needs of growing human population 83 % of the earths surface is affected (excluding Antarctica)by human .Wild life habitat have been degraded,forests have been cleared which provide habitat for thousands of large and small animals. Industries and modern transport networks have not only destroyed the natural habitat of animals but also create noise and thermal pollution. This is seriously affecting growth and reproduction of wild species of plants and animals resulting in loss of biodiversity.

**Human health:** Use of various type of chemicals today have serious health implications. Incidence of cancer, genetic mutations and damage to nervous, immune and hormonal systems. New disease such as AIDS, mad cow diseases, bird flu and swine flu have emerged in fast succession due to growing damage to ecology.

**Increased sensitivity to diseases**: Cultivated species of plants, fishes and other domesticated animals have become increasingly sensitive to pest and diseases.

**Genetic resistance**: An increased use of insecticides, pesticides and antibiotics has speeded up directional natural selection and caused genetic resistance in the pathogens.

**Effect on native populations:** Introduction of new alien species or non-native species reduces the populations growth of native species.

**Stress due to over harvesting:** Overgrazing by livestock results in soil erosion and loss of productivity. Similarly over harvesting of edible fishes reduces population and may become completely extinct if the over fishing continues for long.

**Effect on nutrient recycling:** Use of fertilizers in agricultural fields interferes with the natural biogeochemical cycles.

## 7.10 METHODS TO MINIMIZE HUMAN IMPACT ON NATURAL ECOSYSTEMS

**Reduce our needs:** We should change our habits, curtail our needs and try to conserve our resources especially food, fuel and water.

**Ecoindustrial revolution**: The solution to many of the above problems is ecoindustrial revolution. It refers to a new resource and efficient production system generating minimum waste. Ecoindustry or industrial ecology is to make industrial manufacturing processes more sustainable by redesigning the industrial processes along the pattern of natural processes.

- One way is by recycling or reutilizing most of the industrial waste.
- Networking of different industries in complex resource exchange web where the waste of one industry is used as a raw material by for the other and so on.
- Industry should strive for higher efficiency of energy and resource use.

## INTEXT QUESTIONS 7.6

1. List any two advantages of dams.

______________________________

2. Name the harmful gas that is released during burning of plastics.

______________________________

3. How does the introduction of an alieu species affects the indigenous species?

______________________________

4. What effect does overgrazing by livestock have on grassland?

______________________________

## WHAT YOU HAVE LEARNT

- Human modified ecosystems are man made ecosystem, such a agro ecosystem, aquaculture ponds, cities etc. for his own benefits. They require inputs of fossil fuel for their survival.
- Growth of population and migration of people from rural areas to cities is the root cause of increased urbanization.
- All human modified ecosystems suffer from loss of biodiversity and are not sustainable on their own.
- Most of the current environmental problems are casused by the uncontrolled growth of human population and growing urbanization and industrialization.
- Over harvesting of any species of plant or animal should be controlled to maintain ecosystem balance.
- Agro ecosystems have created many environmental problems such as soil erosion, ground water depletion and environmental pollution by fertilizers and pesticides.
- Ecoindustrial systems should be encouraged to protect the environment.

## TERMINAL EXERCISE

1. Define human modified ecosystems.
2. Give differences between natural and human modified ecosystems.
3. Why the following conditions lead to stress in a population

   a) over crowding b) over harvesting c) human intervention
4. Give characteristics of human modified ecosystems
5. Write short notes on the following
   i) Human population explosion
   ii) Industrial pollution
   iii) Human health and disease
6. What are the advantages of tree plantation?
7. List some impacts those are leading to environmental degradation?

## ANSWER TO INTEXT QUESTIONS

**7.1**

1. Agro ecosystem, plantation forest, urban ecosystem, rural ecosystem aquaculture (any two).

2. (i) Low species diversity, unsustainable and need inputs of human beings in the form of energy, fertilizers and irrigation and human care to survive etc., They are highly susceptible to rapid spread diseases. (any two)

**7.2**

1. $CO_2$, Methane
2. Methyl Isocyanate (MIC),

   Acquired Immuno Deficiency Syndrome (AIDS)
3. Overgrazing, poor irrigation, over cultration, deforestation

**7.3**

1. *Acassia, Lucaenas* (Subabus) *Prosopis, Sesbannia, Caruarin* Jatropa, Monnga and neem (any)
2. Fast growing tree species of economic value are preferred.
3. Refer to text
4. Jatropa curcare

**7.4**

1. Clean and natural environment is available, people have simple life style.
2. For better employment,health and education opportunities and for better living amenities.
3. Refer to text
4. Highly congested and highly polluted (high levels of water, air and noise pollution), shortage of living space leading to slum development. (any two)

**7.5**

1. Aquaculture is the artificial cultivation of aquatic plants and animals whereas fisheries refers to capturing of fish and othwer aquatic organisms from seas and other fresh water bodies.
2. Eel, Tilapia, Rohu, Catla, Cat fish (any two)
3. Tilapia
4. Destroys mangrove forest.

**7.6**

1. They store water, generate hydro electric power increase provide water for crop irrigation and other domestic uses, reduce downstream flooding (any two).
2. Poly chlorinated biphenyles (PCB)
3. Reduced population of nature species.
4. It results in soil erosion and future loss of productivity.
5. It aims to make industrial manufacturing process is more sustainable by redesigning them to mini how nature sustain them.

8

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# HUMAN SOCIETIES

Humans have lived in close contact with the environment ever since they first evolved way back in time between one million to two million years ago. In the beginning they were hunters and gatherers as you have already learnt in lesson-3. Gradually, with time, humans began to lead a settled and well organized life. As humans increased in numbers and progressed culturally, they began to draw more and more from natural resources so much so that environmental degradation has become a matter of serious concern nowadays.

In this lesson you shall learn about the settlements of humans in villages and cities, related characteristics, associated life styles and environmental changes resulting from explosive growth of human population and human settlements.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define urban settlement and differentiate between rural society and urban society;*
- *explain the push and pull factors leading to migration of rural population to cities;*
- *define rural settlements and list the characteristics of rural settlements;*
- *list the special problems of the rural population pertaining to land availability and land use;*
- *list the effect of modern technology on agriculture and its impact on rural life;*
- *describe the significant features of urban life including facilities as well as its difficulties specially in the Indian context;*
- *list the special problems of urban areas, changes in life style, land availability;*
- *list the special problems of urban areas like resource consumption and waste generation;*
- *describe the slum dwelling areas and mention urban planning.*

## 8.1 HUMAN SOCIETIES

Primitive humans passed the hunter– gatherer stage once they discovered the comforts of food sufficiency through agriculture, convenience of mobility with the discovery of the wheel and the security of living in a group (see lesson-2). Humans felt the need for shelter and settled life.

### 8.1.1 Temporary and permanent settlements

Settlement refers to an organized colony of humans with dwelling units (kutcha huts or pucca houses) and roads they use for traveling. Hunters, herders, adventurers set up camps for a limited period of time as temporary settlements. Inhabited villages and urban agglomerates are permanent settlements. Few dwelling units forming a settlement is a **hamlet** while large number of people settling in several clusters of buildings may be found in the towns and metropolitan cities.

In the agricultural era (lesson-2), rural settlements predominated. With industrial revolution, urban settlements, got established which are growing today.

### 8.1.2 Types of settlement: rural and urban

On the basis of size and functions, settlements may be categorized into:

1. Rural (villages) settlements
2. Urban (towns and cities) settlements

There is however, no characteristic criterion to distinguish between the rural and urban settlements. Rural settlements are chiefly engaged in primary activities such as agriculture, fishing, forestry, mining, artifact (craft) making, cloth weaving etc. Urban settlements indulge in nonagricultural activities e.g. industries and manufacturing, trade and commerce, transport and communication, defence and administration.

## INTEXT QUESTIONS 8.1

1. Why did primitive humans decide to lead a settled life?

   ______________________________

2. Mention the basis on which settlements may be termed:

   (i) temporary and permanent ______________________

   (ii) rural and urban ______________________

## 8.2 URBAN SETTLEMENTS

### 8.2.1 What are urban settlements

Life in cities and towns is urban life. Traditional cities were usually walled. The walls separated them from the villages which were mostly found in the countryside. Markets, dwelling units, brick houses or concrete buildings for administrative bodies, religious institutions (temples, mosques, gurudwaras, churches, synagogues and palaces and courts) are common features of towns and cities. Commoners live towards the edges of cities as they come into cities from villages in search of jobs. Urban people coming from rural areas to large cities for employment settle down in shanties, at the periphery of cities. With time and increase in population urban scenario has undergone a big change. Overcrowding and abundance of concrete structures is a common feature today in most Indian cities.

Villagers are moving into cities in search of jobs, opportunities and better facilities.

The migration of rural population towards towns and cities in a country is leading to a conspicuous chaos. As the villagers mingle with the already swollen urban population, they start facing scarcity of water, sanitation, easily affordable housing, public transport, roads, safe waste supply and clear air. Inspite of such difficulties, the influx of rural population into cities is continuing and growing. It is estimated that by 2020, half of the Indian population will be living in cities.

### 8.2.2 Occurrence of urban settlements–push and pull factors

The tendency to concentrate in towns and cities is called **urbanization**. In the 20$^{th}$ century urbanization has taken place at such a fast pace that there has been an unprecedented increase in urban population in almost all the countries of the world. Some of the important reasons for migration of rural folk towards cities are listed below:

**1. In search of better opportunities**

You have already learnt that apart from agriculture and cottage industries for crafts, villages do not offer opportunities for any other vocation whereas cities have many avenues for jobs. Also schools are not well equipped and there are hardly any institutions for higher studies.

**2. For better life style**

Superstitions, social taboos and criticism hold back forward-looking villagers from improving life style so they rush towards cities. Also cities are consistently into trade and economic expansion as well as territorial expansion. Fifty years ago Delhi was limited to old Delhi and New Delhi fenced by the river Yamuna. Today Delhi has expanded in all the four directions and extends upto a great distance beyond the eastern bank of river Yamuna.

### 3. To overcome poverty

Poverty is rampant in most of the villages and villagers come to cities in search of work and jobs. Because of poverty, slavery and prevalence of bonded labour are found in villages. Young villagers run away to cities to break these shackles. Apart from these three major pull factors villagers have also been pushed towards cities in times of war or famine or natural disasters. Religious and political persecution are also common in villages. Racial discrimination forces rural folk to move out of their villages. The factors which push rural folk out of their villages and pull or draw them towards cities or urban areas are tabulated in Table 8.1.

***Table 8.1:*** *Push and pull factors responsible for migration of villagers towards cities*

| Pull factors | Push factors |
|---|---|
| Villagers get attracted to cities for the following.<br>1. Employment.<br>2. Better and more opportunities<br>3. Better social amenities<br>4. Better life style<br>5. Continuous trade and economic expansion<br>6. Territorial expansion. | Villagers are forced to move to cities because of the following.<br>1. Overpopulation (often one or more members move out of large families and then invite others to come to cities)<br>2. Religious/political persecution<br>3. Slavery/bonded labour<br>4. Lack of food<br>5. Racial discrimination<br>6. Natural hazards and climate change<br>7. Fragmentation of family owned land |

Sometimes village youth go to cities to visit relatives and friends and stay on and settle down.

More immigrants are attracted to bigger urban settlements.

### 8.2.3 Characteristics of urban communities

Urban communities are characterized by the following features:

### (1) Social heterogeneity

People from diverse backgrounds and cultures throng the cities for better prospects and like a "melting pot" get absorbed and live together as urban community. Social amenities such as schools, hospitals, avenues for entertainment become readily available.

### (2) Freedom from social control

Away from home, loneliness and sense of alienation bring about secondary associations. Such associations flourish in the absence of control, back at home.

### (3) Voluntary associations

Close proximity, diversity and easy contact among socially diverse people bring them closer. Clubs and associations are established to look into common requirements.

### (4) Individualism

Multiplicity of opportunities, social diversity, lack of familial and social control over decision-making leads to more of self interest and facilitate decision-making by an individual and choose one's career and actions by oneself.

### (5) Social mobility

In a city no-one is bothered about the status at birth. Status in cities is largely based on achievements, competence, efficiency and novelty.

### (6) Availability of facilities

Diagnostic clinics, legal services, banks, commercial centres comprising of markets, malls and departmental stores, hotels and guest houses are available to the city dwellers. It is undoubtedly a better life for urban youth though a more stressful life. Based on the above, table 8.3 highlights the major differences between rural and urban settlements.

The impact of migration from village to cities has not been only rosy as shown in table 8.2.

***Table 8.2:*** *Impact of migration from village to cities*

| Type of impact | At origin | At destination |
|---|---|---|
| Social | Men leave the women behind | • Too many people<br>• Cannot always cope with education and health |
| Economic | • No land for farming<br>• Crops decline<br>• No personnel for service | • Unemployment<br>• Economic insecurity<br>• No professionalism/ vocation<br>• Non taxable, low salary, informal work |
| Environmental | • Slums develop | • Pollution<br>• Trash<br>• Contaminated food and water<br>• Marginal land |

The sadness of leaving the village are echoed in the poem given below:

**WHAT I LEFT BEHIND, WHAT I HOPE TO FIND**

**I left home, to come to school**
**I left farm, to come to food**
**I left my cows, my sheep,**
**But did not have time to weep.**
**Now I know why I cry tonight**
**'Cos I know now what I left behind**
**and today, what I hope to find.**
**Cities full of cars and bikes**
**Restaurants and bars and roaring mikes**
**But I miss the vast sky**
**and my kites to fly**
**And my folks, my friends**
**Seem vanishing trends**
**So I cry tonight but what shall I gain**
**Tomorrow I'll struggle and then day after day again**

***Bharati Sarkar***

## INTEXT QUESTIONS 8.2

1. Define urban settlements.

2. State any three factors which compel village youth to migrate to cities and towns.

3. List any three typical features of urban settlements.

## 8.3 RURAL SETTLEMENTS

### 8.3.1 What are rural settlements?

Primitive humans began to lead a settled life about 10,000 years ago. The settlements were village habitations comprised of an enlarged primary group. Such village habitations are persistent aggregates of human society. Simple living and compact organization characterises rural societies.

Modern civilization considers urban societies to be superior to the rural societies as, traditionally, common villagers are economically weak and inferior in skills and expertise. Rural societies have low population density and limited opportunities. In India villages are significant as Indian culture is still preserved in villages. Most of the villages in different parts of the country have retained their specific cultural and societal features. No wonder India is the best example of 'unity in diversity'.

### 8.3.2 Characteristics of rural settlements

Rural communities possess special features:

1. **Agriculture** forms the dominant occupation. Even those not directly working in fields, have occupations that are indirectly connected to agriculture. Village economy is based on agricultural economy.

2. **Joint family system**: Joint family is a social and cultural institution more commonly found in village communities than in cities.

3. **Caste system**: Social stratification based on castes is more pronounced in villages.

4. **Jajmani system**: Each village is grouped into (i) jajmans and (ii) service provider castes who are paid in cash or kind. Jajmans are land owners. They come from upper castes while service provider castes are at a middle or lower level.

5. **Rural calendar**: In Indian villages people understand the Indian *samvat* and the *Hijri* calendars.

6. **Simple living**: God-fearing and tradition bound villagers lead simple lives untouched by glamour of city life.

7. **Poverty and illiteracy** are because of uneconomic land holdings and poor productivity due to fragmented and barren lands. Colleges, medical facilities, transport and civic amenities are not available inspite of several rural development schemes of the government.

8. **Averse to mobility and social change**: Orthodoxy, illiteracy, superstitions and fear keep back youth from moving out or changing profession, caste and religion. Rural social norms have a big influence in preventing violation of traditional norms of rural society. The punishing authority of panchayats also contributes towards keeping back rural youth from taking new initiatives or adopting any change.

## 8.4 DIFFERENCES BETWEEN RURAL AND URBAN SOCIETIES

The rural life is a world apart from urban life. They are different in many ways as tabulated below:

*Table 8.3: Differences between rural and urban settlements*

| S. No. | Factor | Rural society | Urban society |
|---|---|---|---|
| 1. | Environment | Predominance of nature. People directly related to nature. | Human-made environment predominant. Inhabitants isolated from nature. |
| 2. | Occupation | Agriculture- cultivators and their families are in majority. Few in non-agricultural pursuits. | Mostly industrial workers, traders, professional and working in offices. Mostly engaged administration. All non-agricultural occupations. |
| 3. | Community size | Small | Much larger than rural community. |
| 4. | Population density | Comparatively lower density of population | Large population density. |
| 5. | Social differences and stratification | Much less due to similar vocation | Differentiation pronounced due to work related differences in earnings. Different strata of urban society noticeable. |
| 6. | Homogeneity versus heterogeneity | In racial, cultural and psychological traits much homogeneity noticeable. | Much heterogeneity in the same country and same time. |
| 7. | Caste system | Rampant | Much eroded |
| 8. | Mobility | Social mobility low. Migration of population towards cities mainly due to poverty much more. | Social mobility based on achievement. Migration towards villages low. |
| 9. | Social interactions | Primary contacts. More durable and sincere relationships due to simplicity. | Numerous contacts and wide interactions. Casual, short-lived relations-formal and mostly superficial. |

## INTEXT QUESTIONS 8.3

1. What is a rural settlement?

______________________________________________

2. Why are villages suffering from poverty?

______________________________________________

3. Why are rural-folk more homogeneous socially?

______________________________________________

## 8.5 AVAILABILITY OF LAND AND LAND USE IN VILLAGES

Agriculture is the only major vocation in villages. Village community has (1) land owners and (2) landless agricultural workers. The formers own land and grow crops with the help of the latter.

As a consequence of rapid growth in population of a country, need arises for building roads, dams, railway tracks, houses and industries. Land required for these developmental activities is acquired from villagers by paying them monetary compensation. This has caused colossal shrinkage of agricultural land and has also led to change in landscape.

### 8.5.1 Effect of modern technology on agriculture and rural life

The objective of agriculture, whether traditional or modern is to produce more crops by providing factors necessary for increased crop production. Modern agricultural technology has helped to achieve this objective, through the use of mechanised tools and implements, expansion of irrigation facilities and use of agrochemicals such as fertilizers and pesticides. Since most crop fields are in the countryside where farmers live in villages, modern agriculture has had an adverse impact.

Intensive agriculture, which means enhancing crop productivity of the land with the use of agricultural implements and agrochemicals, along with unplanned urbanization, deforestation and industrialization have severely polluted the fresh water bodies and ground water sources.

(1) Runoffs from crop fields carry soil, and chemicals used and pesticides and fertilizers to water sources. This causes eutrophication and algal blooms about which you will have learn in lesson 10. Eutrophication kills aquatic life including fish which are an important source of food for villages.

(2) Excessive irrigation leads to water logging and salinisation of soil (excessive accumulation of salt content in the soil which in turn adversely affects fertility).

(3) Excessive withdrawal of water from wells for irrigation generally deplete ground water in many areas resulting in serious water scarcity. Pollution of lakes, rivers and other water bodies, has deteriorated water quality in many areas leading to acute shortage of safe drinking water. So has continued use of fertilizers and pesticides which pollute ground water sources and deteriorate the water quality.

(4) Soil erosion, caused by the strike of sharp modern agricultural implements causes siltation of rivers. Silt is the mud or soil that gets washed into water bodies as it gets loosened (soil erosion). Siltation of rivers and lakes reduces their water retention capacity and lead to flooding.

(5) Continuous cropping on the same land or on marginal lands for increasing food production leaves no time for soil to revive through the natural processes. Cultivation of mountain slopes also causes soil erosion. All this causes loss of mineral nutrients.

### 8.5.2 Urban life provides facilities as well as difficulties: The Indian context

Urban life has its blessings and curses. India has a population of over 1.2 billion. Lack of opportunities, poverty, conservative life style and orthodoxy force youth from villages to migrate to cities and towns. The comparatively easier modes of travel in developing India today, is another reason for the rural in villages. The job opportunities are limited in villages and youth no longer wish to continue the occupation of their parents and forefathers. With better exposure through radio, television and mobile phones providing easy connectivity young villagers are lured towards cities and towns. Once they reach the cities they encounter both facilities and difficulties. These are listed below:

**Facilities**

(i) Batter job opportunities.

(ii) Urban opportunities to about small bussiness.

(iii) Higher wages even unskilled labour is able to save money for sending home.

(iv) Easy availability of various kinds of goods and consumables.

(v) Better means of transport and communication.

(vi) Easily available electricity and tap water. In villages women have to walk long distances to procure water. Time thus saved provides an opportunity to devote more time to take care of children and adults can earn money through odd jobs.

(vii) Qualified doctors in hospitals and medical facilities are available.

(viii) Better educational facilities for adults and children are available.

**Difficulties**

(i) Lack of greenery and of open spaces.

(ii) Poor air quality. Villages are largely pollution free, while in urban areas, air is polluted due to industries, automobiles, thermal power plants etc.

(iii) Scarcity of water and acute shortage lead to the growth of cheap lead to slums.

(iv) Lack of sanitation and hygiene.

(v) Overcrowding also causes several social problems.

### 8.5.3 Special problems of urban areas: Changes in life style and land availability

Rapid increase of urban population has necessitated expansion of urban limits. The requirements of housing, construction of roads, industries and dams has led to encroachment on agricultural fields and forests. Growing townships invade productive crop fields and luxuriant forests. Concrete buildings come up on agricultural fields, grazing land and deforested areas. Land use changes irreversibly, land is degraded and affecting agricultural fields on the benefit fringes of urban areas.

In most developing nations high rise condominiums (multistoried flats) are surrounded by squatters and neighborhood slums which attracts new migrants to cities but inadequate living space, lack potable water and light, unhygienic conditions from inadequate sanitation and safe waste disposal causes suffering.

Migrants from villages take no time to adopt urban life style which shows up in their manner of dressing up, feeding habits and interaction with others.

## 8.6 INCREASED RESOURCE CONSUMPTION IN URBAN AREAS

As large number of people permanently settle in small areas to form cities and towns, this leads to increase in the consumption of natural resources. Land availability dwindles as buildings for housing purposes come up. Increased water requirement of the growing urban population causes a sharp decline in water availability. Excessive withdrawal of ground water leads to ground water depletion. To meet the growing requirement of water, result is drawn from distant areas thus disturbing the routes of natural water bodies and affecting ecosystems.

## 8.7 WASTE GENERATION IN URBAN AREAS

Urbanization and industrialization produces colossal quantities of waste. Quantity of Solid waste form domestic and industrial sources is growing problem. They may be biodegradable when they may be used for generation of biogas. The nonbiodegradable waste is dumped in land fills.

Liquid wastes such sewage from domestic sector and industrial effluents are usually discharged without any treatment causing pollution of rivers and lakes. Sewage treatment may help but is either lacking or seriously inadequate.

Urbanization leads to economic development. Increasing number of motor vehicles on the road cause air pollution leading to congestion and traffic jams, apart from causing serious problem of air pollution.

With rapid advancing urbanization, there is growing shortage of housing. This has led to formation of large slums which lack basic facilities and infrastructure in cities. In fact, slums represent the worst form of environmental degradation as they not only contribute towards environmental pollution but also suffer from crime social problems. A large slum “Dharavi” in Mumbai is the largest slum in Asia.

## 8.8 SLUMS AND URBAN PLANNING

- Migrant from villages coming to cities in search of jobs are generally poor and landless. After reaching the city, they squat on vacant lands ultimately develops into a slum which are also known as "**Jhuggi Jhonpri**". Slums are a common feature of the cities in developing countries.
- These are self constructed shelters from scrap materials as plastic, wooden planks, bamboos, jute, straw, plywood, bricks and mud etc. Often slums proliferate rapidly in unplanned manner.
- Slums are clusters of huts or homes in parts of cities. Kutcha or pucca houses, built back to back and edge to edge often lack inadequate sun light, or fresh air due to poor ventilation. Usually they are one- room tenements occupied by several inmates.
- Absence of safe disposal of garbage and solid waste, lack of piped water supply and drainages, electricity creates very precarious situation. Slums are squatter settlements.
- Slums suffer from fire hazards particularly during summer due to short circuit and carelessness of residents.

## INTEXT QUESTIONS 8.4

1. What is intensive agriculture?

______________________________

2. State two major problems emerging from use of modern technology in farming.

______________________________

3. What are slums?

______________________________

## WHAT YOU HAVE LEARNT

- Society formation resulted when humans discovered the security that living in a group provides. They discarded the hunting gathering culture and created human settlements.
- Based on size, settlements may be rural and urban.
- Life in cities and towns is urban life.
- There are several factors which push rural fold out of villages and pull or attract them to lead life in cities.
- Social heterogeneity, individualistic life style, voluntary group formation, social mobility and availability of facilities are characteristics of urban life.

- But migration from villages to cities has had social, economic and environmental implications.
- Rural or village settlements have characteristics such as agriculture as vocation, joint family system, caste system.
- Poverty and illiteracy of villages makes them orthodox and superstitions.
- Rural world and urban world differ with regard to environment, occupation, community size, population density, social activities etc.
- Modern technology has reached the farmers living in villages. Intentive agriculture has helped in growing more food but use of chemical fertilizers and pesticides has degraded not only agricultural fields but also environment per se.
- Urban life in India has had is benefits like work opportunist, higher wages, availability of consumables, comfortable day to day living.
- Difficulties of urban life are lack of greenery, air pollution, overcrowding social problems.
- Urbanisation has led to increased environmental resource consumption and excessive waste generation.
- Slums and squatter settlements are a reality in cities. These upset urban planning and have specific environmental and social problems.

## TERMINAL EXERCISE

1. What are the types of human settlements?
2. List the reasons for which humans move from villages to cities.
3. State the differences between rural and urban settlements.
4. What are the facilities that rural youth come across when they migrate to urban areas?
5. Mention the difficulties faced by villagers who migrate to cities.
6. In what ways has the environment been degraded due to modern technology used in agriculture?
7. Justify the following statement: "Urbanization has led to increased resource consumption and waste generations".
8. Write a short article on 'slums'.
9. How has land use undergone changes with progressive urbanization.
10. Write an essay on 'problems of urban living'.

## ANSWER TO INTEXT QUESTIONS

**8.1**

1. It gave them protection from dangers of hunting gathering life/security.
2. (i) Duration of settlement

   (ii) Size

**8.2**

1. Living in cities and towns
2. Poverty/illiteracy/job opportunity/facilities/better social (any other)
3. Social heterogeneity/ lack of social control/voluntary associations/individualism/ any other

**8.3**

1. Living in villages
2. Illiteracy/lack of job opportunities/agriculture only vocation/ superstition/ bonded labour/ any other
3. Bound together by language/ caste system/same vocation/ similar life style/ any other

**8.4**

1. Growing more crops on a small piece of land.
2. Depletion of natural resources/waste generation/ adverse effect of use of chemical fertilizers/chemical pesticides use.
3. Clusters of huts or houses in parts of cities.

# 9

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# DEFORESTATION

In the previous lessons you have learnt about environment, its components and various ecological concepts. You have also acquainted yourself with natural ecosystem and man-made ecosystems. Humans have altered the ecosystems according to their own needs without thinking about the consequences. Their need combined with greed have caused much damage to the environment, which will affect the coming generations. The expansion of agriculture, urbanization and industrialization needed the land which was obtained by large scale clearing of forests. The deforestation has changed the scenario of developed and developing countries, and has brought out vast changes resulting into a various environmental problems. In this lesson you are going to study about deforestation, its causes and effect on environment.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define forest and describe the shrinking of forest cover throughout the world;*
- *explain the various causes of deforestation;*
- *give examples of exploitation of forest resources;*
- *define biodiversity, give reasons for its rapid decline, express concern about the consequences of biodiversity loss;*
- *relate the fast depletion of wildlife and explain the concept of endangered, threatened and exotic species and other forest resources due to deforestation;*
- *describe how deforestation is contributing towards soil erosion, flash floods and change in climate;*
- *describe the impact of deforestation on tribal communities;*
- *define desert and explain the causes of desertification; and give examples of desertification in India;*
- *identify the consequences of desertification.*

## 9.1 FORESTS

Forests are ecological as well as a socio-economic resource. Forests have to be managed judiciously not only because they are source of various products and industrial raw materials but also for environmental protection and various services they provide.

Approximately 1/3$^{rd}$ of the earth's total land area is covered by forests. The forests provide habitat for wildlife, resources such as timber, fire wood, drugs etc. and aesthetic environment. Indirectly, the forests benefit people by protecting watersheds from soil erosion, keeping rivers and reservoirs free of silt, and facilitate the recharging of groundwater. Forest plays an important role in the cycling of carbon, water, nitrogen and other elements.

**What is forest? Forest is a complex ecosystem consisting mainly of trees that support a myriad forms of life.** The trees are the most important component that help to create a unique environment which, in turn, supports various kinds of animals and plants. Trees are the prime producers for the forest, purify and cool the air and control the climate.

Forests may be subdivided into natural forests and plantations or man made forests. Natural forests are forests composed of mainly naturally grown indigenous (local) trees while plantations are forests established by growing trees by humans.

Climate, soil type, topography, and elevation are the main factors that determine the type of forest. Forests are classified according to their nature and composition, the type of climate in which they thrive, and its relationship with the surrounding environment. India has a many types of forests: They range from rain forest of Kerala and North-East to deciduous forests in the plains, mountain forests to alpine pastures of Ladakh and deserts of Rajasthan.

### 9.1.1 Types of Forests

You have already studied the details of the major types of forests in India in lesson- 6.(Recall Fig.6.2 of lesson-6)

### 9.1.2 Importance of Forests

Early life of humans on this planet began as forest dweller. In early days human were totally dependent on forest for food, clothing, and shelter. Even after agriculture was started humans remained dependent upon the forests for several of their needs. The source of fuel wood and provide raw materials to various wood industries. Indian forests also provide many other valuable minor products such as essential oil, medicinal plants, resins, turpentine etc. Forests are renewable resources which provide a wide variety of commodities. Forests satisfying aesthetic needs of humans and have been a source of inspiration for the development of culture and civilization. Forests are home to a very large variety of plants, animals and micro-organisms. This great richness of flora and fauna which has evolved over the years is an important part of nature. Forests provide habitat and food as well as protection to wildlife species against extremes of climate.

Forests have great biological importance as reservoirs of genetic diversity apart from playing an important role in regulating earth's climate.

Forest carry out many important vital functions given in the following tables.

***Table 9.1:*** *Main functions of the forests*

| Functions | Benefits |
|---|---|
| Productive functions | Production of various types of wood, fruits and a wide range of compounds such as resins, alkaloids, essential oil, latex and pharmaceutical substances. |
| Protective functions | Provides habitats for various organisms conservation of soil and water, prevention of drought, shelter against wind, cold, radiation, noise, sounds, smells and sights. |
| Regulative functions | Absorption, storage and release of gases (most importantly carbon dioxide and oxygen), water, minerals, elements and radiant energy. All such functions improve the atmospheric and temperature conditions and enhances the economic and environmental value of the land .Forests also effectively regulate floods and drought and all the biogeochemical cycles. |

- **Timber**

India and other tropical countries have particularly abundant timber and heartwood resources. Timber accounts for 25% of all photosynthetic materials produced on the earth and about half of the total biomass produced by a forest. A large number of trees are commercially exploited for timber in different parts of India. Timber-based industries include plywood manufacture, saw milling, paper and pulp, composite wood, matches, man-made fibres, furniture, sports goods, and particle boards.

- **Medicinal plants**

About 40% of all the drugs used throughout the world have active ingredients extracted from plants and animals. Drugs which are derived from natural compounds amount to at least $40 billion worldwide sales annually. For example quinine is used to treat malaria (from the cinchona tree); *Digitalis* is used to treat chronic heart trouble (from the foxglove plant, *Cinchona* officinalis); and morphine and cocaine are used to reduce pain;drug for leukemia from *Vinca rosea,* taxol from *Taxus brevifolia* etc; and hundreds of life saving antibiotics. In recent years more than 5000 species of flowering plants have been analysed by scientists for the presence of valuable drugs.

Asprin, which is probably the world's most widely used drug was developed according to a chemical "blueprint", from a compound extracted from the leaves of tropical willow trees.

## INTEXT QUESTIONS 9.1

1. Make the list of plants used for medicinal purposes along with the botanical names and the disease for which they are used.

   ______________________________

2. What are the main functions of forests?

   ______________________________

3. List various timber based industries.

   ______________________________

## 9.2 DEFORESTATION

Deforestation is a very broad term, which consists of cutting of trees including repeated lopping, felling, and removal of forest litter, browsing, grazing and trampling of seedlings. It can also be defined as the removal or damage of vegetation in a forest to the extent that it no longer supports its natural flora and fauna.

The rapid rate of deforestation in the tropics is a key driving force in the yearly increase of flood disasters.

Deforestation refers to the loss of tree cover; land that is permanently converted from forest to non-forest uses such as agricultural pasture, desert, and human settlement.

In the beginning of 20th century about 7.0 billion hectares of forests were present over the land of our planet and by 1950 forest covers was reduced to about 4.8 billon. If the present trend continues forests will be reduced to only 2.35 billion ha hectares in 2000 A.D. In a FAQ/UNEP study it was found that about 7.3 million hectares of rich tropical forests every year and about 14 hectare of closed forest every minute are lost.

*Table 9.2:* *Forest cover as per 2001 assessment*

| Class | Area (km²) | Percent of geographic area |
|---|---|---|
| **I. Forest Cover** | | |
| a) Dense | 416,809 | 12.68 |
| b) Open | 258,729 | 7.87 |
| Total Forest Cover* | 675,538 | 20.55 |
| **II. Non-forest** | | |
| Scrub | 47,318 | 1.44 |
| Total Non-forest** | 2,611,725 | 79.45 |
| Total Geographic Area | 3,287,263 | 100.00 |

***includes 4,482 km² under mangroves (0.14 percent of country's geographic area)**
****includes scrub**

**Forest Cover Assessment 2001**

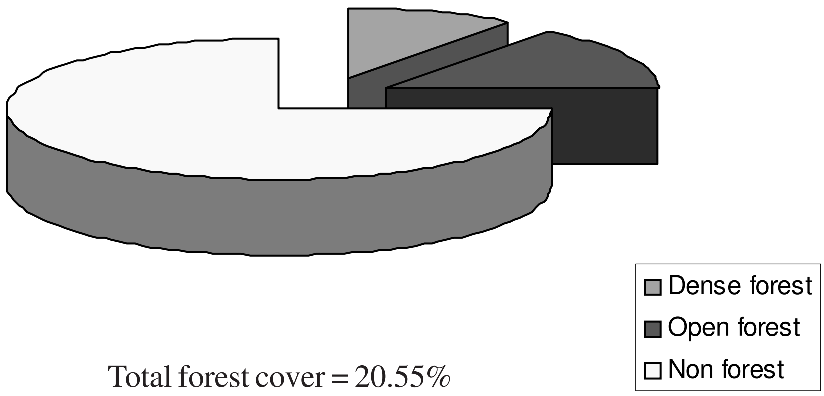


*Fig. 9.1:* *Forest cover in India*

### 9.2.1 Extent of forest loss in India

India is an agricultural country. The country is losing its forest cover steadily because of clearing forests of is done for agricultural purpose, cattle grazing and plantation crops such as tea, coffee etc.

Deforestation is one of the most serious and widespread environmental problems which India is facing. In India surveys conducted in early seventies and found a forest cover of about 22.7%only instead of 33% considered desirable according to "National. Forest Policy".

Soon after independence, rapid development and progress saw large forest tracts fragmented by roads, canals, and townships. There was an increase in the exploitation of forest wealth. In 1950 the Government of India began the annual festival of tree planting called the Vanamahotsava. Gujarat was the first state to implement it. However, it was only in the 1970s that greater impetus was given to the conservation of India's forests and wildlife. India was one of the first countries in the world to have introduced a social forestry programme to introduce trees in non-forested areas along road sides, canals, and railway lines.

## 9.3 CAUSES OF DEFORESTATION

The most common reason for deforestation is cutting of wood for fuel, lumber and paper. Another important cause relates to the clearing of forest land for agriculture, including conversion to crop land and pasture (Fig. 9.2).

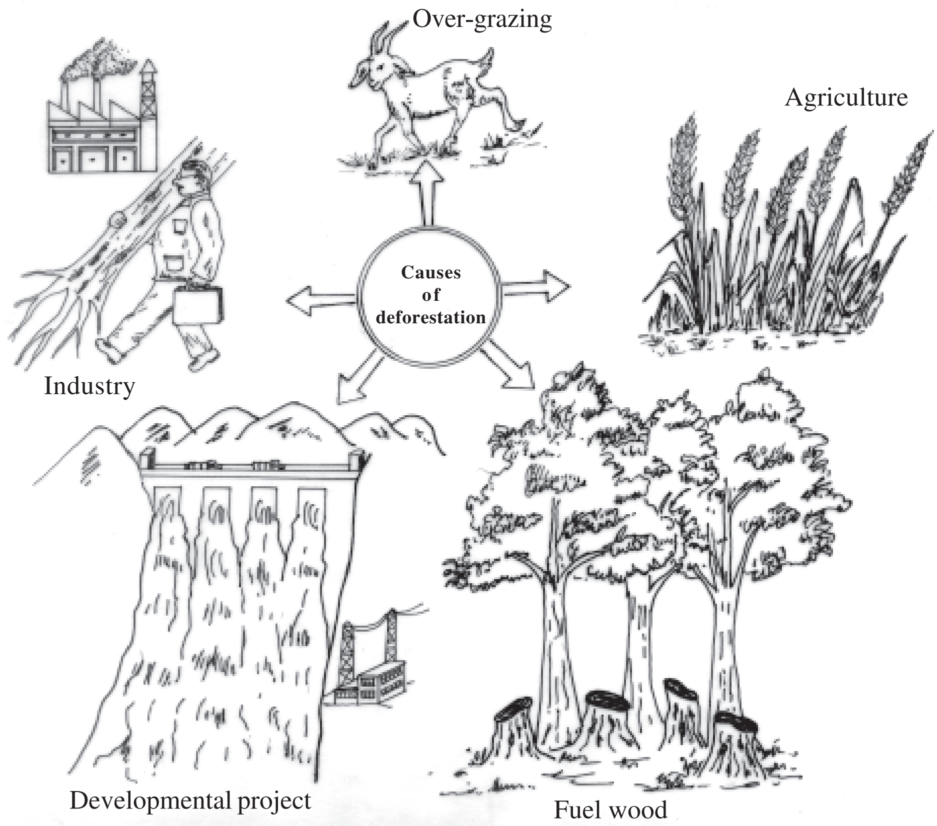


*Fig. 9.2: Various causes of deforestation*

The main causes of deforestation are:

- agriculture;
- shifting cultivation;

- demand for firewood;
- demand of wood for industry and commercial purposes;
- urbanization and developmental projects;
- other causes.

### (1) Agriculture

The expanding agriculture is one of the most important causes of deforestation. Man has always modified the natural ecosystems in such a way that environment becomes more favourable for crop growth whether using traditional or modern methods of agriculture. As demands for agricultural products rises, more and more land is brought under cultivation and for that more forests are cleared, grasslands and even marshes, and lands under water are reclaimed. Thus there is much more ecological destruction than gain in term of crop yield. The forest soil after clearing are unable to support farming for long periods due to exhaustion of nutrients. Once the soils become unfit for cultivation, the area suffers from to soil erosion and degradation.

### (2) Shifting cultivation

Hunting and gathering has been the main form of sustenance practiced in the earlier periods of human history. Shifting cultivation or Jhoom farming is a 12000-year old practice and a step towards transition from food collection to food production. It is also known as **slash-and-burn method of farming.** Annually about 5 lakhs ha (hectares) of forest is cleared for this type of farming. In this type of cultivation there is a limited use of tools with not very high level of mechanization. However, this method of cultivation causes extreme deforestation, as after 2-3 years of tilling, the land is left to the mercy of nature to recover. This type of cultivation was always meant to fulfil local needs or onsite demands to meet the requirements of the cultivating villagers. Even today, shifting cultivation is practiced in the states of Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Andaman and Nicobar Islands.

### (3) Demand for firewood

Firewood has been used as a source of energy for cooking, heating etc. Almost 44% of the total global wood produced fulfils the fuel requirements of the world. Close look at the pattern of utilization of wood produced will show that the developed countries utilize 16% of their share for fuel requirements. India consumes nearly 135-170 Mt (Million tonnes) of firewood annually and 10-15 ha of forest cover is being stripped off to meet the minimum fuel needs of urban and rural poor.

***Table 9.3:*** *Use of wood*

| Region | Total wood consumption (in billion $m^3$) | Wood use (in billion $m^3$) | | Wood use (%) | |
|---|---|---|---|---|---|
| | | Industrial | Firewood | Industrial | Firewood |
| Global | 3.2 | 1.5 | 1.7 | 46 | 54 |
| Developing countries | 1.8 (57%) | 0.324 | 1.476 | 18 | 82 |
| Developed countries | 1.4 (43%) | 1.176 | 0.224 | 84 | 16 |

**(4) Wood for industry and commercial use**

Wood, the versatile forest produce, is used for several industrial purposes, such as making crates, packing cases, furniture, match boxes, wooden boxes, paper and pulp, plywood, etc. 1.24 lakh ha of forest have been cut for various industrial uses. Unrestricted exploitation of timber as well as other wood products for commercial purposes is the main cause of forest degradation. The paper industry accounts for about 2% of country's annual consumption of wood and 51% this requirement is met by bamboo wood. This has led to the depletion of bamboo stocks in most of the peninsular India. For example the apple industry in the Himalayan region has led to the destruction of fir and other tree species, for making wooden boxes used for transporting apples. Similarly, plywood crates were used for packing particularly tea and other produce.

**(5) Urbanisation and developmental projects**

Often urbanisation and developmental activities lead to deforestation. The process of deforestation begins with building of infrastructure in the form of roads, railway lines, building of dams, townships, electric supply etc. Thermal power plants, mining for coal, metal ores and minerals are also important causes of deforestation.

Nowadays you must have heard about the Tehri power project which is a 260.5m high earth and rock fill dam near the Tehri town in Garhwal Himalayas. The project site is situated a little downstream the junction of Bhagirathi and Bhilganga rivers. An estimated 4,600 ha of good forest land will be submerged under water. This has displaced an estimated 3,500 odd families.

**(6) Other causes**

Recent developments everywhere in world have caused large scale environmental degradation, especially in tropical forest areas. The large amounts of resources –living and nonliving (minerals, river, land) found in these forests have attracted both industry and other developmental agencies, which have severely depleted forest cover.

Forests may sometimes suffer from natural calamities such as overgrazing, floods, forest fires, diseases and termite attack.

## 9.4 FORESTS AND TRIBAL SOCIETY

About 4% the world's population lives in special territories .These indigenous or tribal people have claims on a particular place; they have cultural, spiritual and economic ties with the particular area and in most cases they have ability to manage the area and sustain it. In this way they protect the biodiversity of that particular area and the local culture, including knowledge and resource-management skills of the local community.

For example, the tribal people knew the agricultural practices which were ecologically sound and these were passed from generation to generation for many centuries. They knew how to grow different kinds of food and fibre crops simultaneously on the same plots and keep the land productive for several years in a row, and then plots were left to recover for several years to grow back into forests, before clearing the area again to begin the cycle afresh.

> In India the tribal populations constitute about 7% of the Indian population. They live in some 450Communities or tribal units of different sizes.

## INTEXT QUESTIONS 9.2

1. List the causes for deforestation.

   ______________________________

2. Where is Tehri power project?

   ______________________________

3. List the names of the Indian states, where shifting cultivation is still practised.

   ______________________________

4. Give reasons how the tribal communities were able to live in forest without harming it.

   ______________________________

5. What percentage of total wood produced in developing countries is utilized for fuel requirement? (Refer to table 9.3).

   ______________________________

## 9.5 CONSEQUENCES OF DEFORESTATION

Deforestation affects both physical and biological components of the environment.

- Soil erosion and flash flood
- Climatic change
- Loss of biodiversity

(1) **Soil erosion and flash flood**

A shrinking forest cover coupled with over exploitation of ground water has accelerated erosion along the slopes of the lower Himalayas and Aravali hills, making them prone to landslides. Destruction of the forests has altered rainfall pattern. In 1978 India suffered some of the worst flooding in its history. There was two days of heavy rainfall and 66,000 villages were inundated, 2,000 people drowned, and 40,000 cattle were swept away. In 2008 Bihar state suffered worst flood in the river kosi. Several lives were lost and a huge number of cattle were swept away. Lack of forest cover has resulted in water flowing off the ground, washing away the top soil which is finally deposited as silt in the river beds. Forests check soil-erosion, landslides and reduce intensity of flood and drought.

| |
|---|
| The loss of top soil is in India, is 18.5% of the global soil loss. This is indeed very serious, considering the fact that India has only 2.4% of the land area of the world. |

(2) **Climatic change**

Forests enhance local precipitation and improve water holding capacity of soil, regulate water cycle, maintain soil fertility by returning the nutrients to the soil through leaf fall and decomposition of litter. Forests check soil-erosion, landslides and reduce intensity of flood and droughts. Forests, being home of wildlife are important assets of aesthetic, touristic and cultural value to the society.

Forests have profound effect on the climate. Forest absorbed carbon dioxide from the atmosphere and help in balancing carbon dioxide and oxygen in the atmosphere. The forests play a vital role in maintaining oxygen supply in the air, we breathe. They also play a vital role in the regulation of water (water cycle) in the environment and act as environmental buffers regulating climate and atmospheric humidity.

Heat build-up in the atmosphere is one of the important problems of the century known as **green house effect** is the partly caused by the result from deforestation**.** The entire Himalayan ecosystem is threatened and is under severe imbalance as snow –line has thinned and perennial springs have dried up. Annual rainfall has declined by 3 to 4%. Chronic droughts have begun even in areas like Tamilnadu and Himanchal Pradesh where they were not known earlier.

(3) **Biodiversity**

"Biodiversity" include all variety of life forms. Biodiversity - (biological diversity) is a measure of variation, the number of different varieties, among living things. Biodiversity can be expressed in number of ways, which includes the number of genetic strains (differences) within species and the number of different ecosystem in an area. The most common expression of biodiversity is the number of different species, within a particular area (local biodiversity), or in a specific habitat (habitat biodiversity) or in the world (global biodiversity). Biodiversity is not static. It changes over the time during evolution new species have come up while some species become extinct.

Our knowledge is incomplete at the global level; nearly 1.4 million species have been identified. Different species inhabiting the earth have been estimated to vary between 10 and 100 million. There is lot of concern about preserving biodiversity. You will study more about biodiversity conservation in **lesson 15**. The one good reason for preserving biodiversity is that it provides wide variety of products for human use and welfare. It is a great potential resource for agriculture, medicine and industry.

There are several **causes** for biodiversity loss:-

- hunting, poaching and commercial exploitation.
- elimination and disturbance of wildlife habitats.
- selective destruction of habitat/ life forms.
- domestication.
- introduction of new alian species in new area which threaten the indigenous species.
- use of pesticides.
- pests, medical research and zoos.

All the above factors adversely affect biodiversity.

### 9.5.1 Extinct species

Ultimate fate of every species is extinction but after industrialization this rate has increased tremendously. The extinct species only exist in museums and photographs. The most noted example of extinct species is passenger pigeon.

**• Threatened species**

Several plant and animal species are threatened by the possibility of being on the verge of extinction but the seriousness of this threat varies. International Union of Conservation of Nature (IUCN) has categorized threatened species into four categories which are:

(i) **Endangered** A species is considered endangered when its numbers are few and its homeland is very small, or both and if special protection is not given it may become extinct .for example the lion –tailed monkey from rain forests and Sholas of south India.

(ii) **Rare** These are those species whose number is few or they live in such small areas or such unusual environment (endemics), that they could quickly disappear.The Great Indian Bustard (*Ardeotis nigriceps* ) is an example of rare species of India. (Fig. 9.3)

(iii) **Depleted** These are the species whose numbers are greatly reduced from those of the recent past, and they are continuing to decrease. It is the continued decrease, which is the main cause of concern. Animals/ plant in this category can quickly change to a rare or endangered category. In the past few years, the fur of the clouded leopard (*Neofelis nebulosa*) was sold illegally in Kashmir markets.

**(iv) Indeterminate** Those species that seem to be in danger of extinction but their true information regarding their status is not known are the indeterminate species. The snow leopard (*Leo uncia*) was classified as indeterminate species in 1968, and was declared endangered in 1970. You probably know that the snow leopard is hunted for its thick beautiful fur.

***Fig. 9.3:*** *Great Indian bustard*

### 9.5.2 Loss of wild life

Over the past 2000 years, 600 species of animals have become extinct or are going to be extinct from the earth. Similarly, about 3000 species of plants need to be conserved. The shrinkage of green cover has adverse effects on the stability of the ecosystem. Poaching is another factor causing depletion of wildlife. The roll call of victims is endless. In Africa, in recent years, nearly 95 per cent of the black rhino population has been exterminated by poachers for their horns and over one third of Africa's elephants have been wiped out for ivory. The scarlet macaw once common throughout South America has been eliminated from most of its range in Central America. Several species of spotted cats such as the ocelot and jaguar are in danger of extinction due to demand of their fur.

### 9.5.3 Loss of wildlife in India

India has nearly 45,000 species of plants and 75,000 species of animals. This biological diversity ought to be preserved for maintaining stability of ecosystems. Deforestation coupled with desertification has destroyed the natural treasure of the earth to a large extent.

The population of elephant, lion and tiger is fast diminishing. 'Cheetah' is already extinct. Elephants once found all over India have now disappeared from Andhra Pradesh, Madhya Pradesh and Maharashtra. The Asiatic lion which was very common in Asia has practically vanished from Asia except for a few hundred sq km (square kilometer) of Gir forest in India.

In India four species of mammals and three species of birds have been extinct in the last 100 years. Another 40 species of mammals, 20 species of birds and 12 species of reptiles are considered highly endangered due to overexploitations, of forests.

## INTEXT QUESTIONS 9.3

1. Name an endangered species in India.

2. List the main causes for the depletion of wild life.

3. Name the mammal that is already extinct from India.

4. Name the mammal that was once common in Asia is now found in few hundred kilometer at Gir forest in India?

5. Define biological diversity.

## 9.6 DESERTIFICATION

What is desertification? It can be defined as **'the diminution or destruction of the biological potential of the land which can ultimately lead to desert like conditions'.**

The arid and semi-arid areas where climate is dry, restoration is very slow, mining and overgrazing etc. adds to several other desertification pressures. Desertification is a systemic phenomenon resulting from excessive felling of trees which manifests itself in the loss of soil fertility, high wind velocity, low precipitation, increasing aridity and extremes of temperatures in the affected area.(Fig.9.4)

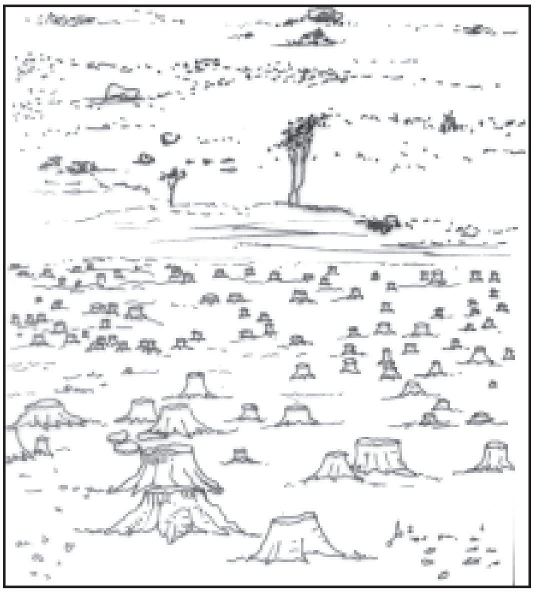

***Fig. 9.4:*** *Excessive felling of trees leads to desertification*

Desert supports very little of vegetation and animals which are especially adapted to extremely unfavorable conditions. Although desertification can develop from natural causes alone, in a majority of instances human intervention promoted arid conditions in an already dry areas. This can happen in any climatic zone or ecosystem, resulting from exploitative interaction of man with the natural ecosystem. Most of the deserts of recent origin have resulted form any one or more of the following human activities.

(i) Uncontrolled and overexploitation of grazing land, indiscriminate cutting of trees and forest resources leading to drought, soil erosion, deterioration of soil fertility which results in stunted plant growth.

(ii) Excessive mining in arid and semi-arid regions for extraction of minerals, coal or limestone resulting in loss of trees, and green cover, and leading to total destruction of conditions conducive to vegetation growing.

(iii) Uneconomic land use for agriculture by cultivation on marginal lands affecting adjacent fertile lands and causing soil erosion.

(iv) Intensive and uneconomic exploitation of water resources leading to fall in water table, seepage and problems of excessive salinisation of soil.

***Table 9.4:*** *Extent and causes of land degradation of the world*

| **Area** | **Causes of land degradation** |
|---|---|
| 580 million ha | **Deforestation --** Vast reserves of forests have been degraded by large scale logging and clearance for farm and urban use. More than 200 million ha of tropical forests were destroyed mainly for food production. |
| 680 million ha | **Overgrazing** – About 20% of the world's pasture and range lands have been damaged. Recent losses have been most severe in Africa and Asia. |
| 137 million ha | **Fuel wood consumption** – About 1730 million $m^3$ of fuel wood are harvested annually from forests and plantations. Wood fuel is the primary source of energy in many developing regions. |
| 550 million ha | **Agricultural mismanagement** – Loss of soil due to water erosion is estimated at 25,000 million tonnes annually. Soil salinization, water logging, chemical degradation and desertification affect about 40 million ha of land globally. |
| 19.5 million ha | **Industrialization and urbanization** – Urban growth, road construction, mining and industry are major factors in land degradation in different regions. Valuable agricultural land is often lost. |

### 9.6.1 Extent of desertification

About 76.15% of the total Indian desert area has resulted from manmade desertification process. Another 19.5% of the total area is subjected to medium or slight desertification. This area is concentrated mostly along the eastern Rajasthan in the north-east to south-west zone parallel to the foothills of Aravalis.

Most of the deserts, in India are found in the states of Rajasthan and Western Gujarat, where about 23.8 mha area has been affected by desertification. About 4.34% of this area lies in the extreme West of Rajasthan in Jaisalmer district. This desert is concentrated along a belt in Ganganagar, Churu, Bikaner, Jaisalmer, Barmer, Jodhpur, Jalore, Jhunjhunu and Nagaur districts. The predominant processes of desertification in this belt are the expansion of sand cover and shifting sand dunes by wind erosion.

**Natural desertification**

In the Asia and pacific region an area of about 4.361 lakhs ha has resulted from natural desertification. These areas can be classified as subtropical, cool coastal, rain shadow and interior continental deserts. Besides these, Polar regions of the world also represent a type of desert, where water is no doubt present in plenty, but being in the form of ice, it is not available for plants and animals. The Gobi desert of north western Asia is a cold desert. The Ladakh region of Jammu and Kashmir covering an area of 0.7 lakh sq. km. and located at an altitude of about 11,000 feet where extreme cold conditions prevail for about 5-6 months in a year, is also a cold desert.

### 9.6.2 Thar Desert—A case study

The Thar Desert exhibited spectacular biological diversity because of its evolutionary history and geographical location. This is a extensive region of sandy desert in northwestern India and eastern Pakistan. The Thar Desert is about 805 km long and about 485 km wide. Rainfall is sparse averaging from 127 to 254 mm annually and temperature rises as high as 52.8°C in July.

**(i) Plants**

Ecologically, vegetation of the major part of Thar Desert region falls under the category of ‘thorn forest type’. However, the natural vegetation cover has become progressively transformed due to prolonged and intense human interference. Nevertheless, natural vegetation makes a substantial contribution to the productivity of trees like **Khejri** which are highly valued and conscientiously maintained. There are as many as 700 species of plants amongst which grasses alone account for 107 species. Large-scale destruction of natural vegetation from this part of the country is due to heavy pressure of overgrazing by livestock, making regeneration of plants process in the desert very difficult.

Human activities and - more fundamental - underlying structural factors and material processes in our society are causing species to vanish at a rate unequalled since the doomsdays of the dinosaur. There's no time to waste. We must protect biodiversity now, for our next generation.

**(ii) Animals**

Thar desert is fascinating. The Asiatic lion, used to inhabit the plains of Rajasthan, Punjab and Sind in the recent past. It is on record that the last lions occurring in the desert were shot during 1976. The cheetah now extinct in India was at one time found in the Kathiawad region. Similarly, leopards and caracal lynx, the wild boar, wild ass, Asiatic wolf, etc. have also met the same fate. Among other mammalian fauna, Indian gazelle, blue bull and black buck are also in the list of endangered animal species.

Predominant bird species are also very scanty, particularly in sandy habitats of western Rajasthan. The great Indian bustard, houbara, and lesser florican populations in the Thar Desert are dwindling as compared to that in the recent past. Pea-fowl, being a national bird, is well protected by people.

Among reptiles, two species of crocodiles and turtles are now restricted to Jawai-dam in Sirohi district at the foot hills of Aravali. The large terrestrial reptile, the rock python found on the foothills of Aravali is also vanishing from the desert.

Thus, looking at the past history of Thar desert, a large number of animals are at the verge of extinction and some .have vanished.

## INTEXT QUESTIONS 9.4

1. What is 'desertification'?

   ______________________________

2. List any three human activities that have resulted into desert formation.

   ______________________________

3. Name the two states where most of the deserts found in India.

   ______________________________

4. Name a mammal, a bird and a plant that were once found in large numbers in thar desert but are now in the list of endangered species.

   ______________________________

## WHAT YOU HAVE LEARNT

- Forests are the backbone of the life forms and the life on earth is sustained through them.
- There are three major functions of the forests i) productive functions .ii) protective functions iii) regulative functions.
- Timber and several models obtained from plants for medicine are still provided by forests.
- Tribal people totally depended on forests for food, shelter and clothing; in turn they also conserve the forests.
- Deforestation of forests is caused due to shifting cultivation, demand for timber, for paper and pulp, commercial wood and fire wood, and mining operations.
- Deforestation also causes soil erosion and floods, climatic changes, loss of wild life.
- Loss of biodiversity during deforestation is immense because several unknown species of biota is lost forever from our planet earth.
- Extinct species are those that were unable to survive in the changed environment and thus perished.
- Threatened species are likely to become extinct if their environment deteriorates further, endangered species are few in number and their homeland is very small and any deterioration in environment can make them extinct.
- Depleted species are those whose number have decreased in the recent years and are continuing to decrease. Indeterminate species are those species whose status is not known due to lack of information.
- Desertification is a natural phenomenon but it is often accelerated by human activities. they are uncontrolled grazing, indiscriminate cutting of forests, excessive mining, uneconomic use of agriculture land, exploitation of water resources.
- Deforestation and desertification are two interlinked problems which have arisen from the overexploitation of natural resources through human activities causing irreparable damage to earth.

## TERMINAL EXERCISE

1. Write any three functions of the forest, which function you think, is the most important and why?
2. Discuss why deforestation is one of the most important factors for wild life loss in the whole world.

3. Match the definition of words given in column A with column B

| Column A | | Column B |
|---|---|---|
| (a) Rare species | i) | A species is considered endangered when its numbers are few and its homeland is very small, or both and if special protection is not given it may become extinct |
| (b) Indeterminate species | ii) | These are those species whose number is few or they live in such small areas or such unusual environment (endemics), that they could quickly disappear. |
| (c) Endangered species | iii) | These are the species whose numbers are greatly reduced from those of the recent past, and they are continuing to decrease. |
| (d) Depleted species | iv) | Those species that seem to be in danger. |

4. Make a project on 'habitat destruction and wild life loss' by giving at least example of five animal species and five plant species, try to give photograph/drawing of the species.
5. Make a list of extinct animal and plant species from India by going through various books and magazine.
6. 'The development projects have harmed the tribal society the most' give your views on the above given statement.
7. Discuss "deforestation results in desertification".
8. Write an essay on the importance of forest in human life. Support your answer with diagram.

## ANSWER TO INTEXT QUESTIONS

**9.1**

1.

| | Plant | Medicinal use |
|---|---|---|
| a. | *Cinchona Officinalis* | Treatment of malaria |
| b. | *Dititalis purspusla* | Treatment of chronic heart disease |
| c. | *Vinca rosea* | Treatment of cancer |
| d. | *Taxus brevifolia* | Treatment of cancer |

2. Protective function, productive function and regulative function.
3. Plywood manufacture, saw milling, paper and pulp, composite word, Matches, Man made fibres, furniture, sport goods and particle boards.

**9.2**

1. Agriculture, shifting cultivation, demand for fire wood and timber, development projects requiring land and raw materials.
2. Near Tehri town, at the junction of Bhagirathi and Bhilganga.
3. Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Andman and Nicobar Islands.
4. Tribal people used ecologically sound agricultural practices and the knowledge of such practices were passed on to the next generations for centuries.
    - they grew multiple crops simultaneously for some years and then plots were left to recover and grew back into forests
    - they have cultural and economic ties with the forest they live in and have the ability to sustain it and protect it.
5. 82%

**9.3**

1. Lion tailed monkey
2. Commercial exploitation
    - Introduction of exotic species
    - Habitat loss/ disturbance in habitat
    - Domestication
    - Use of pesticides
3. Cheetah
4. Asiatic Lion
5. All forms of life including plants, animals and micro organisms in nature constitute biological diversity.

**9.4**

1. Destruction of the *biological potential* of the land which can lead to desert like conditions.
2. Over exploitation/ uncontrolled grazing/ indiscriminate felling of trees / intensive and uneconomic exploitation of water resource leading to fall in water table/ uneconomic land use for agriculture. (Any three)
3. Rajasthan and Gujarat
4. Wild boar/wild ass – Mammal

    Great Indian bustard – Bird

    Kehjri – Plant

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# 10

# ENVIRONMENTAL POLLUTION

Developmental activities such as construction, transportation and manufacturing not only deplete the natural resources but also produce large amount of wastes that leads to pollution of air, water, soil, and oceans; global warming and acid rains. Untreated or improperly treated waste is a major cause of pollution of rivers and environmental degradation causing ill health and loss of crop productivity. In this lesson you will study about the major causes of pollution, their effects on our environment and the various measures that can be taken to control such pollutions.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define the terms pollution and pollutants;*
- *list various kinds of pollution;*
- *describe types of pollution, sources, harmful effects on human health and control of air pollution, indoor air pollution, noise pollution;*
- *describe water pollution, its causes and control;*
- *describe thermal pollution;*
- *describe soil pollution, its causes and control;*
- *describe radiation pollution, sources and hazards.*

## 10.1 POLLUTION AND POLLUTANTS

Human activities directly or indirectly affect the environment adversely. A stone crusher adds a lot of suspended particulate matter and noise into the atmosphere. Automobiles emit from their tail pipes oxides of nitrogen, sulphur dioxide, carbon dioxide, carbon monoxide and a complex mixture of unburnt hydrocarbons and black soot which pollute the atmosphere. Domestic sewage and run off from agricultural fields, laden with pesticides and fertilizers, pollute water bodies. Effluents from tanneries contain many harmful chemicals and emit foul smell. These are only a few examples which show how human activities pollute the environment. **Pollution** may be defined as addition of undesirable material into the environment as a result of human activities. The agents which cause environmental pollution are called **pollutants**. A pollutants may be defined as a physical, chemical or biological substance unintentionally released into the environment which is directly or indirectly harmful to humans and other living organisms.

## 10.2 TYPES OF POLLUTION

Pollution may be of the following types:

- Air pollution
- Noise pollution
- Water pollution
- Soil pollution
- Thermal pollution
- Radiation pollution

## 10.3 AIR POLLUTION

Air pollution is a result of industrial and certain domestic activity. An ever increasing use of fossil fuels in power plants, industries, transportation, mining, construction of buildings, stone quarries had led to air pollution. **Air pollution** may be defined as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere in such concentration that may be directly and indirectly injurious to humans or other living organisms, plants, property or interferes with the normal environmental processes. Air pollutants are of two types (1) suspended particulate matter, and (2) gaseous pollutants like carbon dioxide ($CO_2$), NOx etc. Some of the major air pollutants, their sources and effects are given in table 10.1.

***Table 10.1:*** *Particulate air pollutants, their sources and effects*

| Pollutant | Sources | Effects |
|---|---|---|
| Suspended particulate matter/dust | Smoke from domestic, industrial and vehicular soot | Depends on specific composition Reduces sunlight and visibility, increases corrosion, Pneumoconiosis, asthma, cancer, and other lung diseases. |
| Fly ash | Part of smoke released from chimneys of factories and power plants | Settles down on vegetation, houses. Adds to the suspended participate matter (SPM) in the air. Leachates contain harmful material |

### 10.3.1 Particulate pollutants

Particulate matter suspended in air are dust and soot released from the industrial chimneys. Their size ranges from 0.001 to 500 μm in diameter. Particles less than 10μm float and move freely with the air current. Particles which are more than 10μm in diameter settle down. Particles less than 0.02 μm form persisent aerosols. Major source of SPM (suspended particulate matter) are vehicles, power plants, construction activities, oil refinery, railway yard, market place, industries, etc.

- **Fly ash**

Fly ash is ejected mostly by thermal power plants as by products of coal burning operations. Fly ash pollutes air and water and may cause heavy metal pollution in water bodies. Fly ash affects vegetation as a result of its direct deposition on leaf surfaces or indirectly through its deposition on soil. Fly ash is now being used for making bricks and as a land fill material.

- **Lead and other metals particles**

Tetraethyl lead (TEL) is used as an anti-knock agent in petrol for smooth and easy running of vehicles. The lead particles coming out from the exhaust pipes of vehicles is mixed with air. If inhaled it produces injurious effects on kidney and liver and interferes with development of red blood cells. Lead mixed with water and food can create cumulative poisoning. It has long term effects on children as it lowers intelligence.

Oxides of iron, aluminum, manganese, magnesium, zinc and other metals have adverse effect due to deposition of dust on plants during mining operations and metallurgical processes. They create physiological, biochemical and developmental disorders in plants and also contribute towards reproductive failure in plants.

***Table 10.2:*** *Annual average concentration of pollutants in ambient air in residential and industrial areas (year 2000) mg/m$^3$ in 24 hours*

SPM permissible- residential 140 – 200 mg/m$^3$, industrial 360 – 500 mg/m$^3$

| City | Residential area | Industrial area |
|---|---|---|
| Agra | 349 | 388 |
| Bhopal | 185 | 160 |
| Delhi | 368 | 372 |
| Kanpur | 348 | 444 |
| Kolkata | 218 | 405 |
| Nagpur | 140 | 157 |

### 10.3.2 Gaseous pollutants

Power plants, industries, different types of vehicles – both private and commercial use petrol, diesel as fuel and release **gaseous pollutants** such as carbon dioxide, oxides of nitrogen and sulphur dioxide along with particulate matter in the form of smoke. All of these have harmful effects on plants and humans. Table 10.3 lists some of these pollutants, their sources and harmful effects.

***Table 10.3:*** *Gaseous air pollutants: their sources and effects*

| Pollutant | Source | Harmful effect |
|---|---|---|
| Carbon compound ($CO$ and $CO_2$) | Automobile exhaust burning of wood and coal | • Respiratory problems<br>• Green house effect |
| Sulphur compounds ($SO_2$ and $H_2S$) | Power plants and refineries volcanic eruptions | • Respiratory problems in humans<br>• Loss of chlorophyll in plants (chlorosis)<br>• Acid rain |
| Nitrogen Compound ($NO$ and $N_2O$) | Motor vehicle exhaust atmospheric reaction | • Irritation in eyes and lungs<br>• Low productivity in plants<br>• Acid rain damages material (metals and stone) |
| Hydrocarbons (benzene, ethylene) | Automobiles and petroleum industries | • Respiratory problem<br>• Cancer causing properties |
| SPM (Suspended Particulate Matter) (Any soild and liquid) particles suspended in the air, (flush, dust, lead) | Thermal power plants, Construction activities, metalurgical processes and automobiles | • Poor visibility, breathing problems<br>• Lead interfers with the development of red blood diseases and cancer.<br>• Smoge (skoke & fog) formation leads to poor visibility and aggravates asthma in patients |
| Fibres (Cotton, wool) | Textiles and carpet weaving industries | • Lung disorders |

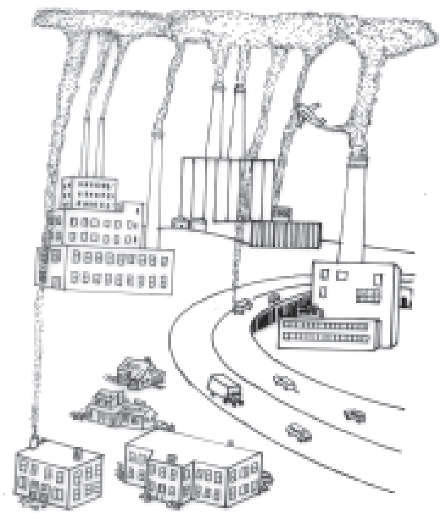

***Fig. 10.1:*** *A chimney billowing smoke- Diesel vehicle ( bus/truck) showing exhaust smoke*

### 10.3.3 Prevention and control of air pollution

**(i) Indoor air pollution**

Poor ventilation due to faulty design of buildings leads to pollution of the confined space. Paints, carpets, furniture, etc. in rooms may give out volatile organic compounds (VOCs). Use of disinfectants, fumigants, etc. may release hazardous gases. In hospitals, pathogens present in waste remain in the air in the form of spores. This can result in hospital acquired infections and is an occupational health hazard. In congested areas, slums and rural areas burning of firewood and biomass results in lot of smoke. Children and ladies exposed to smoke may suffer from acute respiratory problems which include running nose, cough, sore throat, lung infection, asthama, difficulty in breathing, noisy respiration and wheezing.

**(ii) Prevention and control of indoor air pollution**

Use of wood and dung cakes should be replaced by cleaner fuels such as biogas, kerosene or electricity. But supply of electricity is limited. Similarly kerosene is also limited. Improved stoves for looking like smokeless chullahs have high thermal efficiency and reduced emission of pollutants including smoke. The house designs should incorporate a well ventilated kitchen. Use of biogas and CNG (Compressed Natural Gas) need to be encouraged. Those species of trees such as baval (*Acacia nilotica*) which are least smoky should be planted and used. Charcoal is a comparatively cleaner fuel. Indoor pollution due to decay of exposed kitchen waste can be reduced by covering the waste properly. Segregation of waste, pretreatment at source, sterilization of rooms will help in checking indoor air pollution.

**(iii) Prevention and control of industrial pollution**

Industrial pollution can be greatly reduced by:

(a) use of cleaner fuels such as liquefied natural gas (LNG) in power plants, fertilizer plants etc. which is cheaper in addition to being environmentally friendly.

(b) employing environment friendly industrial processes so that emission of pollutants and hazardous waste is minimized.

(c) installing devices which reduce release of pollutants. Devices like filters, electrostatic precipitators, inertial collectors, scrubbers, gravel bed filters or dry scrubbers are described below:

(i) **Filters –** Filters remove particulate matter from the gas stream. The medium of a filter may be made of fibrous materials like cloth, granular material like sand, a rigid material like screen, or any mat like felt pad. Baghouse filtration system is the most common one and is made of cotton or synthetic fibres ( for low temperatures) or glass cloth fabrics (for higher temperature up to 290$^o$C).

(ii) **Electrostatic precipitators (ESP)-** The emanating dust is charged with ions and the ionized particulate matter is collected on an oppositely charged surface. The particles are removed from the collection surface by occasional shaking or by rapping the surface. ESPs are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc.

(iii) **Inertial collectors –** It works on the principle that inertia of SPM in a gas is higher than its solvent and as inertia is a function of the mass of the particulate matter this device collects heavier particles more efficiently. 'Cyclone' is a common inertial collector used in gas cleaning plants.

(iv) **Scrubbers** – Scrubbers are wet collectors. They remove aerosols from a stream of gas either by collecting wet particles on a surface followed by their removal, or else the particles are wetted by a scrubbing liquid. The particles get trapped as they travel from supporting gaseous medium across the interface to the liquid scrubbing medium.

Gaseous pollutants can be removed by absorption in a liquid using a wet scrubber and depends on the type of the gas to be removed e.g. for removal of sulphur dioxide alkaline solution is needed as it dissolves sulphur dioxide. Gaseous pollutants may be absorbed on an activated solid surface like silica gel, alumina, carbon, etc. Silica gel can remove water vapour. Condensation allows the recovery of many by products in coal and petroleum processing industries from their liquid effluents.

Apart from the use of above mentioned devices, other control measures are-

- increasing the height of chimneys.
- closing industries which pollute the environment.
- shifting of polluting industries away from cities and heavily populated areas.
- development and maintenance of green belt of adequate width.

**(iv) Control of vehicular pollution**

- The emission standards for automobiles have been set which if followed will reduce the pollution. Standards have been set for the durability of catalytic converters which reduce vehicular emission.
- In cities like Delhi, motor vehicles need to obtain Pollution Under Control (PUC) certificate at regular intervals. This ensures that levels of pollutants emitted from vehicle exhaust are not beyond the prescribed legal limits.
- The price of diesel is much cheaper than petrol which promotes use of diesel. To reduce emission of sulphurdioxide, sulphur content in diesel has been reduced to 0.05%.
- Earlier lead in the form of tetraethyl lead was added in the petrol to raise octane level for smooth running of engines. Addition of lead in petrol has been banned to prevent emission of lead particles with the vehicular emission.

Alternate fuels like CNG is being encouraged for use in public transport vehicles.

## INTEXT QUESTIONS 10.1

1. Define pollutant and pollution.

2. Name any three devices that control pollution.

3. State two means of controlling indoor air pollution.

4. What is a PUC certificate?

## 10.4 OZONE HOLE-CAUSES AND HARM DUE TO OZONE DEPLETION

The stratosphere has an ozone layer which protects the earth's surface from excessive ultraviolet (UV) radiation from the Sun. Chlorine from chemicals such as chlorofluorocarbons (CFCs) used for refrigeration, air conditioning, fire extinguishers, cleaning solvents, aerosols (spray cans of perfumes, medicine, insecticide) cause damage to ozone layer chlorine contained in the CFCs on reaching the ozone ($O_3$) layer split the ozone molecules to form oxygen ($O_2$). Amount of ozone, thus gets reduced and cannot prevent the entry of UV radiation. There has been a reduction of ozone umbrella or shield over the Arctic and Antarctic regions. This is known as **ozone hole**. This permits passage of UV radiation on earth's atmosphere which causes sunburn, cataract in eyes leading to blindness, skin cancer, reduced productivity of forests, etc. Under the "Montreal Protocol" amended in 1990 it was decided to completely phase out CFCs to prevent damage of ozone layer.

## 10.5 GLOBAL WARMING AND GREENHOUSE EFFECT

Atmospheric gases like carbondioxide, methane, nitrous oxide, water vapour, and chlorofluorocarbons are capable of trapping the out-going infrared radiation from the earth. Infra-red radiations trapped by the earth's surface cannot pass through these gases and to increase thermal energy or heat in the atmosphere. Thus, the temperature of the global atmosphere is increased. As this phenomenon of increase in temperature is observed in green houses, in the botanical gardens these gases are known as green house gases and the heating effect is known as green house effect. If greenhouse gases are not checked, by the turn of the century the temperature may rise by $5^0$C. This will melt the polar ice caps and increase the sea level leading to coastal flooding, loss of coastal areas and ecosystems like swamps and marshes, etc.

## 10.6 NOISE POLLUTION

Noise is one of the most pervasive pollutant. A musical clock may be nice to listen during the day, but may be an irritant during sleep at night. Noise by definition is "sound without value" or "any noise that is unwanted by the recipient". Noise in industries such as stone cutting and crushing, steel forgings , loudspeakers, shouting by hawkers selling their wares, movement of heavy transport vehicles, railways and airports leads to irritation and an increased blood pressure, loss of temper, decrease in work efficiency, loss of hearing which may be first temporary but can become permanent in the noise stress continues. It is therefore of utmost importance that excessive noise is controlled. Noise level is measured in terms of decibels (dB). W.H.O. (World Health Organization) has prescribed optimum noise level as 45 dB by day and 35 dB by night. Anything above 80 dB is hazardous. The table10.4 gives the noise intensity in some of the common activities.

***Table 10.4:*** *Sources of some noises and their intensity*

| Source | Intensity | Source | Intensity |
|---|---|---|---|
| Quiet Conversation | 20-30dB | Radio Music | 50-60 dB |
| Loud Conversation | 60 dB | Traffic Noise | 60-90 dB |
| Lawn Mower | 60-80 dB | Heavy Truck | 90-100 dB |
| Aircraft Noise | 90-120 dB | Space Vehicle | 140-179 dB |
| Beat Music | 120 dB | Launch | |
| Motor Cycle | 105 dB | Jet Engine | 140 dB |

### 10.6.1 Sources of noise pollution

Noise pollution is a growing problem. All human activities contribute to noise pollution to varying extent. Sources of noise pollution are many and may be located indoors or outdoors.

**Indoor sources** include noise produced by radio, television, generators, electric fans, air coolers, air conditioners, different home appliances, and family conflict. Noise pollution is more in cities due to a higher concentration of population and industries and activities such as transportation. Noise like other pollutants is a by product of industrialization, urbanization and modern civilization.

**Outdoor sources** of noise pollution include indiscriminate use of loudspeakers, industrial activities, automobiles, rail traffic, aeroplanes and activities such as those at market place, religious, social, and cultural functions, sports and political rallies. In rural areas farm machines, pump sets are main sources of noise pollution. During festivals, marriage and many other occasions, use of fire crackers contribute to noise pollution.

### 10.6.2 Effects of noise pollution

Noise pollution is highly annoying and irritating. Noise disturbs sleep, causes hypertension (high blood pressure), emotional problems such as aggression, mental depression and annoyance. Noise pollution adversely affects efficiency and performance of individuals.

### 10.6.3 Prevention and control of noise pollution

Following steps can be taken to control or minimize noise pollution-

- Road traffic noise can be reduced by better designing and proper maintenance of vehicles.
- Noise abatement measures include creating noise mounds, noise attenuation walls and well maintained roads and smooth surfacing of roads.
- Retrofitting of locomotives, continuously welded rail track, use of electric locomotives or deployment of quieter rolling stock will reduce noises emanating from trains.
- Air traffic noise can be reduced by appropriate insulation and introduction of noise regulations for take off and landing of aircrafts at the airport.
- Industrial noises can be reduced by sound proofing equipment like generators and areas producing lot of noise.
- Power tools, very loud music and land movers, public functions using loudspeakers, etc should not be permitted at night. Use of horns, alarms, refrigeration units, etc. is to be restricted. Use of fire crackers which are noisy and cause air pollution should be restricted.
- A green belt of trees is an efficient noise absorber.

## INTEXT QUESTIONS 10.2

1. What is noise and in which units it is measured?

   ______________________________

2. State two harmful effects of noise pollution.

   ______________________________

3. State two important indoor and two outdoor sources of noise pollution? Mention method of control for each of them.

   ______________________________

## 10.7 WATER POLLUTION

Addition or presence of undesirable substances in water is called **water pollution**.

Water pollution is one of the most serious environmental problems. Water pollution is caused by a variety of human activities such as industrial, agricultural and domestic. Agricultural run off laden with excess fertilizers and pesticides, industrial effluents with toxic substances and sewage water with human and animal wastes pollute our water thoroughly. Natural sources of pollution of water are soil erosion, leaching of minerals from rocks and decaying of organic matter. Rivers, lakes, seas, oceans, estuaries and ground water sources may be polluted by point or non-point sources. When pollutants are discharged from a specific location such as a drain pipe carrying industrial effluents discharged directly into a water body it represents **point source pollution.** In contrast **non-point sources** include discharge of pollutants from diffused sources or from a larger area such as run off from agricultural fields, grazing lands, construction sites, abandoned mines and pits, roads and streets.

### 10.7.1 Sources of water pollution

Water pollution is the major source of water born diseases and other health problems. Sediments brought by runoff water from agricultural fields and discharge of untreated or partially treated sewage and industrial effluents, disposal of fly ash or solid waste into or close to a water body cause severe problems of water pollution. Increased turbidity of water because of sediments reduces penetration of light in water that reduces photosynthesis by aquatic plants.

**(i) Pollution due to pesticides and inorganic chemicals**

- Pesticides like DDT and others used in agriculture may contaminate water bodies. Aquatic organisms take up pesticides from water get into the food chain (aquatic in this case) and move up the food chain. At higher trophic level they get concentrated and may reach the upper end of the food chain.
- Metals like lead, zinc, arsenic, copper, mercury and cadmium in industrial waste waters adversely affect humans and other animals. Arsenic pollution of ground water has been reported from West Bengal, Orissa, Bihar, Western U.P. Consumption of such arsenic polluted water leads to accumulation of arsenic in the body parts like blood, nails and hairs causing skin lesions, rough skin, dry and thickening of skin and ultimately skin cancer.
- Pollution of water bodies by mercury causes **Minamata disease** in humans and **dropsy** in fishes. Lead causes **displexia**, cadmium poisoning causes **Itai – Itai disease** etc.
- Oil pollution of sea occurs from leakage from ships, oil tankers, rigs and pipelines. Accidents of oil tankers spill large quantity of oil in seas which kills marine birds and adversely affects other marine life and beaches.

### (ii) Thermal pollution

Power plants- thermal and nuclear, chemical and other industries use lot of water (about 30 % of all abstracted water) for cooling purposes and the used hot water is discharged into rivers, streams or oceans. The waste heat from the boilers and heating processes increases the temperature of the cooling water. Discharge of hot water may increase the temperature of the receiving water by 10 to 15 °C above the ambient water temperature. This is **thermal pollution**. Increase in water temperature decreases dissolved oxygen in water which adversely affects aquatic life. Unlike terrestrial ecosystems, the temperature of water bodies remain steady and does not change very much. Accordingly, aquatic organisms are adopted to a uniform steady temperature of environment and any fluctuation in water temperature severely affects aquatic plants and animals. Hence discharge of hot water from power plants adversely affects aquatic organisms. Aquatic plants and animals in the warm tropical water live dangerously close to their upper limit of temperature, particularly during the warm summer months. It requires only a slight deviation from this limit to cause a thermal stress to these organisms.

Discharge of hot water in water body affects feeding in fishes, increases their metabolism and affects their growth. Their swimming efficiency declines. Running away from predators or chasing prey becomes difficult. Their resistance to diseases and parasites decreases. Due to thermal pollution biological diversity is reduced. One of the best methods of reducing thermal pollution is to store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

### 10.7.2 Ground water pollution

Lot of people around the world depend on ground water for drinking, domestic, industrial and agricultural uses. Generally groundwater is a clean source of water. However, human activities such as improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.

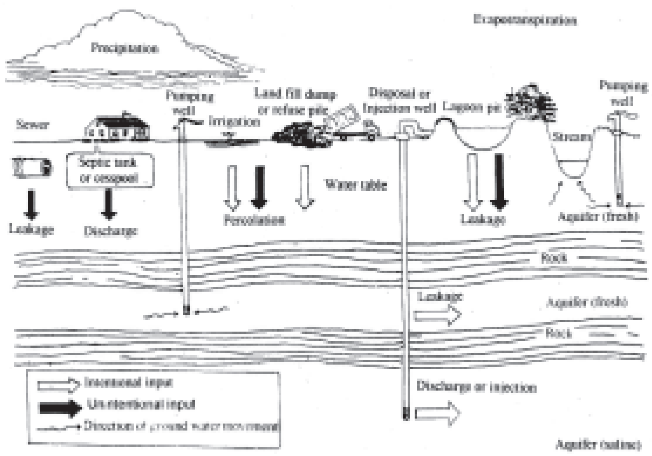


*Fig. 10.2:* *Figure showing how the ground water gets polluted*

### 10.7.3 Eutrophication

• 'Eu' maens well or healthy and 'trophy' means nutrition. The enrichment of water bodies with nutrients causes entrophication of the water body.

Discharge of domestic waste, agricultural surface runoff, land drainage and industrial effluents in a water body leads to rapid nutrients enrichment in a water body. The excessive nutrient enrichment in a water body encourages the growth of algae duckweed, water hyacinth, phytoplankton and other aquatic plants.The biological demand for oxygen (BOD) increases with the increase in aquatic organisms. As more plants grow and die, the dead and decaying plants and organic matter acted upon by heterotrophic prtozoans and bacteria, deplete the water of dissolved oxygen (DO). Decrease in DO result in sudden death of large population of fish and other aquatic organisms including plants, releasing offensive smell and makes the water unfit for human use. The sudden and explosive growth of phytoplankton and algae impart green colour to the water is known as water bloom, or "algal blooms". These phytoplankton release toxic substances in water that causes sudden death of large population of fishes. This phenomenon of nutrient enrichment of a water body is called **eutrophication**. Human activities are mainly responsible for the eutrophication of a growing number of lakes and water bodies in the country

### 10.7.4 Methods for control of water pollution and water recycling

**Control water pollution**

Waste water from domestic or industrial sources or from garbage dumps is generally known as **sewage.** It may also contain rain water and surface runoff. The sewage water can be treated to make it safe for disposal into water bodies like rivers, lakes etc. The treatment involves three stages: primary, secondary and tertiary. This includes 1. sedimentation, 2. coagulation/flocculation, 3.filtration, 4.disinfection, 5.softening and 6.aeration. The first four steps are of primary treatment. The first three steps are involved in primary treatment remove suspended particulate matter. Secondary treatment removes organic solids, left out after primary treatment, through their microbial decomposition. Effluents after secondary treatment may be clean but contain large amounts of nitrogen, in form of ammonia, nitrates and phosphorous which can cause problem of eutrophication upon their discharge into a receiving water body such as river, lake or pond. The tertiary treatment is meant to remove nutrients, disinfect for removing pathogenic bacteria, and aeration removes hydrogen sulphide and reduce the amount of carbon dioxide and make water healthy and fit for aquatic organisms. This treatment of waste water or sewage is carried out in effluent treatment plants especially built for this purpose. The residue obtained from primary treatment one known as sludge.

### 10.7.5 Water recycling

With increasing population the requirement for water is increasing rapidly. However, the availability of water is limited but an ever increasing water withdrawal from different sources such as rivers, lakes and ground water is depleting these sources and deteriorating their water quality. Therefore, it is essential to utilize the available water with maximum economy. This involves recycling of waste water for certain uses with or without treatment. Recycling refers to the use of waste-water by the original user prior to the discharge either to a treatment system or to a receiving water body. Thus the waste water is recovered and repetitively recycled with or without treatment by the same user.

### 10.7.6. Control of water pollution

The following measures can be adopted to control water pollution:

(a) The water requirement should be minimized by altering the techniques involved.

(b) Water should be reused with or without treatment.

(c) Recycling of water after treatment should be practiced to the maximum extent possible.

(d) The quantity of waste water discharge should be minimized.

## INTEXT QUESTIONS 10.3

1. Name the metals which when in excess in drinking water cause Minamata and Itai itai diseases.

___

2. When fertilizers and sewage enter a water body phytoplankton and algae grow rapidly. What is this phenomenon called.

___

3. What is primary treatment? What is removed from water effluents during primary treatment.

___

4. The water used for cooling purposes in industries may be drained industrial into rivers. To what extent does this raise the water temperature of the river?

___

5. What effect does thermal pollution have on the swimming efficiency of fish?

___

6. What effect does thermal pollution have on metabolism of aquatic animals?

___

7. State the term for residue left after primary treatment of waste water.

___

## 10.8 SOIL POLLUTION

Addition of substances which adversely affect the quality of soil or its fertility is known **as soil pollution.** Generally polluted water also pollute soil. Solid waste is a mixture of plastics, cloth, glass, metal and organic matter, sewage, sewage sludge, building debris, generated from households, commercial and industries establishments add to soil pollution. Fly ash, iron and steel slag, medical and industrial wastes disposed on land are important sources of soil pollution. In addition, fertilizers and pesticides from agricultural use which reach soil as run-off and land filling by municipal waste are growing cause of soil pollution. Acid rain and dry deposition of pollutants on land surface also contribute to soil pollution.

***Fig. 10.3:*** *A pile of plastic bags along with leftovers- a cow eating them*

### 10.8.1 Sources of soil pollution

**Plastic bags –** Plastic bags made from low density polyethylene (LDPE), is virtually indestructible, create colossal environmental hazard. The discarded bags block drains and sewage systems. Leftover food, vegetable waste etc. on which cows and dogs feed may die due to the choking by plastic bags. Plastic is non biodegradable and burning of plastic in garbage dumps release highly toxic and poisonous gases like carbon monoxide, carbon dioxide, phosgene, dioxine and other poisonous chlorinated compounds.

**Industrial sources –** It includes fly ash, chemical residues, metallic and nuclear wastes. Large number of industrial chemicals, dyes, acids, etc. find their way into the soil and are known to create many health hazards including cancer.

**Agricultural sources –** Agricultural chemicals especially fertilizers and pesticides pollute the soil. Fertilizers in the run off water from these fields can cause eutrophication in water bodies. Pesticides are highly toxic chemicals which affect humans and other animals adversely causing respiratory problems, cancer and death.

### 10.8.2 Control of soil pollution

Indiscriminate disposal of solid waste should be avoided.

To control soil pollution, it is essential to stop the use of plastic bags and instead use bags of degradable materials like paper and cloth. Sewage should be treated properly before using as fertilizer and as landfills. The organic matter from domestic, agricultural and other waste should be segregated and subjected to vermicomposting which generates useful manure as a by product. The industrial wastes prior to disposal should be properly treated for removing hazardous materials. Biomedical waste should be separately collected and incinerated in proper incinerators.

## INTEXT QUESTIONS 10.4

1. Define soil pollution.

2. Why are plastic bags a big environmental nuisance?

3. Vermicomposting degrades organic waste into a useful substance. What is this substance used for?

## 10.9 RADIATION POLLUTION: SOURCES AND HAZARDS

Radiation pollution is the increase in over the natural background radiation. There are many sources of radiation pollution such as nuclear wastes from nuclear power plants, mining and processing of nuclear material etc. The worse case of nuclear pollution was the cherndoyl disaster in Russia occured in 1986 but the effects still longer today.

### 10.9.1 Radiation

Radiation is a form of energy travelling through space. The radiation emanating from the decay of radioactive nuclides are a major sources of radiation pollution. Radiations can be categorized into two groups namely the non-ionizing radiations and the ionizing radiations.

**Non-ionizing radiations** are constituted by the electromagnetic waves at the longer wavelength of the spectrum ranging from near infra-red rays to radio waves. These waves have energies enough to excite the atoms and molecules of the medium through which they pass, causing them to vibrate faster but not strong enough to ionize them. In a microwave oven the radiation causes water molecules in the cooking medium to vibrate faster and thus raising its temperature.

**Ionizing radiations** cause ionization of atoms and molecules of the medium through which they pass. Electromagnetic radiations such as short wavelength ultra violet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms. Electrically charged particles produced in the nuclear processes can have sufficient energy to knock electrons out of the atoms or molecules of the medium, thereby producing *ions*. The ions produced in water molecules, for example, can induce reactions that can break bonds in proteins and other important molecules. An example of this would be when a gamma ray passes through a cell, the water molecules near the DNA might be ionized and the ions might react with the DNA causing it to break. They can also cause chemical changes by breaking the chemical bonds, which can damage living tissues. The ionizing radiations cause damage to biological systems and are, therefore, pollutants.

### 10.9.2 Radiation damage

The biological damage resulting from ionizing radiations is generally termed as **radiation damage**. Large amounts of radiation can kill cells that can dramatically affect the exposed organism as well as possibly its offspring. Affected cells can mutate and result in cancer. A large enough dose of radiation can kill the organism.

Radiation damage can be divided into two types: (a) **somatic damage** (also called *radiation sickness*) and (b) **genetic damage.** Somatic damage refers to damage to cells that are not associated with reproduction. Effects of somatic radiation damage include reddening of the skin, loss of hair, ulceration, fibrosis of the lungs, the formation of holes in tissue, a reduction of white blood cells, and the induction of cataract in the eyes. This damage can also result in cancer and death. Genetic damage refers to damage to cells associated with reproduction. This damage can subsequently cause genetic damage from gene mutation resulting in abnormalities. Genetic damages are passed on to next generation.

### 10.9.3 Radiation dose

The biological damage caused by the radiation is determined by the intensity of radiation and duration of the exposure. It depends on the amount of energy deposited by the radiation in the biological system. In studying the effects of radiation exposure in *humans*, it is important to realize that the biological damage caused by a particle depends not only on the total energy deposited but also on the rate of energy loss per unit distance traversed by the particle (or “linear energy transfer”). For example, alpha particles do much more damage per unit energy deposited than do electrons.

#### Radiation effects and radiation doses

A traditional unit of human-equivalent dose is the ***rem***, which stands for ***r**adiation **e**quivalent in **m**an*.

At low doses, such as what we receive every day from background radiation (< 1 *m rem*), the cells repair the damage rapidly. **At higher doses (up to 100 *rem*), the cells might**

**not be able to repair the damage, and the cells may either be changed permanently or die. Cells changed permanently may go on to produce abnormal cells when they divide and may become cancerous.**

At even higher doses, the cells cannot be replaced fast enough and tissues fail to function. An example of this would be "radiation sickness." This is a condition that results after high doses is given to the whole body (>100 *rem*).

Nuclear explosions and accidents in nuclear reactors are a serious source of radiation hazard. The effects of atomic explosions in Nagasaki and Hiroshima are still not forgotten. The nuclear reactor accident at Chernobyl in 1986 led to deaths of many reactor personnel and a very large release of radionuclide to the environment causing a long term radiation damage to the people living in the neighboring regions.

**Accidents at nuclear power plants**

Nuclear fission in the reactor core produces lot of heat which if not controlled can lead to a meltdown of fuel rods in the reactor core. If a meltdown happens by accident, it will release large quantities of highly dangerous radioactive materials in the environment with disastrous consequences to the humans, animals and plants. To prevent this type of accidents and reactor blow up, the reactors are designed to have a number of safety features.

Inspite of these safety measures two disasters in the nuclear power plants are noteworthy- namely at 'Three Mile Island' in Middletown (U.S.A.) in 1979, at Chernobyl (U.S.S.R.) in 1986. In both these cases a series of mishaps and errors resulted in over heating of the reactor core and lot of radiation was released into the environment. The leakage from Three Mile Island reactor was apparently low and no one was injured immediately. However, in case of Chernobyl the leakage was very heavy causing death of some workers and radiation spread over large areas scattered all over Europe. People of the city had to be evacuated to safer places and the plant had to be closed down. These two disasters are a reminder that nuclear power reactors require a constant up gradation of safety measures. Accidents with nuclear submarines also points to the same.

## INTEXT QUESTIONS 10.5

1. Which type of radiations are produced in a microwave oven?

2. State the use of absorbed dose of radiation.

3. How much of radiation can damage internal organs upon its exposure for a few days.

## WHAT YOU HAVE LEARNT

- Nature's components such as air, water, soil, forest and fisheries are resources exploited by humans and their pollution are by-product of urbanization and industrialization.
- Pollution in effect is an undesirable byproduct of industrialization and urbanization.
- The agents directly or indirectly responsible for the pollution of the environment are known as pollutants.
- There are six types of pollutions: air pollution, water pollution, noise pollution, soil pollution, thermal pollution, radiation pollution etc.
- Air pollution is a result of industrial and certain domestic activity.
- Air pollutants are of two types (1) suspended particulate matter, and (2) gases like carbon dioxide $CO_2$, NOx etc.
- Use of cleaner fuels such as biogas, CNG and electricity prevent air pollution.
- Segregation of waste, pretreatment at source, sterilization of rooms will help in checking indoor pollution.
- Prevention and control of industrial pollution can be reduced by using cleaner fuels, filters, electrostatic precipitators, inertial collectors, scrubbers etc.
- Use of chlorofluorocarbons cause damage of ozone layer which has resulted in its thinning over the Arctic and Anctartic regions, is know as ozone hole.
- Increase in global temperature or heating effect by green house gases ($CO_2$, methane) is known as green house effect.
- Noise like other pollution is a by product of industrialization, urbanization and modern civilization.
- Indoor sources include noise produced by radio, television and outdoor source includes indiscriminate use of loudspeakers, industrial activities, automobile, rail traffic and aeroplanes etc.
- Addition of undesirable substances in water is called water pollution.
- Natural sources of water pollution are soil erosion, leaching of minerals from rocks and decaying of organic matter.
- Power plants and various industries used lot of water for cooling purposes and hot water is discharged into rivers, streams or oceans. This waste heat increases the temperature of the cooling water upto 10-15$^0$C this is thermal pollution.

- Improper sewage disposal, dumping of farm yard manures and agricultural chemicals, industrial effluents are causing pollution of ground water.
- Nutrient enrichment of a water body is called eutrophication.
- Waste water from domestic or industry or garbage dump is generally known as sewage.
- Addition of substances which adversely affect the quality of soil or fertility is known as soil pollution.
- Sources of soil pollution are plastic bags, industrial sources, agricultural sources etc.
- Radiation is a form of energy traveling through space. Radiation can be grouped into non-ionizing radiation and the ionizing radiations.

## TERMINAL EXERCISE

1. Define the terms pollution and pollutant.
2. List the environmental problems faced by women inside the rural households. Suggest measures to reduce or eliminate them.
3. Why was CNG introduced as a fuel for automobiles in a city like Delhi? Has it made any difference?
4. Manufacture of chlorofluorocarbons is to be phased out as per 'Montreal protocol'. Why?
5. Describe an environmental friendly method to profitably dispose off human waste and cattle waste.
6. Chemical fertilizers are useful to crops. In which way they cause environmental pollution?
7. What steps can be taken to reduce pollution due to particulate matter from industries?
8. What is a PUC certificate? Is it necessary and for whom? In your opinion is it really useful?
9. What is a medical waste? Why it is called hazardous waste? What is the safe way to dispose medical waste.
10. Suggest the way to improve the water quality it has undergone primary treatment?
11. What are the causes and effects of thermal pollution on the life of aquatic animals like fish? What measures you would suggest to prevent thermal pollution?
12. What are ionizing and non-ionizing radiations? Give examples.
13. List the possible damages caused to humans by radiation pollution.

14. How can cancer be caused by radiation?

15. Briefly describe soil pollution, its causes and methods of control.

## ANSWER TO INTEXT QUESTIONS

**10.1**

1. (a) Agents which cause environmental pollution are called pollutants.

   (b) Addition to undesirable materials into the environment as a result of human activities.

2. Filters, electrostatic precipitators, inertial collector, scrubbers (any three)

3. Refer to text

4. Pollution Control Certificate that ensures the levels of certain pollutants are not released in the exhaust of vehicles beyond the legal limits.

**10.2**

1. Decibels (Db)

2. Disturb sleep, emotional problems, annoyance (any two)

3. Better designing and proper maintenance of vehicle, use of noise abatement measures, appropriate insulation and introduction of noise regulation for take off aircrafts, use of electric locomotives, using of sound proofing equipment.

**10.3**

1. Mercury and cadmium

2. Eutrophication

3. Primary treatment removes suspended particulate matter and floating materials.

4. Increase in water temperature upto 10 to $15^0$C above the ambient water temperature.

5. Swimming efficiency of fish declines.

6. Metabolism of aquatic animals increase and affect their growth.

7. Sludge

**10.4**

1. Addition of substances which adversely affect the quality of soil or fertility is known as soil pollution.

2. Plastic bags are indestructible and create colossal environmental harzard.

3. This substance is manure and used in agriculture.

**10.5**

1. Non-ionizing radiations
2. Absorption of radiation to be the amount of energy deposited in the region of the body divided by the mass of the portion of the body that absorbed the radiation.
3. Higher dozes (up to 100 rem) can damage internal organs upon exposure of it.

# 11

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# ENVIRONMENT AND HEALTH

It is well known that various human activities have caused damage to land, air, water and organisms that inhabit them. The degraded environment in turn poses a serious threat to affect human health and social well-being.

In developing countries like India the biological contamination of food, water and air with germs has remained a health menace. Introduction of toxic chemicals and harmful radiations has created new types of potentially serious health problems. Developmental projects have led to pollution of the environment resulting in different type of health problems. Some of those will be discussed in detail in this lesson.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define health and various types of influences (genetic, behavioural, environmental);*
- *list and describe the problems of sanitation in habitations (village/town/city);*
- *differentiate between different modes of spreading of water borne diseases, caused by pathogens, vectors and chemical pollutants;*
- *describe certain water borne diseases, how they spread and consequences thereof;*
- *prepare inventories of dominant air pollutants in agricultural, cottage and large industrial and mining areas and congested townships;*
- *cite examples of the environmental carcinogens and methods of their control;*
- *list the diseases caused due to heavy metal toxicity and methods of their prevention;*
- *list different kinds of occupational health hazards;*
- *explain different ways, by which humans get exposed to air pollution hazards while working in mines, textile, cement, chemical and paper industries.*

## 11.1 HEALTH AND VARIOUS TYPES OF INFLUENCES

Health of a person is the result of interaction of a large number of influences upon the person. These can be considered as **genetic** influences, **behavioural** influences and **environmental** influences.

**Genetic influences-** Genes determine the physical and physiological characteristics of an organism. The inherited abnormalities manifest as the hereditary diseases which are passed on from parents to offsprings. Diseases like allergies, hypertension, diabetes, etc. are not entirely genetic. However, they are due to the interaction of genes with the environment. These are triggered and affected by nutrition, stress, emotion, hormones, drugs and other environmental interactions.

**Behavioural influences –** Alcoholism, smoking, use of drugs, tobacco chewing or irregular food habits causing various kinds of health problems.

**Environmental influences-** Various components of the environment exert their influence on our health. These can be grouped under physical, chemical, biological, sociological and psychological factors.

## 11.2 SANITATION AND OTHER PROBLEMS IN HABITATIONS

- Unregulated growth of habitations, inadequate infrastructure facilities and lack of proper facilities for collection, transportation, treatment and disposal of wastes have all contributed to increased pollution causing health hazards.
- Lack of proper toilets, especially in villages, towns and slum areas of cities does not permit proper disposal of human waste which in turn leads to improper sanitary conditions and health hazards.
- Scarcity of clean drinking water is one of the major causes for the spread of many water borne diseases.
- Poor drainage or improper drainage results in the accumulation of waste water in public places in villages, towns and cities. Animal excreta and movement of cattle in and out of water pools and puddles spreads this filth over larger areas further causing sanitary problems.
- Contamination of food, often due to lack of understanding of the reasons and consequences is another health hazard faced by humans.
- Poor personal hygiene and eating without washing of hands leads to many types of health problems.

### 11.2.1 Villages

One of the major problems of the villages is the lack of safe drinking water supply. Many health problems and diseases in villages are due to use of water which is not clean. Improper disposal or lack of disposal of excreta adds to the sanitation problems. These are linked with high infant mortality rate and low life expectancy. Provision of low cost sanitary latrines in villages is a very important program of rural development. Ignorance of hygiene and sanitation adds to the problems further. Dissemination of knowledge and provision of safe drinking water is an important agenda. Rural households are not properly ventilated as a result they suffer from lack of fresh air and many rural households are single room units which get filled with smoke from burning of fire wood and biomass and do not get adequate sun light. They lack of proper drainage that leads to contamination of ground water and other sources of drinking water.

### 11.2.2 Towns

In most of the cities there is lack of proper drainage. As a result accumulation of waste water form puddles of dirty water. Animals like cattle, dogs and pigs roam freely in cities and their excreta etc. make sanitation problems worse. Roads are not proper and the different types of transport further pollute the environment and cause health problems.

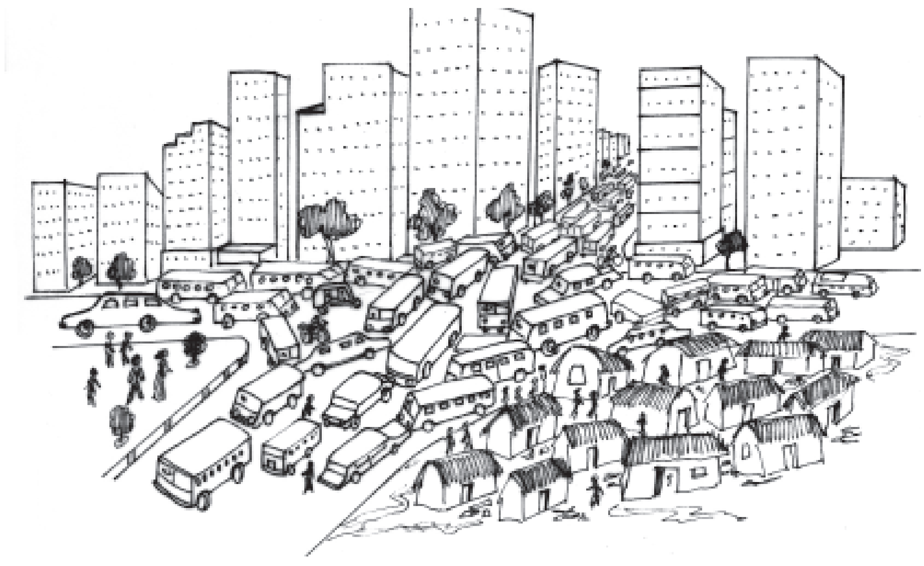

***Fig. 11.1:*** *Frequent traffic chaos in a city*

### 11.2.3 Cities

Rapid growth of urbanization has adversely stressed the environment. About 1/5$^{th}$ of the urban population resides in slums and 1/3$^{rd}$ of the population does not have access to sanitation and clean drinking water which results in poor health. Most cities have many unplanned and haphazard areas with inadequate infrastructure. Industrial areas have been established without environmental assessment. Inadequate commercial areas, inadequate transport network, inadequate green and recreational areas and lack of consideration for environment in planning have led to chaos and environmental degradation. Discharge of sewage into open drains, contaminate city water supply, especially during rainy season.

(a) **Slums-** Are unplanned aggregations of hutments arranged very closely without any space for roads, parks, drains, etc. Often many persons live in each of these small hutments which do not have proper ventilation and cooking on wood burning chullahs fills them with smoke resulting in many respiratory problems and diseases. Generally toilets are absent making life difficult especially for women. Lack of proper drainage leads to very unhygienic conditions. Due to unavailability of clean drinking water, these people suffer from diseases like dysentery which is often fatal to children in these areas.

(b) **Industrial areas-** Many industries are established in unplanned manner and without environmental impact assessment. This results in air, water, soil and noise pollution with their undesirable consequences. The industrial effluents and waste are often hazardous and may contain toxic heavy metals and other toxic materials some of which ultimately to leach down and contaminate ground water making it unfit for drinking and other use.

(c) **Residential and commercial areas-** It is very common in cities to have commercial activities in areas meant exclusively for residential purposes. Since these are unplanned there is no proper infrastructure for these activities. There is lot of over crowding in a confined area. Haphazard parking makes movement of traffic and people difficult. The noise level is high especially because of hawkers selling their wares at a very loud pitch so as to attract the attention of the prospective customers. Daily generation of garbage- both domestic and commercial is often dumped at the roadside making the whole area filled with filth and unhygienic. Burning of tree leaves and plant residues also leads to air pollution especially during winters.

(d) **Traffic-** Most often the traffic is chaotic due to inadequate roads, poor enforcement of traffic rules, too many vehicles and lack of proper public transport. The movement of vehicles leads to atmospheric pollution due to the emission from the vehicles, suspended particulate matter and smoke especially from diesel vehicles.

## INTEXT QUESTIONS 11.1

1. Define health.

_______________________________________________

2. What is the advantage of providing potable water (drinking water) to the community?

3. What are slums?

4. State any two reasons for health problems in villages?

## 11.3 DIFFERENT MODES OF SPREAD OF WATER RELATED DISEASES CAUSED BY PATHOGENS, VECTORS AND CHEMICAL POLLUTANTS

At least $1/5^{th}$ of world population lacks access to safe drinking water. In developing countries, 80 to 90% of the untreated sewage is discharged directly into rivers and streams which provide water for drinking, washing and bathing. Lack of sewage treatment allows pathogenic organisms to spread water-borne diseases. Diseases transmitted by vectors like mosquitoes which live in the water are responsible for about one third of all deaths in the world.

The growing pollution of rivers and other water bodies constitutes a very big threat to public health. Polluted waters lead to various gastrointestinal problems, liver infection, cancer, etc. Large number of children die because of diarrhoea.

### 11.3.1 Modes of transmission of diseases

Disease causing pathogens reach humans in various ways which are described below.

1. **Contact transmission:** Some diseases can be transmitted by either direct physical contact with the infected person or the causative agent can be transmitted to the host indirectly by contact with the infected articles.
2. **Vehicle transmission:** (a) Pathogenic organisms are transmitted through water, food, etc. When the water is infected at the source, it spreads the infection to large populations. Pathogens causing Cholera, Typhoid and Hepatitis are transmitted from one person to another through their domestic water supply. Infection is also transmitted by organisms which live in water e.g. Helminthes (parasitic worms) which spend part of their life cycle in water.

   (b) Many chemical pollutants such as food additives, adulterants, poisonous industrial waste, pesticides and metals get mixed with water including underground water and are consumed by humans and animals resulting in diseases. Inadequate water supply and lack of personal hygiene cause transmission of disease such as trachoma in the eye and skin infections.
3. **Vector transmission:** Vector is a carrier of pathogen. Mosquito spend a part of their life cycle in water. Vector for disases such as malaria, yellow fever, encephalitis, filaria and dengue.

### 11.3.2 Water borne diseases, their spread and consequences

It is estimated that 73 million work days are lost every year in India due to water related diseases. India is rich in rivers and surface flow represents 97% of the available water. But rather than being a boon, these rivers are proving to be quite a disaster because of pollution. River Yamuna becomes highly polluted after entering Delhi due to the addition of untreated sewage, industrial waste and many other pollutants. It has been found that water samples taken in Delhi are about 20 times more polluted than the water samples taken before the river enters Delhi. Water borne diseases are spread by drinking water contaminated by faeces, by water used for personal hygiene, for washing food and other items. Diseases are spread by poor quality water used for washing and include skin diseases like scabies and eye disease such as trachoma and conjunctivitis. Water based diseases spread by parasites living in water include schistosomiasis transmitted by snails. Disease from polluted water include hook worm, round worm, etc. (Fig. 11.2)

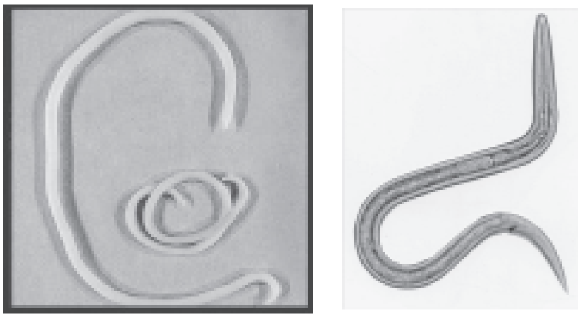

***Fig. 11.2:*** *Pathogens of water borne diseases*

A large number of diseases are transmitted in different ways by water. The diseases caused, mode of transmission and symptoms are tabulated below.

***Table 11.1:*** *Water-borne diseases*

**A. Bacterial diseases:**

| **Disease** | **Causative organism** | **Mode of spread** | **Symptoms** |
|---|---|---|---|
| Typhoid | *Salmonella typhi* | Contaminated food, water, milk, unwashed raw vegetables and flies | Continuous fever which increases day by day Temperature higher in evening than morning, body ache, headache and constipation. Haemorrhage from an ulceration in small intestine |
| Cholera | *Vibrio cholerae* | Water or food contaminated by bacteria from stools of cholera patient | Painless diarrhoea , vomiting, 30-40 stools per day which soon becomes typically watery and colourless with flakes of mucous floating in them |

| | | | |
|---|---|---|---|
| Bacterial Diaorhoea | *Shigella* spp. | Contaminated food, water and by direct personal contact | Diarrhoea, with blood and dysentry mucous in the stools along with severe gripping pain in the abdomen. Stools not too frequent (4-10 per day), faecal matter scanty. Patient looks ill |
| Leptospirosis | *Leptospira* | Rodents primary hosts-carry organisms in kidneys. Infection by wading or swimming in water contaminated with rodent urine | Fever, pain in legs, nausea, vomiting are common, congestion of the conjunctival blood vessels around corneas of the eyes |
| **B. Viral diseases**: | | | |
| Infective Hepatitis | *Hepatitis virus* | Food and water contaminated with virus in stools | Loss of appetite, nausea, vomiting and diarrhoea, accompanied with fever. Urine dark coloured. Eye and skin appear yellow |
| **C. Protozoan diseases**: | | | |
| Amoebic dysentery | *Entamoeba histolytica* | Ingestion of cysts in food and water | Abdominal discomfort and diarrhoea, with or without blood or mucous in stools, fever, chills and gripping pain in abdomen |
| Diarrhoea | *Giardia (=Lamblia) intestinalis* | Food or water contaminated with faeces having cysts | Intestinal disorders leading to epigastric pain, abdominal discomfort, loss of appetite, headache and loose bowels |
| **D. Helminth diseases**: | | | |
| Bilharzia | *Schistosoma* spp | Cercaria larvae of flukes in water penetrate skin of persons wading in water | Allergy-like itch, rash, aches, fever, eosinophilia etc. When infection heavy, eggs may block arterioles of lungs cardio-pulmonary water causing schistosomiasis and may lead to congestive heart failure |
| Guinea worm | *Dracunculus medinensis* | Unfiltered water | Blister near the ankle, causing allergy and aches |

**E. Vector borne diseases related with water:**

Diseases transmitted by mosquitoes-

| Disease | Causative Organisms | Vector | Hosts | Symptoms |
|---|---|---|---|---|
| Malaria | *Plasmodium* sp | Female Anopheles (primary or final hosts) | Man (intermediate hosts) | Shivering, chills and sweating. As chills subside body temperature rises as high as 106º F. When temperature comes down patient sweats profusely and becomes comfortable until next attack which takes place at regular intervals |
| Filaria (Elephantiasis) | *Wuchereria (=filaria)* | *Culex fatigans* | Man (final hosts) | Enlargement of limbs and scrotum |
| Dengue | Barbo - virus | *Aedes aegypti* | Man (reservoir) | Sudden onset of moderately high fever, excruciating joint pain, intense pain behind eyes, a second rise in temp following brief remission, reduction in neutrophilic white blood cells |

## INTEXT QUESTIONS 11.2

1. State one example of disease transmitted by vector.

 ______________________________________________

2. Diarrhoea with or without blood or mucous in stools, fever and gripping pain in abdomen are all symptoms of a water borne aliment. Name it.

 ______________________________________________

3. Name the bacteria which causes Leptospirosis.

 ______________________________________________

## 11.4 AIR POLLUTANTS ASSOCIATED WITH AGRICULTURE, INDUSTRY, MINING AND URBAN AREAS

Atmospheric pollution is an ever-increasing threat to health throughout the world especially in developing countries like India. Air pollution spoils the quality of air that we breathe. Many substances which are harmful to lungs are carried by such inspired air. Air pollutants cause irritation to eyes, burning sensation in eyes, blocking of nose, sneezing and headache etc. There are others which cause more serious problems which in some cases can be fatal. Long exposures to air pollution can cause diseases such as bronchitis, chronic cough, asthma and emphysema.

### 11.4.1 Air Pollution from agricultural operations

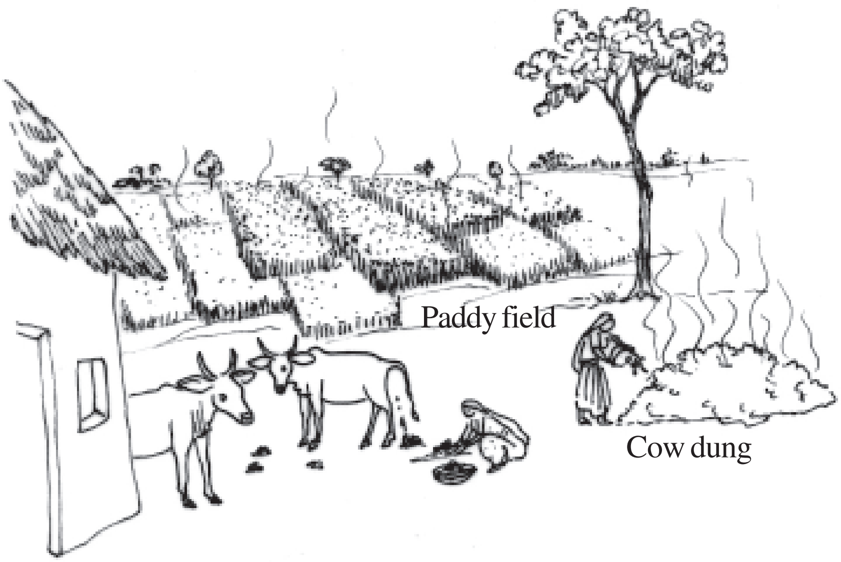


***Fig. 11.3:*** *Cattle defecating and methane release from cow dung as well as from paddy field*

- **Pesticides** – A significant proportion of pesticides applied to crops is vapourized and contaminates the atmosphere over agricultural fields.
- **Smoke** – Burning of crop residues results in production of smoke and many toxic gases.
- **Water vapour** – The humidity in agricultural fields especially after irrigation is generally high. In addition to the above, toxic gases are also released from the use of machinery such as diesel pumps, tractors etc. contaminate agricultural areas.

**11.4.2 Industrial**

- **Smoke –** Smoke is perhaps the major pollutant in industrial areas caused due to burning of fossil fuels such as coal. The chimney belches out dense clouds of pollutants which coat the surrounding areas with a thick layer of white dust or ash (Fig. 11.4).

***Fig. 11.4:*** *Factory chimney emitting thick cloud of smoke and settling of fly ash*

- **Carbon dioxide –** Burning of fossil fuel, wood and crop residues all produce lot of carbon dioxide leading to global warming and climate change.
- **Oxides of sulphur-** Sulphur dioxide is produced by burning fossil fuels and it is a major pollutant released from oil refineries, etc.

In addition to the above, some industries like sugar mills, tanneries etc. release a lot of foul smelling gases. Many other atmospheric pollutants including heavy metals are common in urban atmosphere.

**11.4.3 Mining Areas**

Suspended particulate matter is one of the major pollutants in mining areas. This is especially so in stone quarries, iron mines, etc. Other pollutants are sulphur dioxide and oxides of nitrogen.

Atmosphere of asbestos mines contains asbestos dust which causes **asbestosis**, silica causes **silicosis**, lead, zinc and other heavy metals such as chromium, arsenic, copper and manganese, and radon gas may also accumulate in high concentrations in their respective mines. High levels of alpha and gamma radiation can also be found in and around uranium mines and uranium ore tailings.

### 11.4.4 Pollution in Urban Areas

High level of suspended particulate matter is one of the major pollutants in urban areas. This is caused by multifarious human activities such as movement of traffic, smoke from industries and diesel vehicles from automobiles gases like oxides of sulphur, oxides of nitrogen, hydrocarbons, carbon monoxide and carbon dioxide. In addition many trace metals such as iron, zinc and magnesium are found associated with suspended air particulates.

***Figure 11.5:*** *Traffic congestion in cities during rainy season*

## INTEXT QUESTIONS 11.3

1. From which industries are foul smelling gases released.

2. Which air pollutant is released from stone quarries and iron mines?

3. In congested townships movement of traffic on dusty roads, smoke from industries and diesel vehicles result, a pollutant gathers in air which pollutant is it?

4. List the major pollutants in agricultural areas.

## 11.5 ENVIRONMENTAL CARCINOGENS AND METHODS OF THEIR CONTROL

Cancer is a group of related diseases that begin in cells of the body. Normally cells divide to produce more cells when body needs them for development, growth and repair of cell damage. Process of continuous division and growth of cells keeps the body healthy and normal. However, at times cells keep on dividing even when new cells are not required. These cells form a mass of tissue known as a **tumor**. The tumors can be either benign or malignant.

The **benign tumors** are not harmful. Generally they can be removed surgically and do not reappear. Further, cells from these tumors do not move to other parts of the body and rarely endanger life. On the other hand, **malignant tumors** are cancerous. Cells of these tumors are abnormal and they divide and re-divide without any control. They can invade and damage nearby tissues and organs. Cells from these tumors can break away and enter the blood stream or lymphatic system and spread from the original site to form new tumors in other organs.

Leukemia and lymphoma are cancers which are initiated in blood-forming cells. Most cancers are named after the organ concerned e.g. Cancer that begins in lungs is lung cancer and the one in skin is known as melanoma. The cancer-causing agents are known as **carcinogens**. Agents present in the environment are the **environmental carcinogens**.

### 11.5.1 Tobacco

Smoking tobacco or being regularly exposed to tobacco smoke are responsible for about 85% of all cancer deaths. Smoking may increase the chances of getting cancers of stomach, liver, prostate, colon and rectum. Use of smokeless tobacco, chewing tobacco and snuff cause cancer of mouth and throat. Exposure to environmental tobacco smoke, termed **passive smoking** also increases the risk of lung cancer for non-smokers. The risk of cancer begins to decrease soon after quitting smoking and chewing tobacco. This risk continues to decline gradually after quitting.

***Figure 11.6:*** *People eating tobacco/ snuff and showing cancer of mouth*

### 11.5.2 Ultraviolet (UV) radiation

UV radiation coming from sun can cause premature aging of and skin damage prolonged exposure to UV radiation may lead to skin cancer. The formation of ozone hole by compounds like chlorofluorocarbons and others, increase the incidence of UV radiation reaching the earth. This is because ozone layer acts as a shield to prevent passage of UV radiations preventing melanoma. Avoiding exposure to direct midday sun light (from 10 a.m. to 3 p.m.) is perhaps the best way of reducing the risk of skin cancer. Wearing of a broad-brimmed hat, use of UV absorbing sunglasses and clothing to cover the body adequately also offers protection against UV.

### 11.5.3 Ionizing radiation

High levels of radiation like those from radiation therapies and X-rays, and from radioactive substances can damage normal (somatic) cells and increase the risk of developing leukemia and cancers of the breast, thyroid, lung, stomach and other organs. Studies with survivors of the atomic bomb in Japan showed that ionizing radiation increases the risk of leukemia and other cancers. It is always desirable to minimize diagnostic and therapeutic exposure to ionizing radiation and protect other parts of the body during such procedures.

### 11.5.4 Chemicals and other substances

***Figure 11.7:*** *Spraying of defoliators and fall out of spray on people*

**Pesticides:** Excessive use of pesticides particularly herbicides like 2,4-dichlorophenoxyacetic acid (2,4-D) has been associated with a 200-800% increase of NHL (Non-Hodgkin's Lymphoma) – one type of cancer in Sweden. Pesticides such as toxaphene, hexachlorocyclohexane (BHC), trichlorophenol, dieldrin, DDT are known to cause lymphatic cancer in rats and mice. The danger is increased due to the persistent nature of the residues of these pesticides in the environment resulting in chronic exposure to low levels of pesticides. The use of all these pesticides has now either been banned or restricted. Organic farming and emphasis on Integrated Pest Management (IPM) as an alternate and environment friendly method of pest control. Asbestos, nickel, cadmium, radon, vinyl chloride, benzidine and benzene are well known carcinogens. Reduction in exposure to these will reduce the incidence of various types of cancer.

### 11.5.5 Allergens and allergy

Substances in the environment that cause allergic reactions, are known as **allergens**. Allergens stimulate within the body an immune response which may be in the form of a reaction. An allergic person's immune system believes allergens to be damaging and so produces a special type of antibody immunoglobulin E (IgE) to attack the invading material. This leads other blood cells to release further chemicals (including histamine) which together cause the symptoms of an allergic reaction.

The most common symptoms are sneezing, runny nose, itchy eyes and ears, severe wheezing, coughing, breathelessness, sinus problems, a sore palate and nettle- like rash. Other commonly known problems could include asthma, eczema and headaches.

The most common allergens are pollen from specific trees and grasses, house dust mites, moulds, cats, dogs, insects like wasps and bees, industrial and household chemicals, medicines and foods such as milk and eggs.

Allergens contain protein which is often regarded as a constituent of the food we eat. There are some non-protein allergens including drugs like penicillin- but they need to be bound to a protein once they are in the body. The best method to combat allergy is to identify the allergen (often difficult) and avoid coming into contact with it.

- **Blue Baby disease**

Modern agriculture uses a lot of nitrogenous fertilizers and manures. This leads to increased levels of nitrates in the ground water as nitrates being soluble in water easily leach into the soil. Once the level exceeds 10 ppm it may become harmful. In areas where ground water is the only source of drinking water, this causes **methaemoglobinaemia** particularly in bottle fed infants who are very sensitive to this pollutant.

Babies drink large quantities of water; water is used to mix powdered or concentrated recipes or juices. When water containing nitrates is consumed and it reaches intestines, the intestinal bacteria convert nitrates into nitrites. The nitrite ions combine with haemoglobin to form methaemoglobin which inhibits the oxygen carrying capacity of the blood causing a kind of anaemia known as **methaemoglobinaemia.**

Methaemoglobin is formed when iron in the haemoglobin molecule is oxidized from $Fe^{2+}$ (ferrous) to $Fe^{3+}$ (ferric) form. Due to reduced carrying capacity for oxygen the babies gradually acquire a blue tinge and hence the name – "**Blue Baby disease**". Symptoms are sleeping, poor feeding, decreased energy, etc. Nitrates can be removed from the water by processes like electrodialysis and reverse osmosis. Nitrites in the water can be oxidized to nitrates by introducing a strong oxidant like ozone in the water.

- **Asthma**

It is a chronic (long term) disease of the respiratory passages. It is characterized by reversible airflow obstruction (tightening of the smooth muscles around airways), inflammation (swelling) and mucous production when airways are exposed to various stimuli (triggers). Asthma has no cure but there are effective medications to control the symptoms and prevent asthma attacks. Asthma can be life threatening, requiring emergency room care or hospital admission. Asthma can develop at any age. What exactly causes bronchial tubes to become swollen is still not known. However, possible risk factors for developing asthma in childhood includes-

- family history of allergy and allergic disorders.
- high exposure of airborne allergy causing substances ( pet dander, house dust mites, cockroaches, moulds, etc) among susceptible children in the first year of life.
- exposure to tobacco smoke.
- frequent respiratory infections early in life.

Symptoms of asthma are breathelessness, wheezing, chest tightness or pain around the chest, persistent cough that can last several weeks.

## INTEXT QUESTIONS 11.4

1. Name three pesticides which are known to cause lymphatic cancer in rats and mice.
2. What measures can be taken to minimize the incidence of skin cancer?
3. What are the possible programmes which can be taken up to minimize damage from pesticides?
4. What is the cause of the Blue Baby Disease?
5. Give two major symptoms of Asthma.

## 11.6 HEAVY METAL TOXICITY AND METHODS OF THEIR PREVENTION

Toxic metals are dispersed in the environment through metal smelting industrial emissions, burning of organic wastes, automobiles and coal based power generation. Heavy metals can be carried to places far away from their source of origin by winds when they are emitted in gaseous form or in form of fine particulates. Rain ultimately washes the air having metallic pollutants and brings them to the land and to water bodies.

Heavy metals may endanger public health after being incorporated in food chain. Heavy metals cannot be destroyed by biological degradation. Incidence of heavy metal accumulation in fish, oysters, mussels, sediments and other components of aquatic ecosystems have been reported from all over the world. The heavy metals often encountered in the environment include lead, mercury, arsenic, chromium. These are known to cause toxic effects in living organisms.

### 11.6.1 Lead

Lead enters the atmosphere from automobile exhaust. Tetraethyl lead (TEL) was added to petrol as an anti-knock agent for smooth running of automobile engines. TEL has now been replaced by other anti-knock compounds to prevent emission of lead by automobiles. Lead in petrol is being phased out by introduction of lead free petrol. Many industrial processes use lead and it is often released as a pollutant. Battery scrap also contain lead. It can get mixed up with water and food and create cumulative poisoning. It can cause irreversible behavioural disturbances, neurological damage and other developmental problems in young children and babies. It is a carcinogen of the lungs and kidneys.

***Fig. 11.8:*** *Lead pollution – recovering lead from old batteries*

### 11.6.2 Mercury

In Japan, mass mercury poisoning (Minamata disease) was observed in 1960s, caused by eating fish from Minamata Bay which were contaminated with methyl mercury. Largest source of mercury pollution is through aquatic animals such as fish which accumulate mercury as methyl mercury. Mercury kills cells in the body and damages organs which come in contact with mercury and thus impairs their functioning. Inhalation of mercury vapours is more dangerous than its ingestion. Chronic exposure causes lesions in the mouth and skin and neurological problems.

Typical symptoms of mercury poisoning are irritability, excitability, loss of memory, insomnia, tremor and gingivitis. Exposure to mercury can be prevented by taking care that mercury is not released in the environment as well as by replacing mercury by other materials. Mercury thermometers used earlier are getting replaced by mercury free thermometer.

### 11.6.3 Arsenic

Arsenic is associated with copper, iron and silver ores. Arsenic is emitted from fossil fuel burning. Liquid effluents from fertilizer plants also contain arsenic. Ground water contamination with arsenic is very common in areas where it is present. People depending on ground water containing arsenic get exposed to this pollutant. Chronic arsenic poisoning leads to loss of appetite, weight, diarrhoea, gastrointestinal disturbances and skin cancer. The water from underground sources contaminated with arsenic should not be used for drinking and cooking purposes. Surface waters are generally free from arsenic pollution and should be preferred for drinking and cooking. Alternatively the tube well/ hand pump water should be purified to remove arsenic before consumption. Techniques for removing arsenic from water are available.

**Arsenic Pollution—A Case Study**

A patient from Balia, Utter Pradesh came to All India Institute of Medical Sciences (AIIMS), New Delhi for consultation in summer, 2004. An injury in his leg in 1996 did not heal. His two fingers got ulcers which could not be treated and had to be ultimately amputated. Subsequently he was diagnosed to be suffering from skin cancer. His blood had 34.40 ppb (ppb = arsenic which is many times higher than normal).

Out of a population of 1800 about 100 persons who were examined (age more than 35 years) were suffering from **melanosis**. Many of them were suffering from **keratosis** and some had breathing problems. Arsenic levels in hairs of two persons were 4790 and 6310 ppb (normal 80 to 250 ppb), nails 2480 ppb (normal 430-1080 ppb). Large number of people had died due to cancer. Examination of water from hand pumps, which was the main source of drinking water, showed that more than half had arsenic higher than 10 ppb in their blood ( permissible limit). In 8 % cases arsenic was higher than 500 ppb.

If a person drinks water contaminated with arsenic for about 10 years, dark spot develop on the upper chest, back and arms known as **melanosis.** The next stage is **keratosis** in which palms become hard and patient may suffer from diarrohea, stomach pain, breathing problems, etc. Later along with dark spots, develop white spots, legs become swollen and walking become difficult and painful, some wounds start bleeding, the liver and kidney suffer damage.

### 11.6.4 Cadmium

Mining especially of zinc and metallurgical operations, electroplating industries, etc. release cadmium in the environment. It may enter the human body by inhalation or from aquatic sources including fish, etc. It may cause hypertension, liver cirrhosis, brittle bones, kidney damage and lung cancer. Itai-itai disease first reported from Japan in 1965 was attributed to cadmium contamination in water and rice caused by discharge of effluents from a zinc smelter into a river.

### 11.6.5 Other Heavy Metals

Metals such as zinc, chromium, antimony and tin enter food from cheap cooking utensils. Preserved foods stored in tin cans also cause contamination by tin. Zinc is a skin irritant and affects pulmonary system. Problems of heavy metal toxicity can be prevented by avoiding the use of utensils made from materials containing these heavy metals or use of drinking water and consuming fish having these heavy metals.

## INTEXT QUESTIONS 11.5

1. What is heavy metal toxicity?

______________________________

2. State two symptoms of arsenic poisoning due to consumption of groundwater containing arsenic.

______________________________

3. Mention the form in which mercury acts as a poison.

______________________________

4. Which metal does battery scrap leave in the environment?

______________________________

## 11.7 OCCUPATIONAL HEALTH HAZARDS

Most people spend the largest proportion of their waking hours at the work place. Many, however, often undertake agricultural or cottage industry activity within the home or in fields. In favourable circumstances work contributes to good health and economic achievements. For some, the work environment exposes them to health hazards that contribute to injuries, respiratory diseases, cancer, musculoskeletal disorders, reproductive disorders, cardiovascular diseases, mental and neurological illnesses, hearing loss, etc. Such health hazards are termed occupational health hazards, being associated with occupation.

### 11.7.1 Heavy physical workload

Workers who are exposed to heavy physical work loads are miners, lumberjacks, construction workers, farmers, fishermen, storage workers and healthcare personnel. Repetitive tasks and static muscular load can lead to injuries and musculoskeletal disorders and may result in short-term and permanent work disability. Unshielded machinery, unsafe structures and dangerous tools are some of the most prevalent work place hazards.

***Fig. 11.9:*** *People cutting trees and carrying logs*

### Black lung disease

In coal mining areas coal dust is the main air pollutant to which miners are exposed everyday. The deposits of coal dust makes miners lungs look black instead of a healthy pink and hence the name black lung disease. Black lung disease is the common name for **pneumoconiosis** (CWP) or anthracosis, a lung disease of older workers in the coal industry, caused by inhalation over many years, of small amounts of coal dust. Although people who live in cities often have some black deposits in their lungs from polluted air, coal miners have much more extensive deposits.

The particles of fine coal dust accumulate in lungs as they cannot be destroyed within the lungs or removed from them. Eventually this build-up causes thickening and scarring making the lungs less efficient in supplying oxygen to the blood.

The primary symptom of the disease is shortness of breathe which gradually gets worse as the disease progresses. In severe cases it may eventually cause heart failure. In some cases a progressive massive fibrosis develops, in which damage continues in the upper parts of the lungs even after exposure to dust has ended.

Often some patients develop emphysema (Shortness of breathe), as a complication of black lung disease. X-rays can detect black lung disease before it causes any symptoms. Patients who develop this disease at an early age, or who have progressive massive fibrosis, have a higher risk of premature death.

**Prevention-** The only way to prevent black lung disease is to avoid long-term exposure to coal dust. Coal mines may help prevent this condition by lowering coal dust level and providing protective clothes to coal miners.

### 11.7.2 Noise

Workers in mining, manufacturing and construction industries are exposed to high levels of noise which is a very important stress factor. Sound levels higher than 80 to 90 dB (dB- decibles- unit of sound) for more than eight hours are harmful to human ear. Some of the adverse effects of sound are –

(a) **Psychological**: Noise leads to emotional disturbances such as annoyance, disturbed sleep, lack of concentration and reduced efficiency.

(b) **Auditory effects**

(i) **Auditory fatigue** – Occurs when noise level is in the range of 85 to 90 dB e.g. noise of a food blender.

(ii) **Deafness or impaired hearing** – It may be temporary or permanent. Temporary hearing loss occurs on continuous exposure to noise as in case of telephone operators which disappears within 24 hours after a period of rest. Repeated or continuous exposure to noise more than 90 dB may result in permanent loss of hearing. This effect is more serious in case of persons having ear diseases and they should avoid noisy working environment.

***Fig. 11.10:*** *Noise pollution*

**(c) Non-auditory effects**

**(i) Interference with speech and communication:** In the presence of high level of noise, one needs to strain his voice by increasing loudness to make speech intelligible e.g. in foundries, boiler cabins, etc. Street hawkers or salesmen of small stalls in busy markets need to yell continuously at the top of their voice so that they are heard. Due to this they suffer from voice disorder or even cancer of voice-box later in life.

**(ii) Annoyance:** Most people are annoyed by noise and some may become neurotic. Neurotic people lose their temper quickly and become irritable.

**(iii) Efficiency:** High level of noise at the work place reduces working efficiency. Quiet environment helps in increasing efficiency.

**(iv) General change in the body**: Exposure to noise increases blood pressure, pulse rate, breathing and sweating or headache. giddiness, nausea, fatigue, disturbs sleep, distorted colour perception and reduced night vision are general symptoms observed in victims of noise. Persons working in night shifts or those suffering from hypertension get affected by noise earlier than others.

### 11.7.3 Chemicals and Biological Agents

Workers in many industries are exposed to chemicals which are hazardous and may be even carcinogenic such as in textiles, cement and construction industries. Substances such as benzene, chromium, nitrosamines and asbestos may cause cancers of lung, bladder, skin, mesothelium, liver, etc. The only effective control strategy is primary prevention that eliminates exposure completely or that effectively isolates the worker from exposure to carcinogens. Occupational asthma is caused due to exposure to organic dusts, microorganisms, bacteria, fungi and moulds and several chemicals. Silicosis first reported from Kolar gold mines in 1947 is a common disease among miners, pottery and ceramic industry workers. Pneumoconiosis and byssinosis are common among mica and textile industry workers respectively.

## INTEXT QUESTIONS 11.6

1. Which workers are involved with heavy physical work?

2. What kind of problem does sound level of 120 dB for a few hour may lead to?

3. State any two symptoms of long exposure to noise pollution?

## WHAT YOU HAVE LEARNT

- Environmental pollution may adversely affect the health and well being of humans.
- Lack of clean drinking water, unhygienic conditions and pollution of the environment in villages, towns and cities are responsible for spread of diseases and large number of health problems
- Many water borne diseases such as cholera, infective hepatitis, dysentery and diarrhea, Bilharzia and malaria are transmitted by different ways. The mixing of untreated or improperly treated sewage in rivers cause extensive water pollution and related adverse health effects.
- Major air pollutants in agricultural areas are ammonia, methane and pesticides; in cottage industries and large industrial areas they are smoke, carbon dioxide and oxides of sulphur.
- In mines such as coal mines, the workers exposed to coal dust for long time suffer from Black Lung Disease for which there is no treatment except stoppage of exposure before it becomes very serious.
- At times, cells in certain parts of the body keep on dividing even though not required. These cells become cancerous and form malignant tumors. There are many environmental agents-termed carcinogens, which cause cancer. Examples are tobacco-smoking and chewing, ultraviolet and ionizing radiations and certain pesticides.
- Sneezing, runny nose, hayfever, etc are caused by exposure to some substances in the environment known as allergens, not necessarily harmful by themselves.
- Presence of high nitrate concentrations in drinking water often causes methaemoglobinaemia (Blue Baby Disease) in bottle fed infants. The nitrites produced from nitrates bind with haemoglobin to form methaemoglobin which inhibits oxygen transport in the body.
- Asthma is a disease which causes in obstruction to air flow in the respiratory passages and may be an allergic disorder which may even be fatal.
- Many heavy metals such as lead, mercury, arsenic and cadmium present in the environment at higher concentrations, cause adverse reactions often leading to cancer and death.
- Workers in mines, stone quarries, some industries etc. exposed to lot of noise for varying lengths of time. Long exposure to sounds more than 85/90 dB may cause annoyance, disturbed sleep, high blood pressure and temporary to permanent loss of hearing.

## TERMINAL EXERCISE

1. What are some of the sanitary problems in villages?
2. Describe the transmission of the following diseases – Typhoid, Filaria (Elephantiasis), and Amoebic dysentery. What is the causative organism for each of these diseases?
3. Describe a disease often prevalent in coal miners working for many years. State the measures required to control it.
4. What are some of the major pollutants from a thermal power plant? What can be done to minimize these?
5. Describe the symptoms of arsenic poisoning from drinking polluted ground water. In which parts of the body can arsenic accumulation be detected?
6. Discuss the problems caused in infants by high nitrate concentration in drinking water.
7. List auditory and non-auditory problems caused by too much noise.
8. Discuss the significance of addition of tetraethyl lead to petrol. Why has been the use of leaded petrol discontinued?
9. How does a cancerous tumor differ from a non-carcinogenic tumor?
10. What are some of the major effects of smoking and chewing tobacco?

## ANSWER TO INTEXT QUESTIONS

**11.1**

1. Health of a person is the result of interaction of a large number of influences upon the person.
2. To prevent for spreading many water borne diseases.
3. Slums are unplanned aggregations of hutments arranged very closely without any space for roads, parks, drains etc.
4. Lack of safe drinking water supply, improper disposal of excreta, high infant mortality (any other).

**11.2**

1. Malaria, yellow fever, encephalitis (any one)
2. Bacterial dysentery
3. *Leptospira*

**11.3**

1. Sugar mills and tanneries industries.
2. Suspended particulate matter.
3. Oxides of sulphurs, oxides of nitrogen, hydrocarbons, carbon monoxide, carbon dioxide.
4. Ammonia, pesticides smoke and water vapour.

**11.4**

1. Toxaphene/hexachlor cyclo hexane – HCH, BHC, dieldrin DDT (any three)
2. Clothing cover hands and feet, weary of broad. brimmed using of sunglasses.
3. Organic farming and Integrated Pest Management (IPM)
4. Elevated levels of nitrates in ground water.
5. Shorten of breathe, wheezing, chest lightness, pain around the chest, persistent cough that can last several weeks (any two).

**11.5**

1. Toxic metal are dispersed in the environmental through industrial effluents burning of organic wastes, transport and power generation. It may endanger public health after being incorporated in food chain.
2. Loss of appetite, loss of weight, diarrhea, gastrointestinal disturbance, skin cancer. (any two)
3. Methyl mercury.
4. Lead (Tetraethyl lead TEL)

**11.6**

1. Miners, lumberjacks, construction workers, formers, fishermen, storage workers and health care personnel.
2. Annoyance, temporary hearing loss, disturbed sleep.
3. Auditory fatigue, deadness or impaired hearing blood pressures, breathing and sweating, giddiness. (any two)

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# 12

# DISASTERS AND THEIR MANAGEMENT

In nature catastrophes such as floods, drought, earth quake, tsunami, happen from time to time causing immense damage to life and property. It is important to devise means and methods to manage and minimise from natural disasters as far as possible.

Disasters caused by human activities such as fires, accidents, epidemics are no less sudden than natural disasters and may be equally devastating. In this lesson you shall learn about causes, effects, prevention and management of natural as well as human made disaster.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain how ecological balance is maintained in nature;*
- *classify disasters into natural and man-made;*
- *explain the causes, effects and management of flood, cyclone, drought (water and climate related disasters);*
- *explain the causes, effects and management of earthquake (geologically related disasters);*
- *explain the causes, effects and management of forest fire, oil spill accident related disaster to industrial accidents;*
- *explain the causes, effects and management of biologically related disasters (epidemics namely dengue, HIV and cattle epidemics);*
- *explain the role of community and government in disaster management.*

## 12.1 ECOLOGICAL BALANCE IN NATURE

Nature is bountiful full of resources used by the living organisms use for their survival and well being. But nature has its own control systems. Resources used up are replenished excesses are checked, all naturally through the biogeochemical cycles, the food chains and webs and other natural phenomena. Thus equilibrium is maintained in nature. This is called ecological balance and has in recent times been disturbed by human activities.

## 12.2 NATURAL DISASTERS

The Indian sub continent is highly prone to natural disasters. Floods, droughts, cyclones and earthquakes are recurrent phenomena in India. Susceptibility to disasters is compounded by frequent occurrences of man-made disasters such as fire. The changing topography (topo = land) due to environmental degradation also increasing vulnerability to natural disasters. In 1988, 11.2%of total land area was flood prone, but in 1998 floods inundated 37% geographical area. Four major disasters that India has experienced in the recent past are the earthquake in Latur (Maharashtra in 1993), super cyclone in Orissa (1999), the earthquake in Gujarat (2001) and Tsunami in Tamilnadu and Andhra Pradesh in December 2004. Frequent disasters lead to enormous loss of life and property. Physical safety-especially that of the vulnerable groups is routinely threatened by hazards. Natural disasters can not be prevented but their damaging impact can be reduced through better forecast, and preparedness to take up effective rescue measures. The four major disasters mentioned above have very clearly illustrated that we need multi-hazard prevention, response and recovery plans for natural hazards so that threat to human life and property is minimized. Disaster risk management is essentially a development problem. Preparedness and planning for disaster management have to be taken up along with environmental concerns that the country is facing today.

### 12.2.1 Type of disasters

There are two types of disasters namely natural disasters and man made disasters. For example: fire, accidents (road, rail or air), industrial accidents or epidemics are some of the examples of man-made disasters, both natural and man-made disasters which have devastating input resulting loss of human life, loss of livelihoods, property and environmental degradation. Disasters disrupts normal functioning of society and leave long lasting impact. Earth quake, cyclone, flood and drought are examples of natural disasters.

### A. Natural disasters

Certain disasters occur in nature, without human provocation. They are described below.

(a) **Floods**

Floods are sudden and temporary inundation of a large area as an overflowing of rivers or reservoirs.

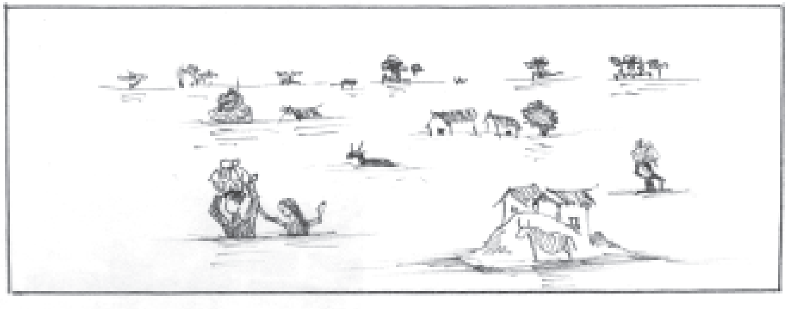

*Fig. 12.1: Flood*

(i) **Causes**

Floods are caused by rains, high winds, cyclones, tsunami, melting snow or dam burst. Flood can happen gradually or can happen suddenly due to heavy rains, breach of the water storage and control structures, spillover. Siltation of the rivers and reservoirs, and this can enhance the incidence and magnitude of floods.

(ii) **Effects**

- **Casualties**

Human and livestock death due to drowning, serious injuries and outbreak of epidemics like diarrhea, cholera, jaundice or viral infections are common problems faced in flood affected areas. Even wells, other source of drinking water get submerged resulting in acute shortage of safe drinking water during floods. Consequently often people are forced to drink the contaminated floodwater, which may cause serious diseases.

- **Structural damage**

During floods mud huts and buildings built on weak foundations collapse endangering human lives and property. Damage may also be cause to roads, rail, dams, monuments, crops and cattle. Floods may uproot trees and may cause landslides and soil erosion.

- **Material loss**

Household articles including eatables, electronic goods, beds, clothes, furniture get submerged in water and get spoilt all materials mounted on ground e.g. food stock, equipment, vehicles, livestock, machinery, salt pan and fishing boats can be submerged and spoilt.

- **Utilities damage**

Utilities such as water supply, sewerage, communication lines, power-lines, transportation network and railways are put at risk.

- **Crop loss**

Apart from the loss of human and cattle life, floods cause severe devastation of standing agricultural crops. Floods water spoils the stored food-grains or harvested crop. Floods may affect soil characteristics and may turn them infertile due to the erosion of the top soil or in coastal areas agricultural lands may turn saline due to flooding by sea water.

**• Flood control**

Flood control can be achieved through various means. The floodwater can be reduced by reducing the run-off water through afforestation. Forests promote rainwater percolation in the ground, thus recharging the groundwater and reducing the run-off water. Construction of dams also reduces flood water through storage. Dams can store water, which can not be accommodated in the river downstream may cause floods. Water can be released in a controlled manner from the dam. Desilting, deepening and increasing embankment increase the capacity of a river/channel/drain.

(iii) **Management**

The flood damage can be considerable reduced and loss of human lives can prevented through proper planning of flood control and management measures.

**• Identification of flood prone areas**

A rational planning for flood management involves identification the flood prone areas and frequency and magnitude of flooding in these areas.

**• Flood forecasting**

Normally there is a reasonable timely warning by alerting people and moving them to safer area well in time. Measurement of intensity of rainfall in the catchment area provide sufficient clue to hydrology engineers to calculate the possible submergence area along a river well before the flooding occurs. Accordingly expected run-off volume people can be warned to evacuate the likely areas to be flooded and advise to go to safer places along with their belongings including livestock. In India has a large network of rain measuring stations, flood warnings are issued by the Central Water Commission (CWC), Irrigation and Flood Control Department and Water Resources Department.

**• Land use planning**

Land use planning is very important for all the developmental activities. No major development should be permitted in flood prone areas. If construction is unavoidable it should be able to withstand the flood forces. Buildings should be constructed on elevated areas.

Afforestation should be encouraged. Deforestation in the catchments areas should be discouraged because deforestation results in excessive run off water and causes soil erosion, which is the main cause of river siltation resulting in floods. Any construction, which causes obstruction in drainage flow, should not be permitted. Encroachment of the storm water drains should not be allowed.

This reduces the risk of floods. Some precautionary measures are as follows -

- Build houses away from flood prone area.
- Keep yourself alert and updated to weather and flood forecasting information.
- In case evacuation warnings are issued, immediately go to the shelters provided.
- When you are moving to a shelter, move your valuable articles to safer elevated places so that they are not destroyed by flood water.
- Store extra food, such as rice, pulses etc. for emergency.
- Do not touch any loose electric wire to avoid electrocution.
- Do not spread rumours or listen to them.
- Make provision for adults and children who need special diet.
- After the flood is over, get yourself and your family members inoculated against diseases and seek medical care for injured and sick.
- Clear the house and dwellings of debris.
- Report any loss to the revenue authorities.

(b) **Drought**

Drought is an event that results from lower than normal expected rainfall over a season or period. The low rainfall is insufficient to meet the needs of human beings, plants, animals and agriculture. Short fall in rain results in drying of rivers, lakes, reservoirs and drying of wells due to excessive withdrawal and poor recharge of ground water and loss of crop yield due to shortage of water are some of the main indicators of drought.

**(i) Causes**

Drought occurs due to shortage of rainfall. As per Meteorological Department if rainfall is deficient by more than 10% of the annual average rainfall, the condition is said to be that of drought. The severity of drought is determined by the extent of deviation of rainfall from the average. In the recent past frequency of periods of drought have increasing due to deforestation and environmental degradation.

**(ii) Effects**

Drought has severe effects on agriculture. To start with drought affects mostly rainfed crops and subsequently the irrigated crops. The herdsman, landless labours, subsistence farmers, women, children and farm animals are most affected.

- Crop failure or food shortage leading to large scale starvation and death.
- Affects dairy activities, timber and fisheries.
- Increases unemployment.

- Depletion of ground water.
- Increases energy consumption for pumping water from deep aquifers.
- Reduces energy production in hydro-electric power plants.
- Loss of biodiversity; and reduced landscape quality.
- Causes health problems, increased poverty, reduced quality of life and social unrest leading to migration.

**(iii) Management**

The adverse effects of drought can be minimised if some measures are taken. A regular monitoring of rainfall, water availability in reservoirs, lakes and rivers as well as in comparison it with the demand. When water availability decreases than demand, water consumption need to be reduced by adopting various water conservation measures. These include economizing water consumption, by increasing water use efficiency, reducing wastage, reusing the wastewater for inferior uses. Use of efficient methods of irrigation and sowing low water-consuming crops are some important measures to overcome drought. Rain water harvesting increases water availability. Water harvesting is done by either allowing the run-off water from all the catchment areas to a common point and storing it in a reservoir or allowing it to percolate into the ground so far recharging groundwater.

**(c) Earthquake**

Earthquake is a sudden release of energy accumulated in deformed rocks of earth crust causing the ground to tremble or shake. Earthquake can occur suddenly any time of the year without any warning causing severe loss of life and property (Fig. 12.2). We are aware of the severe damage caused by earthquakes of Latur (1993) and Bhuj (2002).

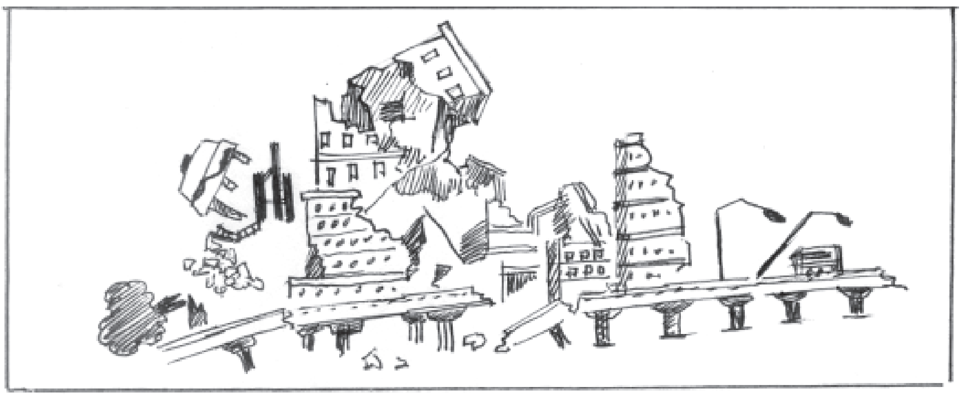

***Fig. 12.2:*** *Earthquake*

The intensity of an earthquake is related to the amount of energy released when rocks give way to the forces within the earth. It is measured with the help of an instrument known as

**seismograph**. (Fig. 12.3) The intensity is measured on Richter scale (after inventor C.F. Richter). Following values indicate degree of damage.

| Intensity on Richter Scale | Extent of damage |
|---|---|
| upto 3 | No damage |
| 3-5 | Cracks in old building |
| 5-7 | Cracks in roads |
| Above 8 | Collapsing of Buildings |

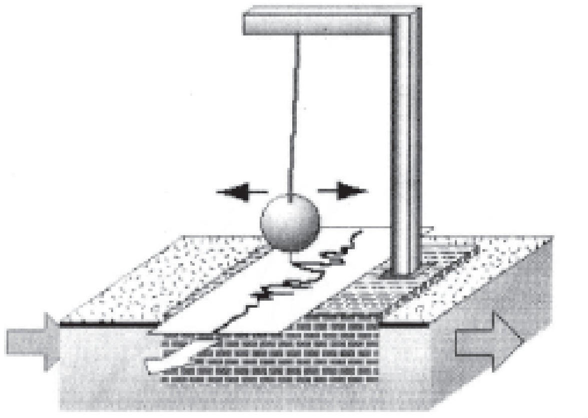

***Fig. 12.3:** Seisomograph*

(i) **Causes**

Earthquakes are natural ways of releasing energy by earth. An earthquake occurs in certain pockets of the earth which has geological faults. Such areas have already been identified.

(ii) **Effects**

• **Structural damage**

Earthquakes may cause physical damage to the buildings, roads, dams and monuments. High rise buildings or building built on weak foundations are especially susceptible to earthquake damage. Household articles including electronic goods and furniture get damaged. Human and livestock deaths or serious injuries from collapsing of building are common followed by outbreak of epidemics like cholera, diarrhoea, and infectious diseases. Utilities such as water supply, sewerage, communication lines, power-lines, transportation network, and railways get damaged.

• **Management**

The effects can be minimized if some of the following measures are taken:-

### Design of buildings

The buildings should be designed especially in earthquake prone areas in such a manner that they can withstand the stress of earthquake. Physical characteristics of soil should be analysed in order to ensure the strength to withstand the earthquake. Bureau of Indian Standards has formulated building designs and guidelines for constructions that withstand against earthquakes. Generally building design is approved by the concerned municipal authorities according to build by laws and safety requirements. Training of the builders, architects, contractors, designers, house owners and government officials is important.

Some of the precautionary measures in the event of an earthquake are as follows:

- Move out in the open;
- Keep calm, do not rush and panic, never use lift, keep away from windows, mirrors and furniture;
- Stand under strong beams that may not fall or creep under the dining table or a strong bed;
- If you are under a building and unable to move, cover your head and body with your arms, pillows, blankets to protect yourself from falling objects;
- If in a multi storey building stay on the same floor. Do not use elevators or run towards the staircase;
- If travelling stop the vehicle away from building, walls, bridge, trees, electricity poles and wires;
- Check for structural damage and clear the blockage;
- Check for injuries. Apply first aid. Help others;
- If your home is badly damaged by earthquake, come out immediately. Collect all emergency supplies like food, water, first aid kit, medicines, flash light or torch, candles, matchbox, clothes etc; if possible;
- Keep away from buildings especially old and tall ones, electricity poles, wires and walls.

### (d) **Cyclone**

Cyclones are violent storms, often of vast extent, characterised by strong and high winds rotating about a calm center of low atmospheric pressure. This center moves onwards, often with velocity of around 50 km/h. Cyclones strike suddenly though it takes time for them to build up. Cyclone is generally followed by heavy rains causing floods. Satellite tracking can predict on possible affected areas and inhabitants fore-warned can be made for warning. Warning and evacuation is done along the projected path.

#### (i) **Effects**

Light weight structures built of mud, wood, old buildings with weak walls and structure without proper anchorage to the foundation are at risk. The settlements located in low lying areas of coastal regions are directly vulnerable. Settlements in adjacent areas are vulnerable to floods, mudslide or landslide due to heavy rain. Telephone and electricity poles and wires, fences, light building structures such as thatched, tin sheds roofs, signboards, hoardings, fishing boats and trees are most vulnerable to cyclone damages. Due to heavy rains people and their property might be washed away in floods or blown away by cyclone itself. The cyclone along in the coastal areas may cause sea waves to enter on land and flood it. This may cause saline water contamination of soil and water in the affected area, affecting water supply and severely affecting agricultural crops.

(ii) **Management**

It is important to identify the cyclone prone areas. No development should be permitted in cyclone – prone areas. The building should be designed to withstand forces of wind and floods. All the elements holding the structures need to be properly anchored to resist the uplift. Coastal green belt has been found very effective in minimizing the effects of cyclones. Such green belts (trees growing along the coast) need to be developed along the coasts.

(e) **Tsunami**

Tsunami is also called seismic sea wave, or tidal wave, catastrophic ocean wave, usually caused by a submarine earthquake occurring less than 50 km (30 miles) beneath the seafloor, with a magnitude greater than 6.5 on the Richter scale. Underwater or coastal landslides or volcanic eruptions also may cause a tsunami. The term tidal wave is more frequently used for such a wave, but it is a misnomer, for the wave has no connection with the tides.

In a tsunami a train of simple, progressive oscillatory waves is propagated to great distances at the ocean surface in ever-widening circles, much like the waves produced by a pebble falling into a shallow pool. The observation has enormous practical value, enabling seismologists to issue warnings to endangered coasts immediately after an earthquake and several hours before the arrival of the tsunami.

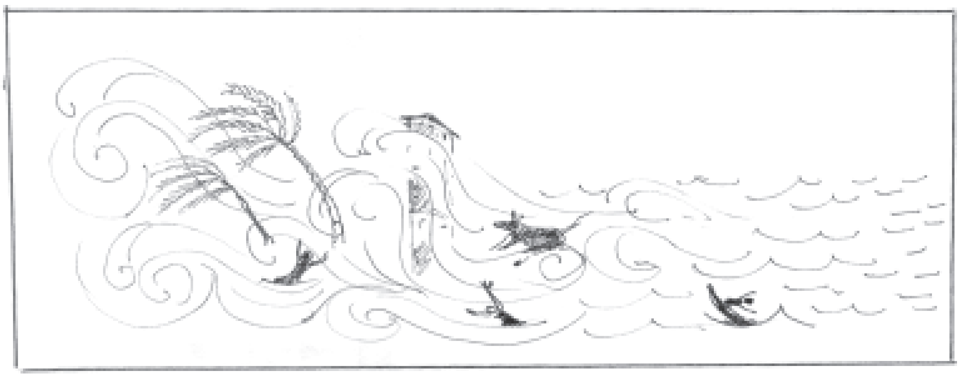

***Fig. 12.4:*** *Tsunami*

As the waves approach the continental coasts, friction with the increasingly shallow bottom reduces the velocity of the waves. This results in increased wave height up to 50 meter and above. Three to five major oscillations generate most of the damage. The effects of tsunami however, vary widely from place to place.

(i) **Effects**

The effects of tsunami are quite similar to those of cyclones or floods. Huge waves of sea water enters with great force and floods the land and washes away human settlements, agricultural crops and other properties. The famous tsunami of December 2004 has had devastating effects in many countries particularly in Indonesia, Malaysia, Srilanka, India etc. One large area of coastal districts of Andhra Pradesh and Tamilnadu. More than 2 lacs people died in 8 Asian countries including India.

(ii) **Management**

The mitigation measures are quite similar to those for cyclone or flood.

## INTEXT QUESTIONS 12.1

1. Define: (i) Floods (ii) Earthquake (iii) Cyclone (iv) Tsunami

2. Mention two ways by which floods may be controlled.

3. State any one effect of tsunami.

4. Why is a cyclone, generally, followed by floods?

5. State the change in the ocean with predicts the advent of tsunami.

### B. Manmade or Anthropogenic Disasters

Certains disasters occur in nature by humans activities. They are described below:

(a) **Fires**

Fires are events of burning something. They are often destructive taking up toll of life and property. It is observed that more people die in a fire than in a cyclone, earthquake, floods and other natural disasters combined. Fires are a great threat to forests and wild life because they spread speedily and cause tremendous damage in a short time. In cities fires break out in home, jhuggis, buildings specially godowns and factories. Fire can spread to a large area. Many people may die of burns and asphyxiation. It may also cause contamination of air, water and soil, which may affect the crops, plants and animals, and soil fertility.

(i) **Causes**

During summer months such fires results in casualties and enormous economic losses.

There are numerous causes of fires. Some important ones are given here-

- Throwing burning matchsticks or cigarettes irresponsibility.
- Heating sources can cause fire in houses e.g. clothes may catch fire while cooking on kerosene stove or gas stove.
- Cooking accidents are a major cause of fire at home. Fire can result due to unattended cooking.
- A short circuit in an electric wiring can cause fire. Overheating of electric appliances, poor wiring connections, use of sub-standard quality appliances can also result in a fire.
- Rubbish and waste materials often lying on roadsides or near houses may catch fire when people throw burning matchstick or cigarette butt.
- Storage and transportation of inflammable material or explosive chemicals without proper precautions may cause fires.
- Forest fires may result from human negligence or carelessness.

(ii) **Effects**

- **Casualities**

Death of humans and livestock may occur due to burning or serious injuries from fire. In rural areas often the entire harvested crop stored in securely may catch fire and burn to ashes resulting in heavy loss to the owner.

(iii) **Management**

- Obey fire safety rules and remember the evacuation route in case of fire.
- Keep and handle inflammable materials with utmost care.
- Keep a fire extinguisher in the house and learn how to use it.
- When you leave home, make sure to shut off all electrical and gas appliances.
- Do not plug several devices into one socket.
- Keep matches away from children.

- Do not block access routes by cupboards or any furniture.
- In the event of a fire call the fire department immediately.
- In the smoke filled corridor, crawl on all floors or on your belly as the smoke is less on the floor.
- Find at least two ways to escape from your home.
- Make sure that you remove all the waste material from work place and home on regular basis.
- Hazardous materials such as paints, solvents, adhesives, chemicals or gas cylinders should be kept in separate storage, well away from fire.
- Fire crackers on Diwali is a major cause of fire in our country. Use them carefully under supervision of elders.

(b) **Road, rail and air traffic accidents**

(i) **Road accidents**

Road networks are developed for better connectivity and service. Increased number of vehicles, violation of traffic rules, speeding, drunken driving and poor maintenance of vehicles as well as of roads are some of the main causes of road accidents. In order to avoid accidents following safety measures can be adopted:

- Look on either side of the road before crossing.
- Use zebra crossing while crossing the road by foot.
- Wear helmet while riding a two-wheeler.
- Use seat belt provided in your car.
- Drive only if you possess a proper driving license.
- Be familiar with road markings and honour them.
- Maintain a safety distance from the vehicle in front.
- Do not jump lanes. It becomes difficult for other vehicles, on the road to anticipate your move.
- Do not be rash and do not try to overtake unnecessarily.
- The best way to be safe on roads is to follow “lane driving”
- While driving avoid sudden acceleration and deceleration.
- Replace the worn tyres and faulty headlamps.
- Check the tyre pressure, radiator water, brake oil and fuel frequently.
- Dip your beam whenever you spot an oncoming vehicle.
- Follow the maintenance schedule prescribed by the manufacturer.
- Overcome impatience, anger and intoxication during driving. Road rage is dangerous.
- In case a mishap occurs stay calm.
- In case of fire, try to get out as early as possible and do not worry about the baggage.

(ii) **Rail accident**

The most common type of rail accident is derailment due to human error, sabotage or natural landslide in a hilly track, or fire. Rail accidents lead to large number of casualties and material damage. Indian Railways incur heavy loss due to such accidents every year. Some of the common safety measures are:-

- At railway crossings pay attention to the signal and the swing barrier. Do not get underneath and try to get across.
- In case of a unmanned crossing, get down from the vehicle and look at either sides of the track before crossing.
- Do not stop the train on a bridge or tunnel where evacuation is not possible.
- Do not carry inflammable material in a train.
- Do not lean out of a moving train.
- Do not smoke in train.
- Do not pull the emergency cord unnecessarily.

(iii) **Air accidents**

Air accidents may occur due to technical problems, fire, poor landing and take-off, weather conditions, hijacking, bombing etc. Some of the common safety measures are:

- Pay attention to the flight crew safety demonstration.
- Carefully read the safety card in the pocket.
- Know where is the nearest emergency exit and learn how to open it.
- Always keep your seatbelt fastened when seated.
- Stay calm, listen to the crew members and follow their instructions.
- Before you try to open any emergency door yourself, look outside the window. If you see a fire outside the door, do not open it or the flame may spread into the cabin. Try to use an alternate route for escape.
- Remember, smoke rises. So try to stay down if there is smoke in the cabin.
- If you have a cloth, put it over your nose and mouth.

(d) **Industrial accidents**

Industrial accidents can be due to explosion, fire and leakage of toxic or hazardous chemicals and lead to heavy loss of life and material. Leakage of chemicals and explosion may be due to human error, technological failure or geological hazards like earthquakes, flood etc. Fire in an industry may result from human error or electrical faults (short circuit).

(i) **Effects**

The industrial premises and immediate surroundings are at high risk in the event of an industrial accident. Employees and residents of nearby localities and their live-stock and crops in nearby areas are severely affected. The environment over a large area gets polluted. Hazardous chemicals released into the atmosphere or into a water body may travel long distances and may even damage the entire ecosystem around the industrial area. This is what has happened in Bhopal in the year 1984, when about 45 tonnes of methyl isocyanide (MIC) gas leaked into the atmosphere killing more than 2500 people.

Explosion or fire or leakage of corrosive chemicals severely damage structures. If the chemical is in gaseous form the geographical spread is fast and wide . Many people may die either due to mechanical damage from explosion or fire or due to toxicity of the poisonous chemicals. The routes of exposure to chemical released from an accidents are from inhalation, eye exposure, skin contact and ingestion. The polluting agents can have both immediate or long term effects. The immediate effects include death or other symptoms like dizziness, headache, irritation etc. The long term effects may include cancer, heart failure, brain damage, disfunction of immune system, deformation, genetic disorders or congenital(by birth) disorders in children.

(ii) **Management**

- **Inventory of hazardous chemicals**

It is important to have an inventory of hazardous chemicals along with their quality, storage locations, characteristics along with possible hazard associated with hazardous chemicals and this informed all employees and people living in the neighbourhood should informed about the potential risk. The inventory as far as possible high risk areas demarcated and displayed along with indicating affected zone and safe routes for evacuation in the event of emergency.

- **Location of industries**

Industries should not be sited in residential areas. A large buffer zone, in form of a green belt, for separating an industrial area from residential areas.

- **Community preparedness**

The community should be aware of the hazardous installations and know how to combat the situation. Some members of the community should monitor the potential risk and participate in safety training organised by industries.

- **Other measures**

Limit storage capacity of the toxic chemicals. Improve firefighting capability, warning systems and measures for preventing pollution dispersion. Develop emergency relief and evacuation planning for employees and nearby settlements. Adopt insurance for employees and surrounding population which is mandatory under the law.

## 12.3 BIOLOGICAL DISASTERS

### 12.3.1 Epidemics

**Epidemic** is defined as occurrence of an illness or other health related event that is unusually affecting a large population. An epidemic can be anticipated by a sudden increase in the number of people suffering from a particular disease, increase in the population disease carrier. In order to control the spread of epidemics urgent measures are essential. Outbreaks of communicable disease to ready epidemic level are potentially high after a disaster.

(i) **Cause**

The outbreak of diseases is mainly due to poor sanitary condition leading to contamination of water or spread of disease form breeding of the disease vectors. Other factors include seasonal changes that favour breeding of insects. Vectors, exposure of a non-immune population (eg tourists or migrants), poverty and overcrowding.

(ii) **Effects**

Epidemic may cause mass illness or death. There are secondary effects such as disruption in the society and economic losses. Vulnerability is high among those who are poorly nourished, people living in unhygienic in sanitary conditions, poor quality of water supply, lack of access to health services.

(iii) **Management Measures**

Preventive public health measures needs to be strengthened. Personal protection through vaccination is an effective mitigation measure. Improvement of sanitary conditions, fumigation of vector breeding sites and proper disposal of domestic and municipal wastes greatly reduce chances of epidemic spread of diseases. Contingency plan for dealing with the epidemics that are likely to occur in the region. Early warning system and regular surveillance are primary requirements so as to mount an effective control response in early stages to prevent any outbreaks.

Some common diseases that may reach epidemic proportions are described below:-

(a) **Dengue**

Dengue is also called **Breakbone Fever**, or **Dandy Fever**. It is an acute, infectious, mosquito- borne hemorrhagic fever. Besides fever, the disease is characterized by an extreme pain and stiffness of the joints (hence the name "breakbone fever"). Dengue is caused by a virus transmitted through a mosquito called *Aedes aegypti* or Asian tiger mosquito.

A mosquito becomes infected only if it bites an infected individual (humans) during the first three days of the victim's illness. It then requires 8 to 11 days to incubate the virus before the disease can be transmitted to another individual. Thereafter, the mosquito remains infected for life. The virus is injected into the skin of the victim. There is no specific therapy; therefore attention is focused on preventive measures involving mosquito control is only effective way to prevent spread of dengue.

(b) **HIV and AIDS**

The year 2001 was the 20th anniversary of the initial reports of a mysterious deadly immune-system disorder that came to be known as AIDS (or Acquired Immuno Deficiency Syndrome). The disease epidemic that had killed more than 21 million people in the World. In 2001 an estimated 36 million people were living with HIV infection. This disease is caused by virus, called HIV (Human Immune Virus) which is mostly transmitted through sexual union and blood transmission

(c) **Mad Cow Disease** (**Bovine spongiform encephalopathy**)

Bovine spongiform encephalopathy (BSE or mad cow disease) in cattle is caused by an infectious agent that has a long incubation period, between two and five years. Death usually follows within a year of the onset of symptoms. No treatment or palliative measures are known.

First recognized in cattle in the United Kingdom in 1986, Mad cow disease (BSE) became epidemic there, particularly in southern England. After the emergence of mad cow disease, concern grew over a possible relationship between the animal disease and the occurrence of brain fever disease in man (Creutzfeldt-Jacob disease). Possibly due to consumption of infected beef.

## INTEXT QUESTIONS 12.2

1. Name three disasters caused by human carelessness.

2. How can road accidents be prevented?

3. Why should chemicals be stored away from human settlements?

4. State two causes of disasters fire?

5. Why are diseases such as HIV/AIDS considered as a disaster?

## 12.4 COMMUNITY LEVEL DISASTER MANAGEMENT

At the time of disaster, various agencies such as government, NGOs and community plays an important role for disaster management.

These are preparedness, response, recovery and prevention details are on follows:

Disaster management has four basic components:

**Preparedness**: Measure to ensure that communities and services are capable of coping with the effect of disaster. It has the following main elements:

- Community awareness and education;
- Preparation of disaster management plans for community, school, individual;
- Mock drill, training and practice;
- Inventory of resources both material resources and human skill resources;
- Proper warning systems;
- Mutual aid arrangement;
- Identifying the vulnerable groups;

**Response**: Measures taken in anticipation of, during and immediately after a disaster for minimizing its adverse impact. It has following main elements:

- Activate the emergency operation centres (control room);
- Deployment of search and rescue teams.
- Issuing updated warning;
- Setting up community kitchens using local groups;
- Set up temporary living accomodation and toilet faciliites;
- Set up medical camps;
- Mobilising resources;

**Recovery:** Measures are initiated to undertake reconstruction of the physical infrastructure and restoration of economic and emotional well being. The main elements are as follows:

- Community awareness on health and safety measures;
- Counselling programme for those who have lost the near and dear ones;
- Restoring the essential services -roads, communication links, electricity etc.;
- Providing shelters;
- Collecting usable materials for construction from rubble;
- Providing financial support;

- Finding employment opportunities;
- Reconstructing new buildings.

**Prevention:** Measures to eliminate or reduce the incidence of severity.

- Land use planning;
- Preventing habitation in risk zones;
- Disaster resistant buildings;
- Finding ways to reduce risk even before the disaster strikes;
- Community awareness and education.

The first few hours before and after a disaster are critical and precious for saving lives and reducing further injury. Often external help may take time to reach the disaster site. In any disaster, often the neighbours are first to respond. The first responders are people who act first in a disaster situation, usually lack basic response skills to deal medical or other emergencies. The aim of community level management is to train the individuals and the members of local community to deal with emergency situation effectively. Trained community members are life saving assets in such situations. Thus community level management involves people's participation.

## 12.5 GOVERNMENT INITIATIVES ON DISASTER MANAGEMENT

The Government of India has set up a National Committee on Disaster Management (NCDM) under the Chairmanship of the Prime Minister. The recommendations of this National Committee would form the basis of national disaster risk management programme and strengthening the natural disaster management and response mechanisms. United Nations Development Programmes (UNDP) has also been supporting various initiatives of the government to strengthen disaster management capacities.

The programme components would include the following:

- Development of state and district disaster management plans.
- Development of disaster risk management and response plans at Village/ Ward, Gram Panchayat, Block/Urban Local Body levels.
- Constitutions of Disaster Management Teams and Committees at all levels with adequate representation of women in all committees and team. (Village/ Ward, Gram Panchayat, Block/Urban local body, District and State.)
- Capacity Building of Disaster Management Teams at all levels. Special training for women in first aid, shelter management, water and sanitation, rescue and evacuation, etc.

- Capacity Building in cyclone and earthquake resistant features for houses in disaster-prone districts, training in retrofitting, and construction *of* technology demonstration units.
- Integration of disaster management plans with development plans *of* local self governments.

## INTEXT QUESTIONS 12.3

1. Name the form components of disaster management.

2. Why is community level disaster management important?

3. Define NCDM?

## WHAT YOU HAVE LEARNT

- The Indian sub continent is highly prone to natural disasters. Floods, droughts, cyclones and earthquakes are a recurrent phenomenon in India.
- Susceptibility to disasters is compounded by frequent occurrences of human made or anthropogenic disasters such as fire, epidemics etc.
- Four major disasters that India has experienced in the recent past are the Earthquake in Latur (Maharashtra in 1993), Super cyclone in Orissa (1999), the Earthquake in Gujarat (2001) and Tsunami in Tamilnadu and Andhra Pradesh in December, 2004.
- Floods are temporary inundation of large region as a result of increase in level of river or reservoir due to heavy rains, high winds, cyclones, tsunami, melting snow or dam burst. Floods cause heavy toll on life of people, livestock and materials. Deforestation resulting in soil erosion causing siltation of the rivers and reservoirs can enhance the incidence of floods.
- Drought is an event which results from lower rainfall than expected over a season or period. The rainfall is insufficient to meet the need of human beings, plants, animals and agriculture.
- The most important effect of drought is on agriculture. It affects dairy activities, fisheries, increases unemployment. Causes loss of biodiversity, groundwater depletion and food

shortage causing starvation deaths, health reduction, increased poverty, reduced quality of life and social unrest leading to migration.

- Earthquake is a sudden release of energy accumulated in deformed rocks of earth crust causing the ground to tremble or shake.
- The most important effect of earthquake is collapse of buildings especially high rise buildings or building built on weak foundations endangering human lives and properties.
- Fires are events of something burning and is often destructive taking up toll of life and property. It is observed that more people die in fire than in cyclone, earthquake, floods and other natural disasters combined.
- Accident on road, rail and air also take a major toll on life and property.
- Following regulations can prevent majority of such accidents. Epidemics of various diseases occur mostly due to ignorance.
- If proper mass awareness programmes are conducted for the people. A majority of them can be avoided.
- Community level participation in disaster management is very useful as they are the first responders.
- Government of India is conducting several initiatives in order to involve public at various level in order to implement the disaster management plan effectively.

## TERMINAL EXERCISE

1. Why do floods occur?
2. How can you mitigate the effects of floods?
3. Why is drought common in our country?
4. How can the ill effects of drought overcome?
5. What is tsunami?
6. Why do epidemics occur in our country?
7. Write a note on fire mitigation measures
8. Give a brief account of damage caused by industrial accident
9. What arc the advantages of involving the community in disaster management?
10. What is the contribution of the government in disaster management?

## ANSWER TO INTEXT QUESTIONS

**12.1**

1. (i) Are temporary inundation of a large region as a result of increase in level of river or reservoir.

   (ii) Is a sudden release of energy accumulated in defamed rocks of earth crust causing the ground to tremble or shake.

   (iii) Are wild storms often of vast extent, characterised by strong and high winds rotating about a calm centre of low atmospheric pressure.

   (iv) Is a catastrophic ocean wave, caused by a submarine earthquake.

2. Through afforesting, construction of dams, Desalting, deepening and increasing embankment increase the capacity of a river/channel/drain./channel. (any two)

4. Sea water floods the land and wash away human settlement, agriculture and other properties

5. Due to heavy rain causes flood and vulnerable form of flood is followed by cyclone.

**12.2**

1. Fires, Accidents (rail, road, air), industrial accidents

2. Drive safely, lane driving by following traffic rules, any other

3. To prevent industrial accidents

4. To throw burning match sticks or cigarettes, heating sources, short circuit of electric wires, storage and transportation of inflammable material or explosive chemical (any two)

5. Because it affects a large number of population.

**12.3**

1. Prepareness, response, recovery, prevention

2. Because community or neighbours respond first to disaster situation

3. National Committee on Disaster Management (NCDM) has set up by Government of India under the chairmanship of the prime minister.

# 13

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# NATIONAL ENVIRONMENTAL ISSUES

By now you are familiar with the term environment. You are also aware that the environment has no geographical boundaries. Whatever damage is done to the environment at a place it affects nearby or even distant places. These effects show up immediately or slowly.

The explosive growth of the human population has been accompanied by rising expectations and increase in the standard of living. More food, more houses, more transport, more energy and more of everything is required. This growing human need has resulted in depletion of natural resources; deforestation, loss of biodiversity, water and energy scarcity, increasing exploitation of mineral resources etc. have led to the degradation of the environment. It is important to identify and address important issues to conserve and improve the environment. Some major national environmental issues such as land and forest management, water scarcity, energy, fast depletion of natural resources and many other will be discuss in the lesson.

## OBJECTIVES

After completing this lesson, you will be able to:

- *provide statistics of land and forests of India;*
- *define growth and analyze the shifts in population growth curves;*
- *analyse the demographic factors that influence the changes in human population;*
- *trace the pattern of human population growth;*
- *explain the impact of increasing human population on the environment;*
- *correlate urbanization with the changing environmental patterns;*
- *appreciate the importance of fresh water as a resource;*
- *describe the natural resource degeneration in terms of desertification, deforestation, soil-degradation and biodiversity loss in brief.*

## 13.1 LAND AND FORESTS OF INDIA

Our country occupies south central peninsula of Asia. India consists of the main land and two groups of islands Andaman and Nicobar in the Bay of Bengal and Lakshadweep islands in the Arabian Sea. The physical map of India (Fig. 13.1) shows the relief (physical features) and coastline of India. India has a total of about 32,87,263 sq. km of land and more than 7500 km long coastline. Being situated totally north of the equator, India belongs to the Northern Hemisphere. Though India is the seventh largest country in the world, it occupies only 2.42% of the world's total area.

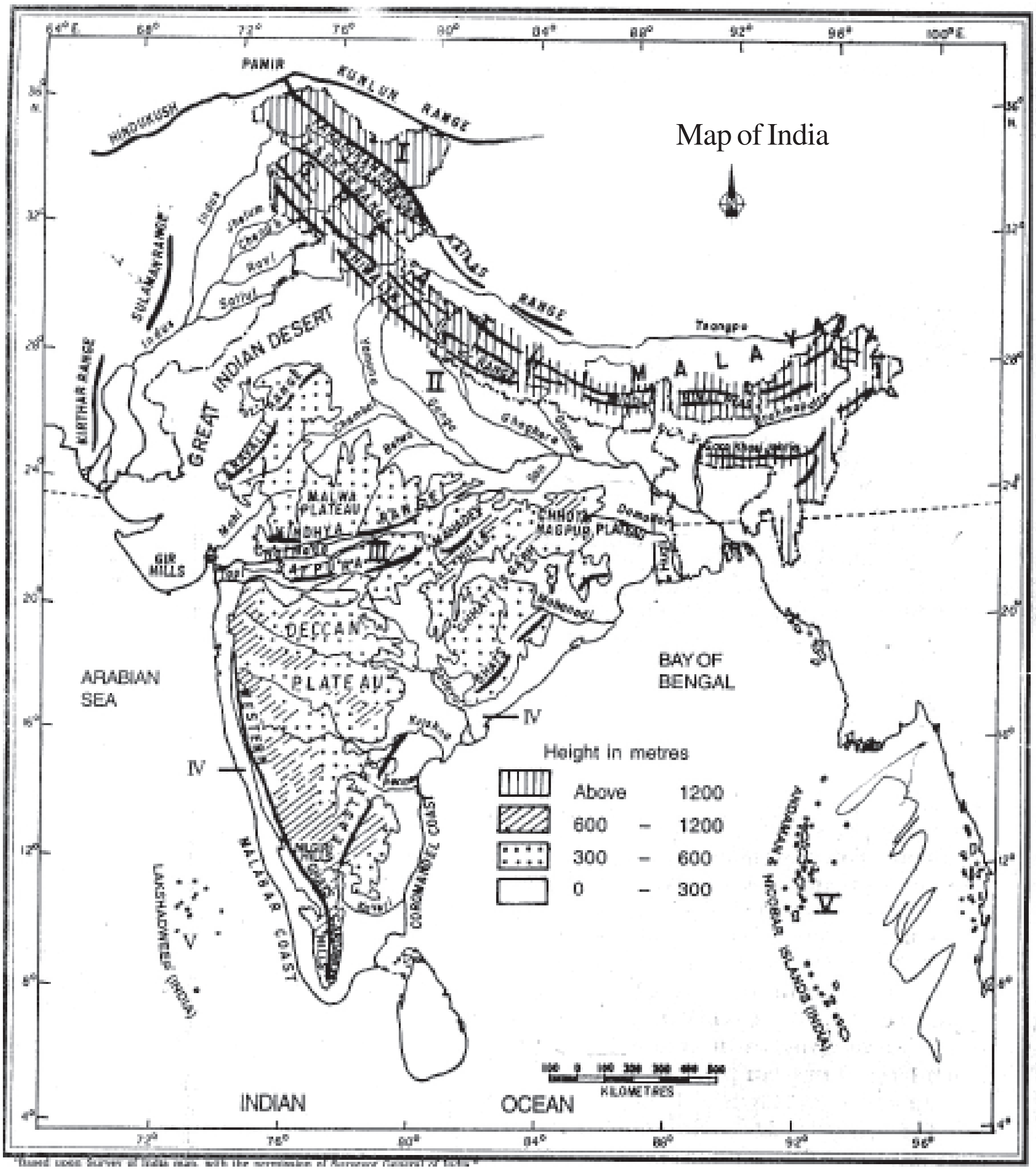


*Fig.13.1: Physical map of India*

### 13.1.1 Land

India is characterized by a great diversity of physical features. In the North, there is a vast expanse of terrain, consisting of sedimentary and metamorphic rocks, a chain of lofty peaks of mountains, enclosing plateaus and deep and narrow valleys.

The surface of north Indian plains along the expanse of the river Indus, the Ganga, and the Brahmaputra is made up of alluvium. The northern plains are the granaries of the country. The peninsular plateau in the south is made up of igneous and metamorphic rocks. This peninsular plateau is rich in minerals. The coastal region, and the islands provide sites for fishing and port activities and oceanic wealth. In addition, the island groups have vast coral deposits, rich bio-diversity and are of great strategic importance for defence purposes.

### 13.1.2 Forests

A forest is a community of living trees or plants and associated organisms covering a considerable area, utilizing sun-shine, air, water and material from the soil to sustain and reproduce itself. Forests provide wood canes, gums, resins, dyes, tannins, fibres, medicines, food etc., to humans.

**• Flora and fauna**

India has very rich flora and fauna. It is home to about 8100 animal species and 49, 000 plant species of which 15000 are flowering plants. Most of the Himalayan and peninsular regions are covered with indigenous flora. Some of them are totally endemic (local, not found elsewhere). The forests and the vegetation therein, is classified and determined by climatic factors such as temperature, heat, precipitation, soil, relief, drainage etc. The following major types of forests may be identified in India.

i) Tropical rain forests

ii) Tropical deciduous forests

iii) Temperate broad leaf forests

iv) Temperate needle – leaf or coniferous forests

v) Alpine and Tundra Vegetation

You have already studied the details of the various types of forest in lesson 5 and lesson 9.

Table 13.1 provides data on covered areas under forests of different types.

***Table 13.1:*** *Forest cover in India**

| Class of forest | Area in sq. Km | Percent of geographical area |
|---|---|---|
| Dense Forest | 3,77,358 | 11.48 |
| Open Forest | 2,55,064 | 7.76 |
| Mangrove | 4871 | 0.15 |
| Scrub | 51,896 | 1.58 |
| Non-Forest | 25,98,074 | 79.03 |
| Total | 32,87,623 | 100.00 |

* As per 1999 assessment done with the help of imageries produced by IRS-1B; IRS-1C and IRS-1D

Of the total forest cover in India, seven North-East states together have 25.7% followed by Madhya Pradesh (20.68%) and Arunachal Pradesh (10.8%).

## INTEXT QUESTIONS 13.1

1. What does the statement, "some Indian flora and fauna are endemic", mean?

   ______________________________

2. Which part of India holds the 'granaries' and which part is mineral – rich?

   ______________________________

3. List five major forest types of India.

   ______________________________

4. Name any three materials that forest provide to us.

   ______________________________

## 13.2 POPULATION GROWTH

The large human population issue is one of the most important issues of the environment. The human populations pose danger to the environment through two main factors: (1) the number of people and (2) the impact of each person on the environment. You know that in last 40 years world human population has doubled from 2.5 billion to more than 6 billion. In the same period in our country it has risen from 431 million to 1027 million.

> Population is defined as a group of individuals living in the same given area and capable of interbreeding and sharing genetic material.

**Why study population?**

On economic terms a population constitutes both consumers as well as producers. It's study helps us to:

- provide data on the total manpower available now and in future;
- estimate the total amounts of goods/ services required currently and in future;
- to promote cultural/regional/linguistic harmony.

### 13.2.1 Major periods of human population growth

Through history, four major periods of human population growth worldwide can be traced:

(1) **An early period of hunters and gatherers**: At that time the total population was less than a few million.

(2) **The period of rise of agriculture**: This period led to greater density of people and caused the first major rise in the human population.

(3) **The industrial revolution**: This resulted in better food supply, improved healthcare which, in turn, led to rapid rise in the population, and

(4) **The present**: When the population is slowing down in the wealthy and industrialized nations but is still growing rapidly in poorer and developing and underdeveloped nations.

On economic terms, population can be categorized as follows: if the resources of a region are more than adequate for its people, the region is called (i) **under populated** -If these are just enough, then the region is said to have (ii) **optimum population**. However, if the resources get overused and it is not possible to produce the same amount of goods or services for every individual of the region, the region is termed (iii) **over populated**.

Therefore, it is not only the number of individuals but also the quality of life of each of them in a region is very important. Disparities in such qualities are quite often the cause of social tension/ imbalances.

### 13.2.2 Demographic features

The study of various aspects of a population is called **demography.** The major parameters used for study of demography are size; growth; age structure; demographic transactions; fertility; birth rate; death rate; standard of living and growth rates and migration.

**(i) Size**

The size of the population is measured in terms of the number of persons of a region/ country. The population count by census 2001, by the Registrar General of India shows that India's population is 102 crore. The absolute rise in the last decade 1991-2001 has been more than 18 crores. Compare this when the absolute rise in 1901-1911 decade was just 1.36 crores

Are we as a Nation providing every individual essential goods/services? This is a very important environmental issue that our country faces today.

**(ii) Growth of the population**: The growth of population at different times can be expressed in terms of growth rates. The growth rate, that is the rate of change per 1000 individuals, determines the changes in population.

**Calculation of growth rate of population**

For the calculation of growth rates, we have to first calculate the birth rate and death rate.

We can calculate them as follows:

**Birth rate**: Rate at which births occur in a population

Let N= Total number of individuals in the population, B= Number of births per unit time by the total population 'N', b = birth rate

Then, b= Birth rate or Total no of individual added in the population *N* = number of births per unit time by the total population

$$b = \frac{B}{N}$$

**Death rate**: Rate at which death occur in population

Let N = Total number of individuals in the population
D = Total number of deaths per unit time in the population 'N'
d = death rate

Then, d = death rate – total number of individual in the population
N Total number of deaths per unit time in the population

$$d = \frac{D}{N}$$

**(iii) Growth rate**

The growth rate (g) is the result of the number of births **minus** the number of deaths per unit time divided by the total number of individuals in the population.

To calculate the growth rate,

Let B = total number of births per unit time.
D = total number of deaths per unit time
G = the difference between the total births and the deaths of the individuals per unit time.
N = The total number of individual in the population.
g = growth rate for that per unit time

then $$g = \frac{(B-D)}{N} \text{ i.e. } g = \frac{G}{N}$$

i.e. g = G/N or the difference between the total births and the deaths of the individuals per unit time. The total number of individual in the population

**(iv) Mortality**

Mortality refers to the death of individuals. In a population, members die due to various causes, such as, malnutrition, disease, old age, accidents, natural calamities and war etc. It is equal to death rate.

### (v) Natality

Natality is an expression of the addition of new individuals in a population. It is equivalent to birth rate.

### (vi) Migration

**Migration** means the movement of individuals of a population. The movement of the individuals out of one's own country is called **emigration**. Emigration may occur because of various reasons, viz: better job opportunities elsewhere; better education facilities elsewhere; illegal transfer; war; natural calamities; internal disturbances in the host country. For example, **emigration** of youth of our country to USA, New Zealand, Australia. The movement of individual from one region of a country into another region of the same country is called **internal immigration**. Does internal immigration affect the population size of the country?

***Table 13.2:*** *Distribution of migration by reason (percentage)*

| | 1981 | | 1991 | |
|---|---|---|---|---|
| **Reasons** | **Male** | **Female** | **Male** | **Female** |
| Employment | 1.9 | 31.8 | 1.8 | 27.0 |
| Education | 1.0 | 5.1 | 0.8 | 4.8 |
| Family Moved | 14.3 | 30.3 | 11.0 | 26.6 |
| Marriage | 73.4 | 3.3 | 76.1 | 4.0 |
| Others | 9.4 | 29.5 | 10.3 | 37.6 |
| Total Migration (Crore) | 14.52 | 62.5 | 16.78 | 64.3 |

The **internal migration (look at the table 13.2)** within the country is usually from rural areas to urban sector. The population in rural areas rise sharply as compared to urban areas. Lack of demand for labour for agriculture, increased job opportunities in cities and better education facilities in cities, better health care in cities, better living conditions are some of the key factors deciding internal migration from rural areas to urban areas. Why do you think that internal emigration from rural area to cities is a very important environmental concern in our country? (Hint: pressure on essential resources; slums)

### Exponential growth rate

Whenever something increases in such a way that the increase is a fixed proportion of its own size at any time, the increase is called **exponential.**

Population growth of human beings also follows the same pattern as seen for bacteria (See box and Fig. 13.2), you would find similar J-shaped curves in both bacteria and human growth rates. You shall also note the decrease in time it took to add each additional billion in human population. It took thousands of years to reach a billion of human population. It took, further, 130 years to reach 2 billions, only 30 years to reach 3 billion, and only 11 years to add another billion (Fig.13.3). When the population approaches the full carrying capacity (the capacity sustain itself at equilibrium), the growth rate decreases and the growth changes from J-shaped curve to S-shaped curve. (Sigmoid curve).

When bacteria divide every 30 minutes, their number increases exponentially. This set of figures assumes a zero death rate, but even if a certain percentage of each generation of bacteria died, exponential growth would still occur, it would only take a bit longer to reach the high number. When data is graphed, the curve of exponential growth has a characteristic "J" shape.

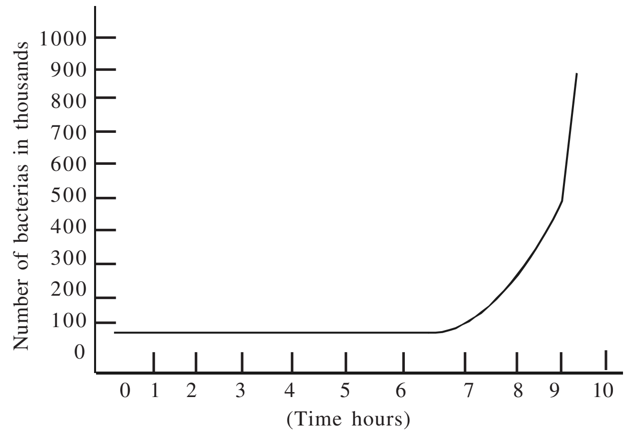


***Fig. 13.2:*** *Exponential growth in bacteria*

If we know the growth rates in percentage for years, we can easily calculate/predict the time 't' in years for a population to double by using formula

T = 70/annual growth rate in percentage

For example: If a population is growing at the rate of 2% annually, the population shall double in 70/2 = 35 years.

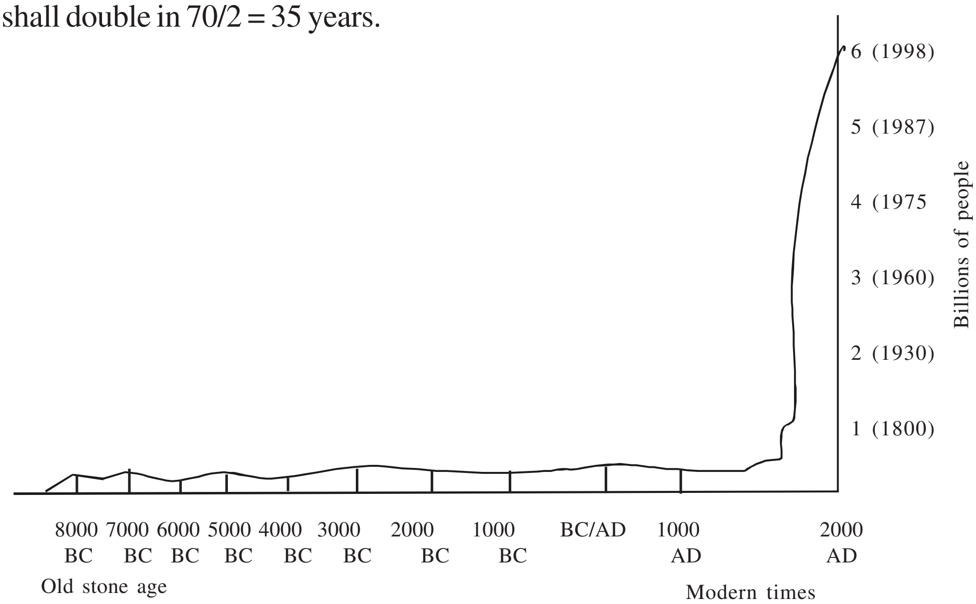


***Fig. 13.3:*** *The human population has been increasing exponentially from the New Stone Age to the present. It also represents a J-shaped curve.*

## INTEXT QUESTIONS 13.2

1. Define population
2. List four major periods of human population growth
3. List major parameter for the study of demography
4. Define exponential growth
5. Why internal migration within a country does not affect its total population size? What kind of migration does affect the population size of a country?

## 13.3 STRUCTURE OF POPULATION

In population studies, the structure of a population is determined by certain characteristics such as population density, dispersion, age structure and sex ratio. Let us understand these terms.

### 13.3.1 Density

Density represents the number of individuals of a species inhabiting a unit area. It reflects the success of a population. The complete count of the individuals in an area is called **census**. Such censuses have been regularly conducted in our country. The last census was completed in the year 2001. The process for Census 2011 has already been initiated. The density map of India is shown in fig.13.4. Some countries with higher density than India are: Japan (332 sq km$^{-2}$), The Netherlands (456 sq Km$^{-2}$), Bangladesh (915 sq km$^{-2}$), islands of Malta(1163sq km$^{-2}$). Why should the density of population be of some concern to us? Look at the table 13.2 and box 13.2 to appreciate the problems associated with increased population density.

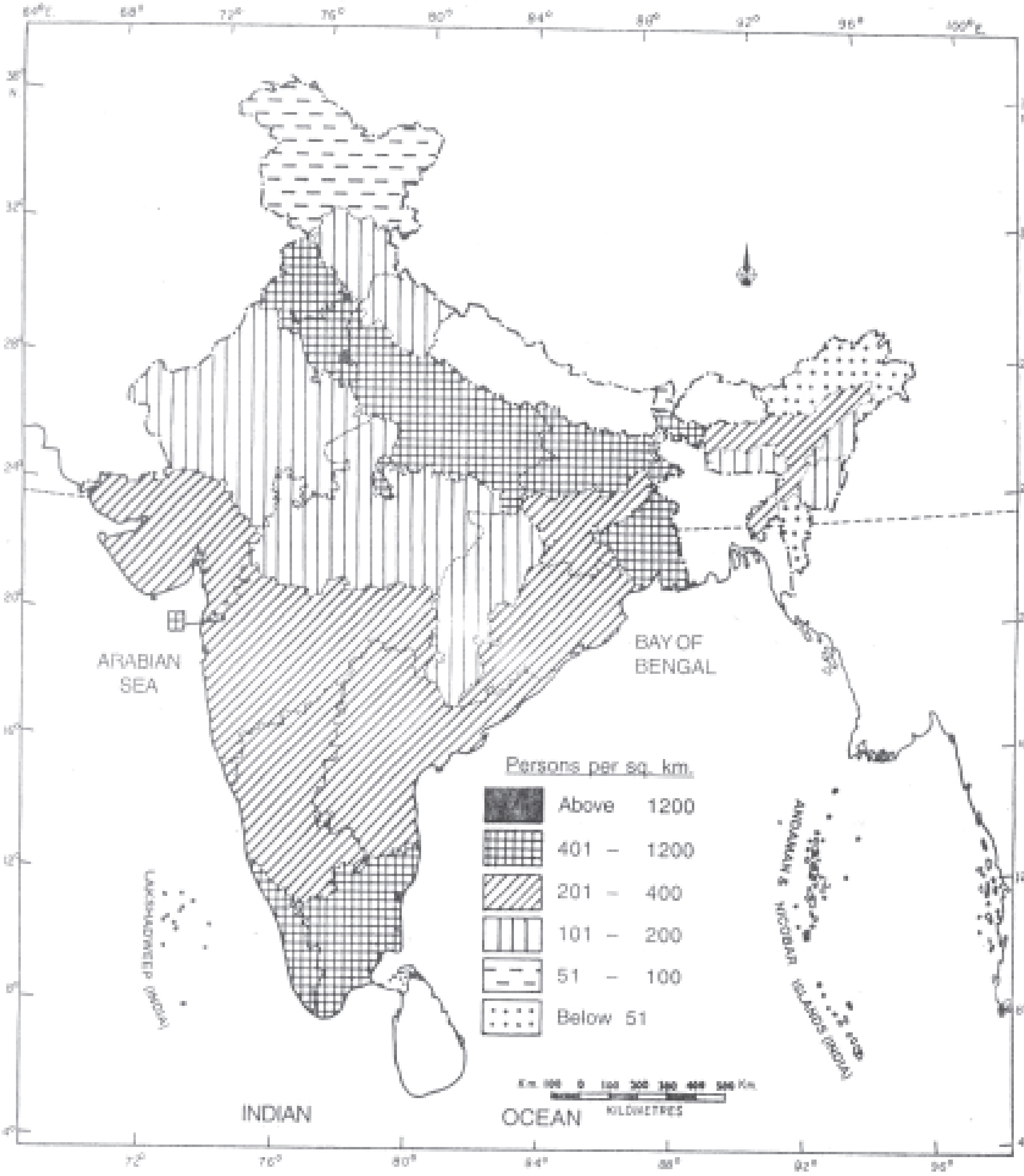


*Fig. 13.4: Density Map of India as per census 2001*

**Box-13.2**

The problems arising out of increase in population density are very alarming. Some of them are:

- per capita income decreases;
- basic needs of life can become limited;
- available natural resources such as water, land, fuel decreases;
- shortage of essential goods results in rise of prices;

- non-availability of essential goods leads to disparity/interest;
- land mass used for housing/industry;
- agricultural space decreases;
- fall in farm output as well as decreased forest cover;
- lack of balanced diet to all the members of the family; leading to malnutrition; loss of efficiency, increased susceptibility to disease;
- increased demand for healthcare services;
- fall in job ratio leading to unrest;
- lack of adequate educational facilities, lowering of standards, increased number of uneducated people;
- severe stress on sanitation; increased pollution of air, water and soil
- overall harmful effects on human health.

### 13.3.2 Dispersion

Dispersion pattern of a population is the dispersion of its individual members relative to one another in a given area. For example, human population, it is not uniformly dispersed. Only one third of the total land area is inhabitated by humans. Even out of this one-third, some areas are thinly and others are very heavily populated. (Fig. 13.5)

The distribution variation depends on availability of the requirements of life. About 56 percent of world population resides in Asia. Prepare a dispersion map for your locality. (Expand this activity)

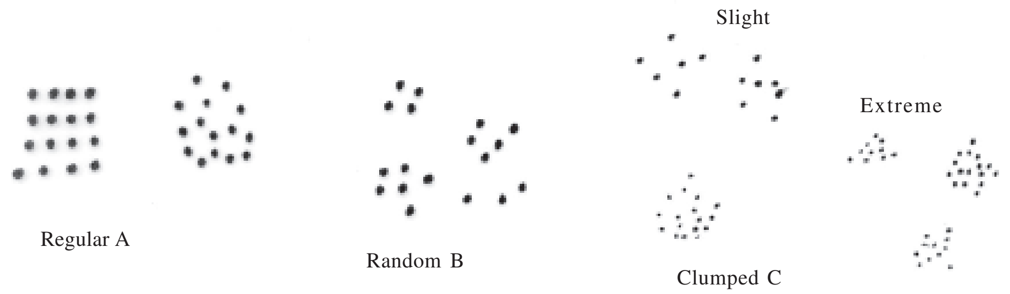


***Fig. 13.5:*** *Dispersion patterns in population in clumped, clumps may themselves be regularly or randomly dispersed*

### 13.3.3 Age structure

In a population, individuals are of different ages. The proportion of individuals in each age group is called **age structure** of that population. Look at the age structure of India in fig.13.6 and table 13.3.

*Table 13.3:* Age structure of population by selected groups (per cent)

| Group | Age group | 1911 | 1921 | 1931 | 1961 | 1971 | 1981 | 1991 |
|---|---|---|---|---|---|---|---|---|
| Children | 0-14 | 38.8 | 39.2 | 38.3 | 41.0 | 41.4 | 39.7 | 36.5 |
| Adults | 15-60 | 60.2 | 59.6 | 60.2 | 53.3 | 54.4 | 54.1 | 57.1 |
| Old | 60+ | 1.0 | 1.2 | 1.5 | 5.7 | 5.2 | 6.2 | 6.4 |

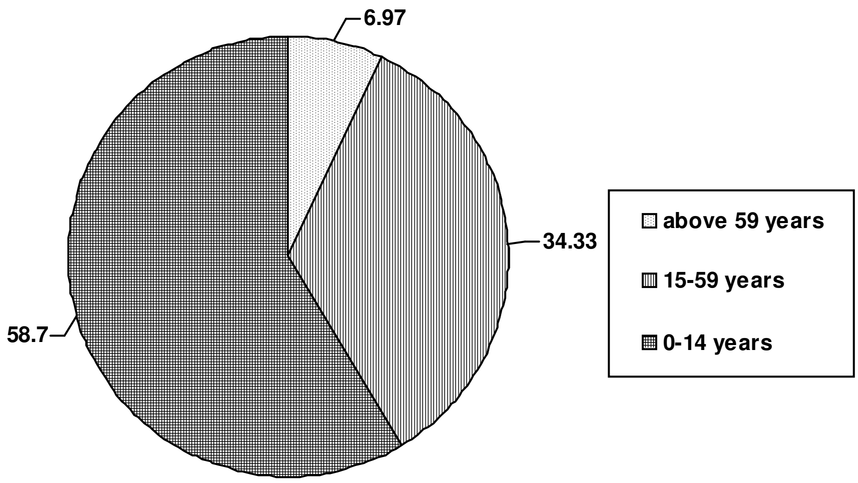


*Fig. 13.6:* Age Structure of Indian Population

Box 13.3 provides you information as to why study of age structure is so important.

Study of age structure is important because:

It provides

- current and future status of age profile;
- possible effects on environment;
- insights in to population history;
- available and future work force (15-59 years)/manpower;
- status of elderly people needing social support, now and in future;
- projection for current, future educational needs;
- projection for job needs
- projection for medical/social/housing/healthcare needs;
- economic status of the society.

### 13.3.4 Sex ratio

Ideally there should be a balance in number of males and females in a population. However, in Nature, there are more male births than female births. If there is no discrimination on the part of the society, the sex ratio of a population should remain more or less constant or balanced. Any deviation from this balance is not desirable for the population. In our country, there were 972 females per every 1000 male (i.e. sex ratio is 972) in 1901. By 2001, the sex ratio has fallen to 933 to every 1000 male. There are, however, very sharp regional differences. For example: in Kerala and Pondicherry, the sex ratio is 1058 and 1001 respectively, it is very poor in Delhi(821), Haryana (861), Punjab (874), Chandigarh (773). What is a poor sex-ratio with much fewer women compared to men suggestive of? (Hint: discrimination against female child, social presume, female feticide etc.)

***Table 13.4:*** *Sex Ratio of Indian Population during past century*

| Year | 1901 | 1911 | 1921 | 1931 | 1941 | 1951 | 1961 | 1971 | 1981 | 1991 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sex Ratio | 972 | 964 | 955 | 950 | 945 | 946 | 941 | 930 | 934 | 927 | 933 |

## INTEXT QUESTIONS 13.3

1. Name atleast three countries which have higher density population than India.

2. Prepared a dispersion map of your locality.

3. Why is age structure data of a population so important.

4. What does poor sex-ratio of a state / country suggestive of?

## 13.4 HUMAN POPULATION AND THE ENVIRONMENT

Human beings are part of the environment and important components of biosphere. Like any other living organism humans exchange materials with the surroundings. Besides this give and take from the environment, human influence on other life forms and ability to change and control the environment to some degree, has affected the global environment drastically. Hence, one can say that humans population and human activity has immense impact on the environment.

### 13.4.1 Impact on environment

Human activities have had lasting impact on the environment. Some of such activities that have modified or degraded the environment are:

- ability to produce food through agriculture.
- transfer excess food to regions of food shortage.
- store excess food in warehouses, cold storage and canneries, thereby preventing food-deterioration.
- impressive and innovative efficiency of energy utilization has caused shift from wood energy to fossil energy to electric energy to atomic energy.
- ability to provide shelter for self (housing), elderly and the young, protection against for unfavourable weather or enemies.
- ability to destroy animal enemies e.g. lions, tigers, wolves, snakes, rats, mice, house-hold insects etc.
- ability to reduce competition from other animals by fencing crops and live-stock.
- reducing the mortality rate by controlling a number of life threatening diseases through proper sanitation, medication, immunization etc.

Inspite of all the intelligence at its source, human beings have not been able to conquer the environment completely. Natural as well as human-made modifications in the environment have, through various periods, offered fatal blows to the human population. Some such problems confronting us are:

(1) **Food shortage or famine**: It could be because of less agricultural production; transfer of agricultural land for utilization; improper and inadequate storage, transport- facilities; economic poverty to purchase food etc.

(2) **Inadequate shelter**: Every individual is not provided with safe shelter and is exposed to extremes of high and cold temperatures of atmosphere, and falling prey to tigers, lions, wolves, leopards, rats, snakes etc.

(3) **Diseases** : Malnutirion, inadequate sanitation, lack of medical facilities, increased susceptibility to disease especially among young and old, as well as invasion and mutation of the pathogens leads to epidemic/fatal attacks of bubonic plague, malaria, yellow fever, typhoid, tuberculosis, HIV-AIDS, dengue, influenza etc.

(4) **Calamities**: Natural calamities such as floods, cyclones, earthquakes, volcanoes, tsunami, avalanches etc. uproot human settlements and damage property.

(5) **Miscellaneous**: Various mostly human-made, accidents involving explosions, fire, pollution, ship wrecks, air and road accidents wipe out lives.

Thus, you should be able to imagine the tussle between man to change environment to his liking and the environment striking back in one form or the other.

If, humans are able to interact with the environment judiciously, an environment friendly life can be led by them.

### 13.4.2 Standard of living

A population is also characterized by certain parameters, such as:

- life expectancy (should be high)
- infant mortality rate (should be low)
- income per head (should be high)
- literacy (maximum of individuals be literate)
- consumption of food, natural resources (should be balanced)
- kind of energy used (eco-friendly)
- eco-friendly activity.

Such parameters decide the standard of living of a population. The developed rich countries have better standard of living and underdeveloped, poor countries have a poor standard of living.

## INTEXT QUESTIONS 13.4

1. Enumerate atleast three human activities that cause lasting impact on the environment.

2. List three parameters that characterize the standard of living of a population.

3. When we modified environment, what are the problems generally failing by us?

## 13.5 URBANISATION AND ENVIRONMENTAL PROBLEMS

With economic development comes urbanization and with urbanization comes destruction of the environment.

**What happens when cities grow?**

Urbanization causes environmental and social upheaval. Some of them are listed in box 13.4 and 13.5.

**Box 13.4 Urbanisation and environmental degradation**

- Since cities are located near rivers, along coastlines, the expanded urban inhabitants often overtake the good agricultural land for housing, industry etc.
- Loss of such an important and delicate habitat effects many rare and endangered species.
- Forests are cut.
- Wetlands are filled with soil.
- Soil is removed from productive use.
- Many hazardous materials are released into surroundings.
- Air, water and soil are polluted.

**Box 13.5 Urbanisation and socio-economic factors**

- Population is redistributed;
- Peasant society changes to factory/business dependent community;
- Automobiles/industries pollute air;
- Civic amenities are unable to cope with increased sewage disposal;
- Poor sanitation leads to water and soil pollution
- Poor sanitation breed pathogens/vectors resulting in rise of communicable diseases;
- Over crowding, unemployment lead to unbalanced urban life which causes, in turn, a number of social evils.

The urban population in our country has grown 11.1 times over the last century. From 254 lakh in 1901 to 2850 lakh in 2001. In relative terms the rural and urban population ratio has decreased from 8.1:1 to 2.6:1. During the same period. Presently, 27.8 percent of the Indian population is urban. During the period 1991-2001, 678 lakhs people were added to the urban population (Census of India 2001; The figures exclude the population of Jammu and Kashmir and Assam).

### 13.5.1 Urbanization and limited energy resources

Energy is a critical input for most of the production processes and consumption activities. With urbanization comes increased need for energy sources. In last sixty years we have had more than four-fold increase in total energy use for less than one-third rise in the population. However, the commercial activity has shown a 10 fold rise during the same period. This shows that the bulk of non-commercial energy use has had shifted to commercial use(mostly, due to urbanization). Of the various sectors that use commercial energy around 70-75% is consumed by industry and transport.

Our country has three major kinds of generating plants: hydroelectric, thermal and nuclear. They roughly contribute about 21%, 75% and 4% of our energy requirement. As of now, non conventional resources of energy such as solar, garbage, wind are negligible and insignificant. With growing population and increasing rural migration to cities, our country must cope with increased energy requirement. Production of energy is very costly. At individual levels prevention of wasteful expenditure of energy can contribute to national cause.

India is world's 6$^{th}$ largest energy consumers accounting for 3.4% of global energy consumption. This demand is growing at an average of 3.6% per year over past 30 years.

Although India generated 680 billion kwh of power during the year 2006, about 5000 million Indians still have no access to electricity. As compared to the world's average of 2200kwh per capita power consumption, in our country the per capita power consumption is about 600 kwh. The total demand for electricity in India is expected to cross 9,50,000 MW by the year 2030.

If we have to succeed as a nation, we must attain the capability to either generate or purchase the required per capita power consumption comparable to a developed, industrialized country. In the mean time, we must optimize the use of the power available and minimize the wasteful expenditure. What measures do you suggest to save the wasteful expenditure of energy?

### 13.5.2 Urbanisation and scarcity of water

Regular supply of water on earth is maintained through its circulation in the atmosphere. Precipitation of water vapour, in the form for rain, snow, dew, hail etc. is the main source of water in the environment. Water vapours present in the atmosphere, in turn, come from the water bodies such as lakes, streams, oceans, ponds, moist earth as well as from living organisms.

Of the total water present on the earth, oceans have 97% and only 3% of total water is available as fresh water.

Water on earth is classified into following three types:

a) Fresh water: It is inland water and its salt content is less than 5 ppt or 0.5%;

b) Marine water: It occurs in seas, oceans and its salt content is more than 35 ppt or 3.5%.

c) Brackish water: It's salt content is more than 5 ppt but less than 35ppt. It is present in estuaries, salt marshes and salt lakes. A lot of underground water in Rajasthan, Gujarat, Haryana and Punjab is brackish.

With rapid population growth and rising migration from villages to cities, expectation for better life, the natural resources of our earth face even increasing pressure. Along with air and land, water especially the fresh water resource is the one that we must protect for our own survival. Of all the 3% fresh water resource that we have glaciers and ice-caps account for about 2%. The rest of the fresh water is beneath the earth surface. Rivers and lakes contain only 1/5$^{th}$ of the total 1% of earth's fresh water (i.e. about 37 million km$^3$ ).

The ultimate source of this water is rainfall. India receives about 2750 km$^3$ of rainfall per year. About 600 km$^3$ of its seeps into the grouind and about 900 km$^3$ evaporates water vapour back into environment. Can you imagine how precious is our fresh water resource?

As per 2001 census India's population is 1027 million. It is expected to rise and stabilize around 1640 million by the year 2050. The gross per capita water availability in year 2001 was ~1820 m$^3$/yr. By the year 2050 the per capita availability of water is expected to decline to as low as ~1140 m$^3$/yr. The total water requirement of the country for various activities around the year 2050 has been assessed to be 1459 km$^3$/yr. The current availability is about 500km$^3$/yr. It is apparent that by the year 2050 our water availability has to be trebled.

The scarcity of urban water is due to:

(i) **Careless attitude**: Release of untreated sewage and other waters into rivers ands lakes;

(ii) **Lowering of water table**: Due to excessive pumping of ground water;

(iii) **Waste in agriculture**: Water is lost due to seepage or evaporation during irrigation and poor water management practices;

(iv) **Increase in water demand**: Due to increased urbanization and increased population and increase in per capita water consumption.

(v) **Water pollution**: Pollution of ground water by nitrates, fertilizers, toxic chemicals, sewage, industrial effluents, domestic wastes etc.

To meet the growing requirements of water, it is imperative not only to develop the new water resources but also to conserve, recycle and reuse water whenever or wherever possible. It has also been shown that conservation of water through rain water harvesting and artificial ground water recharge can generate about 125km$^3$/yr of additional water. Augmentation of existing water supply through desalination of sea water in an additional possibility.

Similarly, recycling of municipal and industrial waste water can, regenerate another 177km$^3$/yr water.

How does the water gets polluted? Can you imagine? Drinking , bathing, swimming, recreation, irrigation, all require good, uncontaminated, potable water. Domestic effluents too cause water pollution. It develops fowl smell and create unhygienic condition in the surrounding affecting our health. In most of our cities and towns, the liquid waste produced daily in kitchen, bathroom and toilet are discharged directly or indirectly without any treatment, into rivers or any other water bodies.

Even in our cities only half of the population has access to sewage system. Therefore, raw sewage affluent are discharged into fresh water bodies. The conditions in the villages is not better.

Such domestic wastes (effluents) contain pathogens that cause various viral, bacterial and other parasitic diseases. Cholera, dysentery, typhoid, jaundice, worm-related diseases affect the health of the population.

House–hold effluents are also rich in nitrates and phosphates (from laundry detergents). These deteriorate the water quality and promote growth aquatic organism making water unfit for human consumption.

Therefore, India as a nation has to now initiate action on all fronts for developing its water resource. Can you imagine the consequences for not meeting this challenge in the next few decades? Our well-being depends on combined efforts of all citizens of the nation?

### 13.5.3 Flood and drought

Floods and drought are also important events connected with water that affect our lives.

**Flood:** Flood is a body of water that covers normal dry lands. Consequences of most floods are as follows. They -

- destroy homes and valuable property.
- carry top fertile soil, leaving the land barren.
- destroy both food and cash crops.
- cause huge losses to human –lives and cattle.
- cause landslide in the hilly-areas.
- cause dam burst.

How the flood occurs? Floods occur when these is too much rain. Heavy rains cause flash-floods. Sudden melting of ice also results in flood. In deserts the floods are caused by thunderstorms. Certain human activities such as deforestation and over-intensive farming are also the causes of flood.

Floods along the sea-coasts are caused by hurricane, cyclones or development of low pressure zones in the atmosphere. Floods can be controlled by building dams to store water; planting trees on eroded land and by building dykes, flood walls, hurricane-barriers along the coast line.

Floods, however can be controlled by proper planning involving (a) storage of water when it is in plenty; (b) migrating people from the affected areas; (c) storing plentiful stocks of food and fodder during good times; (d) cloud seeding; (e) proper and effective water-shed/catchment area management' (f) afforestation etc.

**Drought**

Drought is the condition that results when the average rainfall for an area drops below the normal amount for a long time. The consequences of drought are:

- streams/ponds/well dry up;
- water supply for agriculture, industry, personal use is greatly reduced;
- dry top soil is blown away by hot, dry winds;
- livestocks die;
- increase susceptibility to vulnerable diseases especially diarrhoea.

### 13.6.3 Urbanisation and Pollution

With urbanization population gets unevenly dispersed.. This results in unbalanced demand for resources and even unbalanced release of harmful matter into the surroundings. Such harmful and often hazardous material comes from industrial, domestic, transport, vehicles etc. When released, they severely affect the soil, water and air. The management of pollutants is discussed in detail in lesson-10 pollutants can prove to be dangerous to human beings and other organisms.

## 13.7 NATURAL RESOURCE DEGRADATION

Deforestation, desertification, soil degradation and biodiversity loss are all closely related phenemonon. Urbanization and unsustained development has largely been responsible for these events. Varied aspects about them are discussed in detail in the next lesson.

## INTEXT QUESTIONS 13.5

1. How does one classify water as fresh, brackish or marine?

   ______________________________

2. List four major causes those results in scarcity of fresh water in urban areas?

   ______________________________

3. How doe the improper sewage system in the cities affect quality of water?

   ______________________________

4. Define flood. How does it affect human lives?

   ______________________________

5. List three preventive methods to over come the miseries caused by flood.

______________________________________________

6. Name three major kind of energy generating plants in our country. What are their relative contributions towards our electric energy needs?

______________________________________________

7. List some of measures that you would adopt to prevent the wasteful expenditure of electrical energy in your household.

______________________________________________

8. How does urbanization leads to pollution?

______________________________________________

## WHAT YOU HAVE LEARNT

- India exhibits a great diversity of relief and physical features. Its people, land, forests, oceans constitute abundant natural resource.
- Human population study both as consumer as well as producers help us to provide data for economic planning, conservation of nature, promotion of cultural, regional and linguistics harmony.
- Study of population is called demography. Demography helps to know about size, growth rates, mortality, natality, migration patterns, density, dispersion, and age structure of the population..
- People shift from rural areas to urban cities for better education, prosperity, better health care, and overall increased standard of living.but however urbanization in itself results in large-scale environmental damage such as river-flood plains, coastal wetlands and resultant loss of delicate habitats; deforestation, desertification, loss of biodiversity, contribute towards pollution of air, soil, water leads to scarcity of water and increased energy consumption.
- We all must try to protect and improve our delicate environment.

## TERMINAL EXERCISE

1. "Environment has no geographical boundaries" Explain.
2. How does increase in population leads to depletion and degeneration of natural resources?

3. List major environmental issues that confront us?
4. Emmerate the various climate factors that determine vegetation of a region?
5. Look at the figure 13.2 and answer the following questions:
   a. What kind of forest-type dominate Western India?
   b. Which region of our country has alpine/tundra vegetation?
   c. Which kind of forest type is maximally distributed in India?
   d. In which part of the country tropical rain-forest found?
6. Define: Death rate, birth rate, natality, mortality, growth rate, migration.
7. When would a region be called over populated?
8. Draw the population curve and explain the different phases of the curve?
9. Define census. How does this help a country?
10. Why should the sex-ratio of a population remain more or less constant/balanced?
11. Discuss urbanization and social-economical factors.
12. Visit the various house-holds in you locality (a) and interact with people, interview them and prepare status of energy/water requirement/need and availability. (b)What measures would you propose at local level so that wasteful expenditure of energy and water is avoided?
13. (a) List as many as possible the harmful and hazardous materials from different sources that occur/accumulate in your locality and (b) Suggest measures to minimize this kind of pollution in your locality.
14. Differentiate between floods and drought.
15. List four diseases caused by contaminated home discharged water.
16. How is regular supply of water is maintained on earth?

## ANSWER TO INTEXT QUESTIONS

**13.1**

1. Those plant and animal species that are local i.e. not found anywhere else.
2. The northern plains (granaries) and peninsular plateau (mineral rich)
3. Tropical rain forest, tropical deciduous forest, temperate broad leaf forests, temperate needle leaf or coniferous forest alpine and tundra vegetation

4. Wood, gums, dyes, tannins, fibres, medicines, food (any three)

**13.2**

1. As a group of individuals living in the given area and capable of inbreeding and sharing genetic material.
2. Hint: 13.2.1
3. Size, growth, age-structure, fertility, birth rate, death rate, standard of living, Migration etc.
4. Growth at a constant rate of increase per unit time is termed as exponential growth.
5. Because it is still within a country; emigration, and immigration.

**13.3**

1. Hint: Box 13.2
2. Japan, Netherlands, Bangladesh, Island's of Malta.
3. Hint: 13.3.2
4. Hint: discrimination against female child, social pressure; female foeticide, etc.

**13.4**

1. Refer: 13.4.1
2. Refer 13.4.2
3. Provide analytical answer.
4. Provide analytical answer.
5. Provide analytical answer.

**13.5**

1. Salt content <5 ppt: Fresh water

   Salt content >5 but more than <35 ppt Brackish water

   Salt content >35 ppt: Marine water
2. Careless attitude, waste in agriculture, lowering of water table; increase in demand; water pollution.
3. Hint: a) domestic affluents contain pathogens that cause diseases.

   b) affluent contain nitrates and phosphates; these help growth of aquatic organisms; make water unfit for human consumption.

4. Hint: See section13.5.3
5. i. Improper water, storage capacity.
   ii. Migrate people to safer places.
   iii. Store enough tool and fodder in good times
   iv. Aggressive afforestation
   v. Effective /proper water shed/catchments area management
6. Hydroelectric (21%), Thermal (75%), Nuclear (3%)
7. Refer to text
8. Hint: refer section 13.6.

# 14

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# GLOBAL ENVIRONMENTAL ISSUES

There is much to celebrate and appreciate about the world we live in. It includes our environment. However, mostly due to our actions we are altering the very environment, which sustains us. It would be very difficult for us to live in an unfriendly environment. This lesson exposes you to the various global environmental issues or concerns and possible strategies to cope with them.

## OBJECTIVES

After completing this lesson, you will be able to:

- *identify and list major global environmental issues;*
- *define and correlate global warming with green house effect;*
- *enumerate the major effects of global warming on living and non-living components of the environment;*
- *briefly explain the causes of biodiversity loss;*
- *comment on major causes of desertification;*
- *explain the cause and effects of ozone-layer depletion;*
- *describe acid rain and its harmful effects on living organisms, buildings and monuments;*
- *identify the causes of oil spills and their impact on marine and terrestrial environment;*
- *state problems related to dumping of hazardous waste.*

## 14.1 MAJOR GLOBAL ENVIRONMENTAL ISSUES

Increased human activity, urbanization, industrialization have led to rapid deterioration of the environment. This has severely affected the life supporting system.

The developmental discrepancies in different regions of the world pose a serious threat to our common global environment. Consequently, we are confronted with complex environmental issues deserving attention. The important global environmental issues are:

- green house effect and global warming
- biodiversity loss
- desertification
- depletion of ozone layer
- acid rain
- oil spills
- dumping of hazardous wastes

## 14.2 GREEN HOUSE EFFECT AND GLOBAL WARMING

### 14.2.1 What is the green house effect?

The temperature surrounding the earth has been rising during the recent past. This is due to the 'green house effect'.

A green house is a glass chamber in which plants are grown to provide them warmth by trapping sun light. Sunlight (a form of energy) passes through the glass and it gets absorbed inside releasing heat radiations unlike sunlight, heat radiation can not escape through glass the heat generated there from, cannot escape out of the glass chamber. Thus, even on a cold winter day, the inside of a green house can become quite warm to support plant growth. The phenomenon of heat build up inside a glass chamber from the absorption of solar radiation is called **green house effect**.

But, you may well ask, where is the glass around the earth that prevents escaping of heat from the earth's surface. Look at the fig. 14.1 and trace the following sequence to understand the green house effect.

### 14.2.2 Global warming and green-house effect

The green-house effect is a natural phenomenon and has been occurring for millions of years on the earth. Life on the earth has been possible because of this natural green house effect which is due to water vapour and small particles of water present in the atmosphere. Together, these produce more than 95 percent of total green-house warming. Average global temperatures is maintained at about $15^0$C due to natural green house effect. Without this phenomenon, average global temperatures might have been around $-17^0$ C and at such low temperature life would not be able to exist.

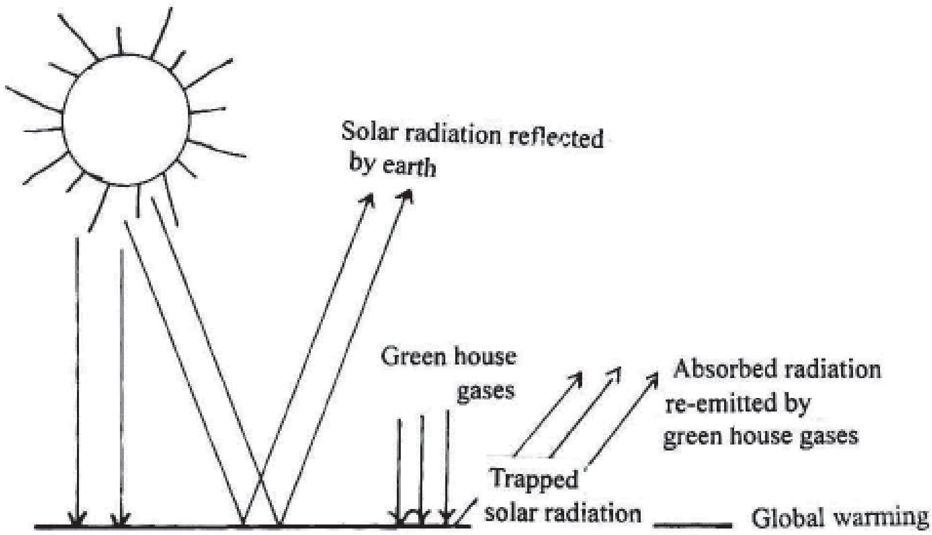



***Fig. 14.1:*** *Solar radiations strike the earth. Some of these radiations are reflected back by the atmosphere into the space, but some pass through the atmosphere towards earth. About half of these are absorbed by the atmosphere and heat the air. The rest reaches the earth's surface. The earth's surface now heats up and gives off longer wavelength, lower energy (infra red or heat) radiations. These infra-red radiations pass back up into the atmosphere. Instead of being radiated 100 percent back into the space, much of it is absorbed by the atmosphere and are reradiated back to the earth's surface. The temperature near the earth's surface as well as that of the atmosphere then rises.*

Before industrialization, simple human activity did not cause any significant increase in the atmospheric temperature. What is particularly worrisome is the increase in the emission of green house gases due to urbanization and industrialization. These green house gases have increased significantly in the atmosphere in recent years. Some important green house gases and their major sources are listed in table 14.1.

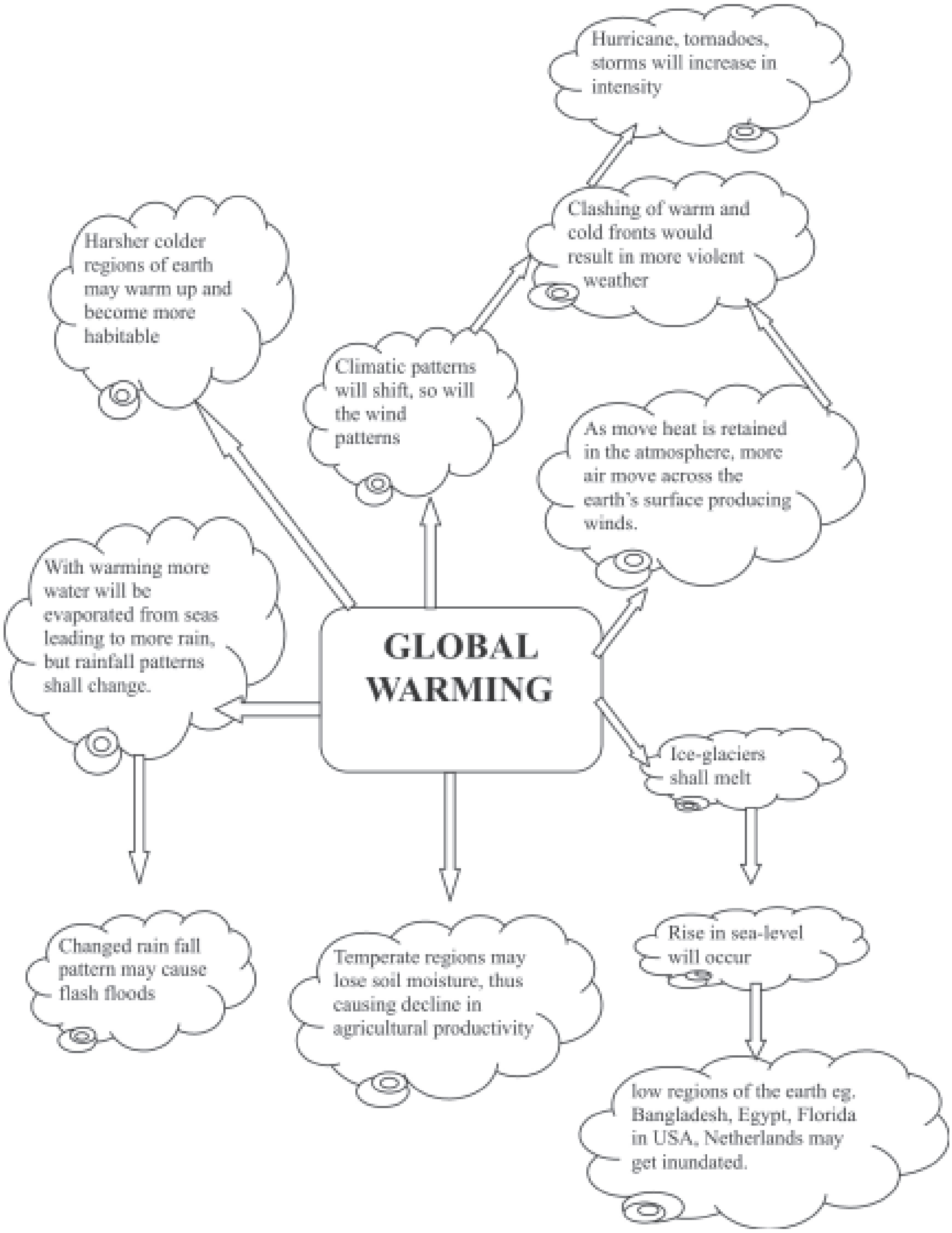
***Table 14.1:*** *Greenhouse Gases: Their sources and Causes*

| Gas | Sources and Causes |
|---|---|
| Carbon dioxide ($CO_2$) | Burning of fossil fuels, deforestation |
| Chlorofluorocarbons(CFCs) | Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses |
| Methane ($CH_4$) | Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, land fills. |
| Nitrogen oxides ($N_2O$) | Burning of fossil fuels, fertilizers; burning of wood and crop residue. |

Global warming affects both living and non-living components of our planet.

### Effect on climate

Observe the following diagram and both the effects of global warming:




### 14.2.3 Effect on living beings

- Increased $CO_2$ concentration in the atmosphere may increase photosynthetic productivity of plants. This in turn produces more organic matter. It may seem a positive effect. But, then-

- Weeds may proliferate rapidly, and that too at the expense of useful plants.
- Insects and other pests that feed on plants may also increase in number.
- Survival of other organisms gets affected.

### 14.2.4 Strategies to cope with greenhouse effect

We must take immediate steps to minimize global warming by reducing emission of green house gases especially carbon dioxides. Following steps would be useful in reducing emission/release of green house gases into the atmosphere:

- Increased fuel efficiency of power plants and vehicles;
- Development/implementation of solar energy/non-fossil fuel alternatives;
- Halting deforestation;
- Supporting and undertaking tree-planting (afforestation);
- Reduce air-pollution.(see table14.1)

## INTEXT QUESTIONS 14.1

1. Why do you think environmental issues are of global significance?

   ______________________________

2. Enumerate at least 3 environmental issues that confront us today.

   ______________________________

3. Define global warming.

   ______________________________

4. Why is green-house effect called so?

   ______________________________

5. Which kind of radiations are not reflected back out of atmosphere causing green-house effect?

   ______________________________

6. Name four green-house gases.

   ______________________________

## 14.3 BIODIVERSITY

Plants and animals of a region constitute biodiversity. Biodiversity is a natural wealth essential for human survival.

### 14.3.1 Classification

Biodiversity could be classified as -

(a) **Species biodiversity**: It includes total number of different taxonomical or biological species. There are more than 200000 species in India of which several are confined to India (endemic).

(b) **Genetic biodiversity**: It includes land traces; horticultural varieties; cultivers, ecotypes (related types differing due to difference in the ecological condition); all within a biological species.

(c) **Ecosystem biodiversity**: It includes various biological zones, like lake, desert, coast, estuaries, wetlands, mangroves, coral reefs etc.

Both flora and fauna, all over the world are under an assault from a variety of indiscriminate human activities. These activities are often related to rapid growth of human population, deforestation, urbanization and industrialization.

### 14.3.2 Reasons for biodiversity loss

Rapid decline of biodiversity is a result of various causes.

(1) **Loss of habitat**: Due to the growing human population, wetlands are being made dry through landfills, as the demand for land increases. Natural forests are cleared for industry, agriculture, dams, habitation, recreational sports, etc. As a consequence-every plant and animal species occupying that ecosystem is temporarily or permanently affected. So are the migrating birds or other animals visiting that habitat.

Thus, the population of different species occupying that habitat become unsettled. An altered ecosystem causes changes in the neighbouring ecosystems.

(2) **Pollution**: Pollution also alters the habitat to such an extent that it becomes critical for survival of some of the species. For example, pollution that leads to green house effect results in global warming. All those species that are slow to adjust to the changed environment are eventually lost.

(3) **Overuse**: Whales for oil, fish for food, trees for wood, plants for medicines etc. are being removed by humans at higher rates than they can be replaced. Excessive cutting of trees, overgrazing, collection of fire-wood, hunting of wild animals for skin (for example tigers from reserve forests of India), ivory etc. all result in gradual loss of species.

(4) **Introduction of foreign species**: With growing volume of international travel accidental introduction of species into a new or foreign area has become easier. There are many species which have invaded new areas to which they were introduced unintentionally. Many of the new species introduced into new regions thrive at the expense of native species. For example: *Parthenium*, *Argemone* and *Lantana* are the common weeds of foreign origin in our country (Fig. 14.2).

***Fig. 14.2:*** *Common foreign origin weeds of our country*

(5) **Environmental degradation**: A vast array of factors causing environmental degradation may result in the loss of biodiversity. Some of these factors are: global warming, increased $CO_2$ concentration in atmosphere, nuclear radiation; UV-exposure; oil spills, etc.

As an example, let us below, compile a combination of factors which results in the loss of marine biodiversity. (Fig. 14.3)

**High Technology Fishing**
Improved technologies, such as radar/sonar/electronic equipments/navigation, aids help locate shoals of fish very accurately. It ensures capture efficiency.

Such capture results in capture of high value fish. A high value fish is the one which is captured prior to completing its life cycle. Thus, it leads to loss of generation.

It result in large scale fishing of newer species. It results in depriving larger fish/mammals/ aquatic birds of their prey. It effects food-chain.

It helps deeper zone fishing, which results in the capture/loss of fish, which were not caught earlier easily.

Improved and substantial aqua cultural practices lead to capture of more fish than they can be reproduce. It leads to loss of biodiversity.

Fish farms destroy large mangrove trees. It causes loss of fish sheltering in the vicinity of submerged roots of mangrove.

Some fish and other edible animals such as Cray fish are cultured at the cost of other natural fish causing imbalances.

Marine fishing endangers the existence of eels, elvers

Many kinds of birds/aquatic mammals/reptiles are unnecessarily caught by the nets used for fishing and left abandoned to perish.

***Fig. 14.3:*** *Loss of marine biodiversity*

## 14.4 DESERTIFICATION

As defined earlier (lesson no. 9) desertification is diminution or destruction of the biological potential of the land which ultimately leads to the formation of desert.

The land that has lost its productivity (ability to grow plants) is called a desert. A desert landscape supports a very limited growth of sparse vegetation and stunted growth of plants. Substantial part of earth's 132.4 million sq km of terrestrial area is facing desertification due to overexploitation and mismanage of land resources for human activities. Some of the principal causes, which promote desertification, are:

- over cultivation,
- overgrazing,
- deforestation, and
- salt accumulation due to irrigation**.**

(a) **Over Cultivation**

Every cycle of cultivation is preceded by ploughing to remove weeds. The ploughed land turns soil upside down thus exposing rich sub-soil to wind and water erosion. Such land may remain barren for most part of the year and in turn lose more soil due to erosion. Such erosion is most pronounced on slopes. Moreover, in regions where rainfall is low, the soil is often dry and is more susceptible to erosion. Ploughed soil loses more water by evaporation.

(b) **Overgrazing**

Deserts receive less rainfall. Deserts have sparce vegetation mostly consisting of grasses and herbs less and best used for grazing. Overgrazing by goats, domestic cattle remove the protective vegetation and expose the soil. Further the movement of grazing animals loosen the soil surface by their hoofs. Unprotected loose soil becomes highly susceptible to erosion by wind and water. Such conditions leads to progressive desertification due to series of events as mentioned in figure 14.4.

(c) **Deforestation**

Forests and vegetation prevent soil erosion and to hold water in soil. Plant roots absorb and recycle nutrients released from the decaying organic matter. Forests are often cleared to agriculture, timber, construction wood, firewood, raw material for paper etc. All this leads to barrenness of the land leading to desertification.

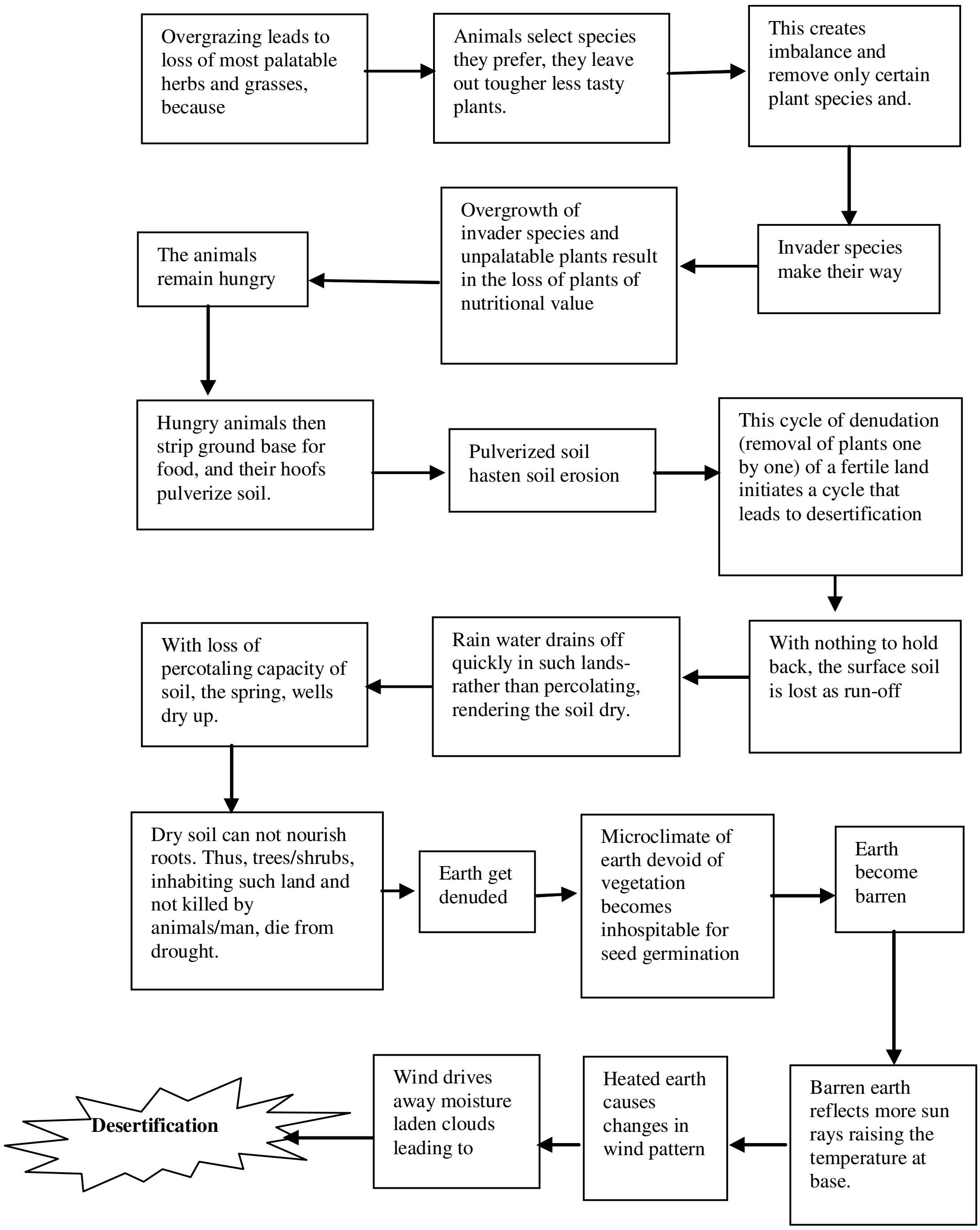



*Fig 14.4: Factors causing desertification*

## (d) **Salting due to Irrigation**

With demand for more land for agriculture, crops are grown in areas that have little access to natural water bodies. The water is supplied to these growing areas by artificial means and improved irrigation methods. Such water brings salts dissolved in it. Even the best quality of irrigation water contain 200-500 ppm of salts. Water used for irrigation is lost from agriculture field through evaporation and transpiration by crop plant. The water gets evaporated but the dissolved salt keeps on accumulating which makes the soils more salty. Saline accumulation of execesive soils prevents retards plant growth. Land devoid of plant cover easily becomes desertified. Accumulation of excessive salt in soil or salinization makes the soil unfit for agriculture.

## INTEXT QUESTIONS 14.2

1. List different components of biodiversity.

2. Why does biodiversity loss occur?

3. How does high-technology fishing affect marine biodiversity?

4. How does a species lose its habitat?

5. What kinds of activities promote desertification?

6. Which kind of sowing is better in long-term: ploughing or tractor – sowing?

7. What is a desert?

## 14.5 OZONE LAYER DEPLETION

### 14.5.1 Formation of ozone layer

Ozone ($O_3$) is a highly reactive molecule containing three oxygen atoms. The upper part of the earth's atmosphere, between 10 and 50 km above the earth surface called stratosphere contains a thin layer of ozone. This ozone layer serves as a natural filter for blocking deadly incoming uv radiation from the sun.

Ultra violet (UV) radiation, with wavelengths shorter than visible spectrum has high energy. UV radiations can be divided into three forms: UV-A (wavelength between 320-400*nm*), UV-B (wave length lesser than 280 *nm*), and UV-C (wavelength lesser than 280 *nm*). UV-C is most damaging to biological systems.

Since, the early 1970's levels of the stratospheric ozone have thined markedly over certain regions of the earth, particularly over the Antarctic region. The Antarctic region contains one of the worlds' most productive marine ecosystems. The thinning of stratospheric ozone layer is termed '"ozone hole".

### 14.5.2 Causes of ozone layer depletion

Ozone ($O_3$) layer can be destroyed both by natural and man-made causes-

(i) **Natural causes**: A number of naturally occurring substances destroy stratospheric ozone. Most important of these compounds are:

Hydrogen oxide ($HO_x$), Methane ($CH_4$), Hydrogen gas ($H_2$), Nitrogen oxides ($NO_x$). Chlorine monoxide (ClO); during volcanic eruptions, significant amount of chlorine may be released in the stratosphere. Tiny particulate matter in the stratosphere, known as stratospheric aerosols, may also lead to ozone destruction.

(ii) **Human activity related causes**: Any event, which release chlorine atoms into the atmospheric, can cause severe ozone destruction, because chlorine atoms in the stratosphere can destroy ozone very efficiently. Most damaging among such agents are human made chlorofluorocarbons (CFCs), which is widely used as refrigerants and to pressurize sprays cans. In stratosphere, chlorine atoms from CFCs react with ozone to form chlorine monoxide and oxygen molecule.

$$Cl + O_3 \text{———} ClO + O_2$$

Chlorine monoxide, may then react with oxygen atoms to release more chlorine atoms:

$$2ClO + O_2 \text{———} 2Cl + 2O_2$$

One chlorine atom can break down 1,00,000 ozone molecules.

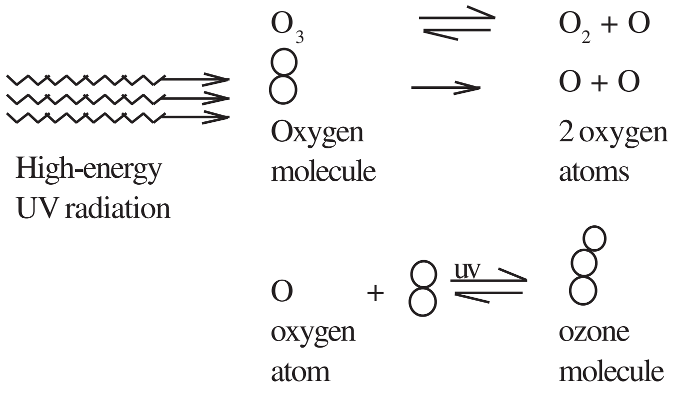



***Fig. 14.5:** Formation of ozone* molecule

*Table 14.2: Important ozone depleting chemicals and their uses.*

| Name of the compound | Used in |
|---|---|
| CFCs | Refrigeration, aerosol, foam, food freezing, warming devices, cosmetics, heat detectors solvents, cosmetics, refrigerants, firefighting |
| Halon | Fire fighting |
| HCFC-22 | Refrigeration, aerosol, foam, fire fighting |
| Methyl chloroform | Solvent |
| Carbon tetrachloride | Solvent |

### 14.5.3 Effect of $O_3$-layer depletion

Why are we so concerned about ozone hole? It is because without the ozone-shield the deadly uv radiation shall pass through the atmosphere and reach the earth surface. A small amount of uv-radiation is necessary for well-being of human beings and other organisms, such as uv-B promote synthesis of vitamin-D. UV-radiation also act as a germicide to control microorganisms. However, increased uv dose is highly dangerous to living organisms.

**Harmful effects on human beings**
- Increase susceptibility of skin-cancer
- Increase cataract
- Damage DNA
- Damage cornea
- Cause retinal diseases
- Suppers human immune systems

**Harmful effects on plants**
- Inhibit photosynthesis
- Inhibit metabolism
- Repress growth
- Destroy cells
- Cause mutation
- Decline forest productivity

**Harmful effects on other organisms**
- Marine/freshwater organisms are very sensitive to UV-rays
- Fish larvae are very sensitive
- Plankton population severely damaged.
- Affect fish/shrimp/crab larvae

**Harmful effects on non-living materials**
- Accelerate breakdown of paints
- Accelerate breakdown of plastics
- Affect temperature gradient levels in the atmosphere
- Affect atmospheric circulation pattern, climatic changes.

### 14.5.4 Measures to prevent ozone ($O_3$) layer depletion

Global awareness and action on the part of world community in the form of Helsinki (1989), Montreal (1990's) conventions and protocol have had some important success on this front. A complete ban on the use of CFCs and other ozone destroying chemicals is recommended. Further, use of HCFCs (Hydrochloric fluorocarbons) as a substitute for CFCs is being recommended on temporary basis because HCFCs are relatively less damaging to ozone layer as compared to CFCs, but they are not completely ozone safe.

## INTEXT QUESTIONS 14.3

1. Which kind of electromagnetic waves are screened by ozone in the stratosphere? Give their wavelength.

   ______________________________________________

2. How many oxygen atoms are these in an ozone molecule?

   ______________________________________________

3. How do volcanoes contribute to $O_3$ depletion?

   ______________________________________________

4. Which kinds of anthropogenic activities are most dangerous to ozone-shield?

   ______________________________________________

5. Name some harmful effects of UV radiation on human-being.

   ______________________________________________

## 14.6 ACID RAIN

Acid rain refers to any precipitation (rain, fog, mist, snow) that is more acidic than normal. Acid rain is caused by atmospheric pollution from acidic gases such as sulphur dioxide and oxides of nitrogen emitted from burning of fossil fuels. Acid rain is formed when the air that contains acidic gases emitted mostly from power plants industries and automobiles, combines with the rain drops. The acid rain affect ecosystems in diverse ways (see fig. 14.5)

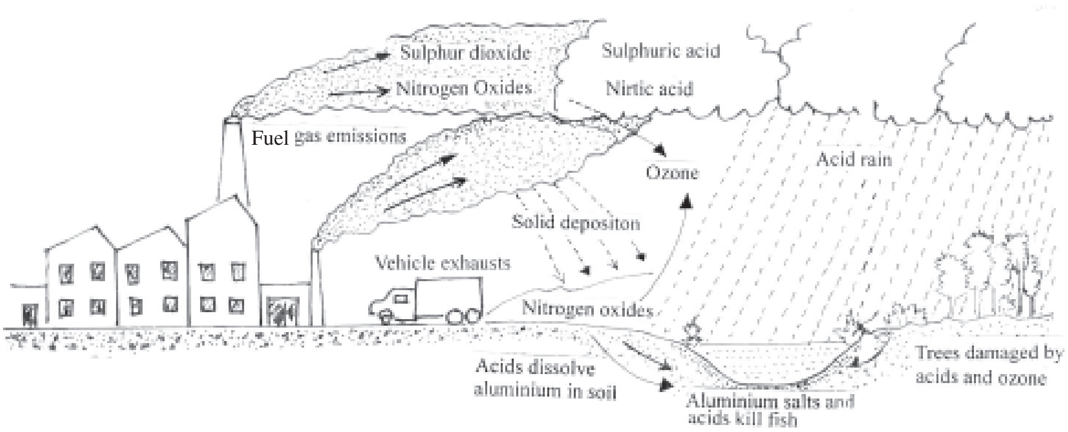



***Fig.14.5:*** *Acid rain*

Therefore, emission of sulphur dioxide oxide and of oxides nitrogen into the atmosphere can lead to the formation of acid rain.

It is also recognized that acidic smog, fog, mist, move out of the atmosphere and settle on dust particleswhich in turn accumulate on vegetation as acid depositions. When rain falls, the acid from these depositions leak and form acid dews.

The table below shall help you to know the sources of gases/materials that contribute to acid rains (table 14.3)

***Table14.3:*** *Acidic gases and their emission sources.*

| Acidic gases | Source |
|---|---|
| $CO_2$ (Carbon dioxide) | Fossil fuel burning, industrial process, respiration. |
| $CH_4$ (Methane) | Paddy fields, wetlands, gas drilling, landfills, animals, termites |
| CO (Carbonmonoxide) | Biomass burning, Industrial sources, Biogenesis, Plant isoprene's. |
| $SO_x$ (Sulphur oxides) | Fossil fuel burning, industrial sources, volcanoes, oceans. |
| $NO_x$ (nitrogen oxides) | Fossil fuel burning, lightening, biomass burning, oceans, power plants |

### 14.6.1 Harmful effects of acid rain

Acid precipitation affects both aquatic and terrestrial organisms. It also damages buildings and monuments.

**(i) Effects on aquatic life**

The pH of the surrounding or medium is very important for metabolic processes of aquatic organisms. The eggs or sperms of fish, frogs and other aquatic organisms are very sensitive to pH change. Acid rain kills their gametes affecting the life cycles and productivity. Death or their inability to increase in numbers affects aquatic food chains in acidic water bodies, causing severe ecosystem imbalances.

Acidic lake waters may kill bacteria/microbes/planktons and the acidic lakes become unproductive and life less. Such acidic and lifeless ponds/lakes adversely affect fisheries and livelihood.

**(ii) Effect on terrestrial life**

Acid rain damage cuticle of plant leaves resulting etiolation of foliage. This in turn reduces photosynthesis. Reduced photosynthesis accompanied by leaf fall reduces plant and crop productivity.

Acidic medium promotes leaching of heavy metals such as aluminum, lead and mercury. Such metals when percolate into ground water affect soil microflora/ micro fauna. The soil becomes lifeless. Absorption of these toxic metal ions by plants and microorganisms affect their metabolism.

**(iii) Effects on forests**

Acid rains damage forests and kill vegetation and causes severe damage to the landscape.

**(iv) Effect on buildings and monuments**

Many old, historic, ancient buildings and works of art/textile etc. are adversely affected by acid rain. Limestone and marble are destroyed by acid rain. Smoke and soot cover such objects. They slowly dissolve/flake away the surfaces because of acid fumes in the air. Many buildings/monuments such as Taj Mahal in Agra have suffered from acid rain.

### 14.6.2 Strategies to cope with acid rain

Any procedure that shall reduce, minimize, or halt emission of sulphur and nitrogen oxides into the atmosphere shall control acid rain. Use of low sulphur fuel or natural gas or washed coal (chemical washing of pulverized coal) in thermal plants can reduce incidences of acid rain.

## INTEXT QUESTIONS 14.4

1. Name two acids that are present in acid rain.

2. How does acid rain affect aquatic life?

3. Use of which type of fuel will help in preventing acid rain?

## 14.7 NUCLEAR DISASTERS

Nuclear energy offers an alternative to many of environmental and social problems. But, it also introduces serious problems of its own. Though environment friendly, it is not yet economically affordable. Nuclear plants pose potential danger of accidents that may release hazardous radioactive materials into the environment. The problems are two fold: (i) nuclear disasters and fall out and (ii) safe disposal of nuclear waste generated by nuclear plants. Some of the major nuclear disasters are given in table: 14.4

***Table 14.4:*** *List of some major nuclear disasters*

| Year | Nuclear power plants |
|---|---|
| December,1952 | Chalk River, Toranto, Canada |
| October,1957 | Windscale Plutonium Production Centre, U.K. |
| April 26, 1986 | Chernobyl Nuclear Reactor, Kiew, Chernobyl, USSR |
| November, 1995 | Monju, Japan |

### 14.7.1 Impact of muclear disasters on the environment

The detrimental effects of nuclear leakage could be quick or slow.

The **quick devastating and immediate effects** of nuclear radiations are well known as witnessed following **Hiroshima and Nagasaki** in Japan during world war II. Therefore, military use of nuclear energy is always fraught with unimaginable consequences.

The **slow nuclear radiations** can also emanate from a variety of sources viz: nuclear reactors, laboratories, hospitals, and direct exposures to radiation for diagnostic purposes (eg X-rays)

Such low dose radiations could have substantial impact on life forms and ecosystems. It is now established that continued small dose exposure to nuclear radiation is very harmful. It can cause: childhood leukemia, miscarriage; underweight babies; infant deaths; increased susceptibility to AIDS and other immune disorders and increased criminilalities.

Underground bomb testing releases radiations in very small doses of radicals that enter water in the soil. This radioactive water is taken by plants through roots. The radioactivity enters food chain when such plants are eaten by animals and humans. Such radioactivity has been detected even in the milk.

## INTEXT QUESTIONS 14.5

1. Enumerate the sources of slow nuclear radiations that can pose danger to life forms.

______________________________

2. Enlist some harmful affects of nuclear radiation on human being.

______________________________

## 14.8 OIL POLLUTION

Oil pollution refers to layers of oil on water bodies. Oil spills are most glaring of all oceanic pollution. Every marine transport vessel poses a potential danger of oil spill.

### 14.8.1 Causes of oil spill

The most common cause of oil spill is leakage during marine transport. It includes both small scale (most often) and large scale (accidental) leakages. Oil spill could occur during off shore oil production. There is a continuous oil slicks concentrated along the supply lines used by oil tankers. Motor boats may release oil into the seas. On an average a ton of oil is discharged into the seas for every 1000 tons of oil transported by sea.

### 14.8.2 Impact of oil spill on marine life

Within hours of oil spill, the fishes, shellfish, plankton die due to suffocation and metabolic disorders. Within a day of oil spill birds and sea mammals die. Death of these organisms severely damages marine ecosystems. Oil spills also either poison or suffocate algal blooms. This in turn makes water body deficient in oxygen. Water deficient in oxygen in turn, is responsible for the deaths of enormous number of fish/marine life.

### 14.8.3 Impact of oil spills on terrestrial life

Bays, estuaries, shores, reefs, beaches particularly near large coastal cities or at the mouth of rivers are relatively more susceptible to the hazards of oil spills. A number of coastal activities, especially recreational such as bathing, boating, angling, diving, rafting are affected. As a result tourism and hotel business in the coastal areas suffers seriously.

## INTEXT QUESTIONS 14.6

1. What is the affect of oil spills on algal blooms?

   ______________________________________________

2. What is the harmful impact of oil spill on marine life?

   ______________________________________________

## 14.9 HAZARDOUS WASTE

Any substance that is present in the environment or released into the environment causing substantial damage to public health and welfare of the environment is called hazardous substance.

Any substance that could have serious irreversible health effects from a single exposure is called very hazardous substance. Any hazardous substance could exhibit any one or more of the following characteristics:

- toxicity
- ignibility
- corrosivity
- reactivity (explosive)

Thus, any waste that contains hazardous or very hazardous substance is called hazardous waste.

Hazardous wastes can originate from various sources such as: house-hold, local areas, urban, industry, agriculture, construction activity, hospitals and laboratories, power plants and other sources.

### Problems related to dumping of hazardous waste

The hazardous waste **per se** or when disposed off release a number of environmentally unfriendly substance(s). some of them are given in table 14.5.

***Table 14.5:*** *Hazardous wastes, its disposal and effect*

| Source | Disposed/used as | Polluting agent | Effect |
|---|---|---|---|
| Industrial waste | Incineration of waste | Toxic fumes e.g. Chlorine polyvinylchlorine | Chlorine could cause acid rain |
| | Incomplete combustion | Dioxins/organo chlorides | Carcinogenic |
| | Release into water bodies | Chlorophenol, fluorine compounds, aldehydes, $SO_2$, CO | Cause environmental pollution |
| | Plastic | Polythene, poly propylene, polyesters etc on burning release gases | Toxic, ecological pollution |
| Nuclear waste | Hospitals Laboratories | Slow/sustained in medical/agriculture use | Health hazard, carcinogenic, mutation |
| Agricultural waste | Forms of Nitrogen wastes | Manure/Dung rich in $NO_3/NO_2^{-2}$ | Accumulate in vegetables, cause methanoglobenemia cyanosis |
| | | Nitrosamines/ $NO_3^-/NO_2^-$ | Carcinogenic contribute to acid rain |
| | | $N_2O$ | Green house effect |
| | | $NH_3^+$ (from livestock breeding) | Affect aquatic life; stimulate fungal growth; epiphytes; cause weathering of forests |
| | Phosphates | | Eutrophicastion of aquatic environment |
| | Phyto sanitary product | Insecticides/pesticides/fungicides/herbicides | Enter soil as run off, polluter water table affect aquatic life, carcinogenic, renal failure |
| | Methane | Ruminating cattle, fermentation of organic matter | Powerful green house effect |

## INTEXT QUESTIONS 14.7

1. Give four important characteristics that make any substance hazardous.

___

2. What is a very hazardous substance?

___

3. Is plastic burning hazardous. Why?

______________________________________________

4. What are phytosanitory products? How are they harmful?

______________________________________________

## WHAT YOU HAVE LEARNT

- All of us are inheritors of common global environment.
- All of us are responsible for its growing deterioration. If the deterioration exceeds a limit, it shall be a dangerous place to live in.
- Pollution, ozone-hole, greenhouse effect, desertification, loss of biodiversity, oil spills, nuclear disasters, hazardous waste management, are some of the global environmental problems that need immediate collective attention.
- Increased human activity, urbanisation, industrialisation are led to rapid deterioration of the environment. This has severely affected the life supporting system.
- A green house is a glass chamber in which plants are grown to provide them warmth by trapping solar radiations and heat. Infrared rays pass through glass and the heat generated there from, cannot escape out of the glass chamber.
- Increased fuel efficiency in vehicles; development/implementation of solar energy/non-fossil fule alternatives; halting further deforestation; support and undertake tree planting (afforestation); reduce air-pollution are the strategies for coping with green house effect.
- Flora and fauna of a region constitute biodiversity. It is considered as natural wealth of the nature.
- Biodiversity can be classified into three types i.e. species biodiversity, genetic biodiversity and ecosystem biodiversity.
- Loss of habitat, pollution, and overuse, introduction of foreign species and contribution of other environmental degradation factors are the reasons of biodiversity loss.
- Desertification is diminution or destruction of the biological potential of the land which ultimately leads to desert. Over cultivation, overgrazing, deforestation and salting sue to irrigation are principal causes for desertification.
- Acid precipitation affects both aquatic and terrestrial life. It also damages buildings and monuments.
- We all need to cooperate at individual, domestic, local. National and international level to maintain our environment clean and sustainable.

## TERMINAL EXERCISE

1. Name an introduced weed in India.
2. Name two green-house gases.
3. Name any two compounds that are harmful to ozone layer.
4. Which has been the most disastrous nuclear accident so far.
5. Name one phytosanitory product.
6. Mention various (at least 5) global environmental issues?
7. Why are environmental issues of global concerns?
8. Why should we avoid use of CFCs and such compounds?
9. Explain briefly:
   (a) Compare the effects of tropospheric and stratospheric ozone on life in our planet.
   (b) Suggest strategies to cope with green house effect.
   (c) How does canal-based irrigation contribute to desertification?
   (d) Chlorine atom causes ozone-hole
   (e) Harmful effect of uv radiations on human being.
   (f) Perils of nuclear disasters
   (g) "Environmental problems need global intervention".

## ANSWER TO INTEXT QUESTIONS

**14.1**

1. Because environment has no frontiers, no geographical boundaries.
2. pollution, $O_3$-hole, green house effect, biodiversity loss, desertification, problems related to dumping of hazardous wastes, nuclear disasters, oil spills (Any three)
3. Global warming is defined as a natural or human induced increase in the average global temperature of the atmosphere near the earth surface.
4. Because it stimulates similar conditions that one encounters in a glass green house.
5. Infrared

6. CFC, methane, nitrogen oxides, $CO_2$

**14.2**

1. Species biodiversity, generic biodiversity, ecosystem biodiversity.
2. Because of loss of habitat, overuse, introduction of foreign species.
3. Because, they help locate shoals of fish very accurately and efficiently.
4. When its habitat is destroyed to make way to housing, industry, agriculture, sports etc.
5. Over cultivation, over grazing, deforestation, salting due to irrigation.
6. Tractor-sowing.
7. The land that has lost the productivity capacity is called a desert.

**14.3**

1. Ultraviolet, 200-400 nm
2. Three
3. By releasing significant amount of chlorine.
4. Any activity that release chlorine atoms into the atmosphere.
5. Causes skin cancer, retinal diseases, damage cornea etc.

**14.4**

1. $H_2SO_4$, $HNO_3$
2. Acid rain lowers the pH of water in which the organism lives. At low pH gametes (egg/sperms) of the organisms cannot survive. It affects the life cycle. Leading to generation/population loss.
3. Solar / nuclear energy.

**14.5**

1. Ignibility, corrosively, reactivity, toxicity.
2. Any substance that could have serious, irreversible health after affects from a single dose of exposure.

**14.6**

1. It may either poisonous or suffocate, damage marine ecosystem
2. Lack of oxygen in the water body is responsible for the deaths of enormous number of fish or marine life.

**14.7**

1. From nuclear reactors, laboratories, hospitals and direct exposure to radiation for diagnostic purposes (X-rays).
2. Quick devastating effect on human and other life forms. Slow effect – childhood leukemia, miscarriages, infant mortality, increased susceptibility to AIOs.
3. It suffocates them, poisons them.
4. If sea water deficient in oxygen, that is very essential for aerobic respiration for the organism living in water.

15

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# BIODIVERSITY CONSERVATION

A wide variety of living organisms including plants, animals and micro-organisms with whom we share this planet earth makes the world a beautiful place to live in. Living organisms exist almost everywhere from mountain peaks to the ocean depths; from deserts to the rainforests. They vary in their habit and behaviour, shapes, sizes and colour. The remarkable diversity of living organisms form an inseparable and significant parts of our planet however, the ever increasing human population is posing serious threats to bio-diversity.

In this lesson we shall learn the ways humans are causing loss of biodiversity and the efforts that are being taken or need to be taken to protect and conserve the biodiversity.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the concept of biodiversity;*
- *describe the importance of biodiversity to human welfare and economic development;*
- *explain the uniqueness of Indian biodiversity and associated regional specificity;*
- *list the causes of biodiversity depletion in Indian and global context;*
- *justify the conservation of biodiversity;*
- *distinguish between extinct, endangered and threatened species;*
- *describe various in-situ and ex-situ methods of conservation;*
- *explain the objectives of specific wildlife conservation projects like project tiger, project elephant, project crocodile etc.;*
- *describe the importance of national parks, sanctuaries and biosphere reserves;*
- *legal measures adopted by national and international bodies.*

## 15.1 WHAT IS BIOLOGICAL DIVERSITY

Sum total of all the variety of living organisms on earth constitute biodiversity. Biological diversity is usually considered at three different levels – a) genetic diversity i.e. at genetic level , b) species diversity i.e. at the level of species, and c) ecosystem diversity i.e. at the level of ecosystem.

### 15.1.1 Genetic diversity

Each species, varying from bacteria to higher plants and animals, stores an immense amount of genetic information. For example, the number of genes is about 450-700 in mycoplasma, 4000 in bacteria (eg. *Escherichia coli)* , 13,000 in Fruit-fly *(Drosophila melanogaster);* 32,000 – 50,000 in rice (*Oryza sativa*); and 35,000 to 45,000 in human beings (*Homo sapiens sapiens).* This variation of genes, not only of numbers but of structure also, is of great value as it enables a population to adapt to its environment and to respond to the process of natural selection. If a species has more genetic variation, it can adapt better to the changed environmental conditions. Lower diversity in a species leads to genetic uniformity of genetically similar crop plants. This homogeneity is desirable in producing uniform quality of grain. But genetic uniformity restricts adaptability of a species to environmental stress as all the plants have same level of resistance.

With the above background, **genetic diversity** refers to the variety of genes contained within species of plants, animals and micro-organisms. New genetic variation in individuals occurs by gene and chromosomal mutation, and in organisms with sexual reproduction may be spread across the population by recombination. For instance, two brothers differ in their structure, although their parents are the same. The differences could be in alleles (different variants of the same gene), in entire gene (the traits determining particular characteristics) or in chromosomal structure. The amount of genetic variation (gene pool) present in an inter-breeding population is shaped or decided by the process of natural selection. Selection leads to certain genetic attributes being preferred and results in changes in the frequency of genes within this pool. This forms the basis of adaptation among the living organisms. India has high genetic diversity and is regarded as a Vavilov's centre of high crop genetic diversity – so named after the Russian agro-botanist N I Vavilov, who identified eight such centres of origin of cultivated plants around the world in the 1950s.

### 15.1.2 Species diversity

Species diversity refers to the variety of species within a geographical area.

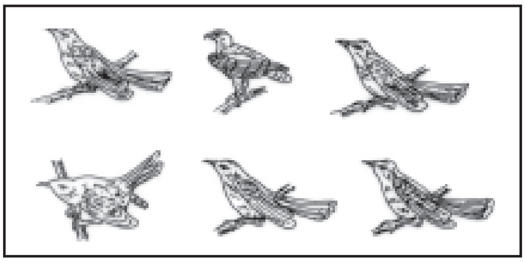
Species diversity can be measured in terms of:

(a) **Species richness –** refers to the number of various species in a defined area.

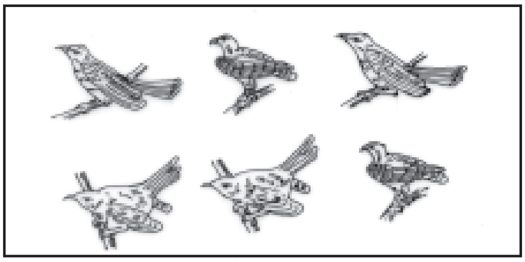
(b) **Species abundance –** refers to the relative numbers among species. For example, the number of species of plants, animals and microorganisms may be more in an area than that recorded in another area.

(c) **Taxonomic or phylogenetic diversity –** refers to the genetic relationships between different groups of species.

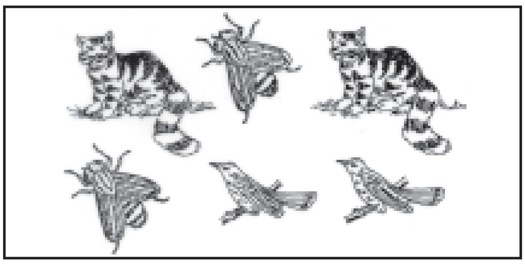
Kinds of species that are present in an area is also important. When taxonomically unrelated species are present in an area, the area represents greater species diversity as compared to an area represented by taxonomically related species. Observe the diagram shown below. Fig. 15.1



Sample Area A



Sample Area B



Sample Area C

***Fig. 15.1:*** *The different sample areas showing species diversity.*

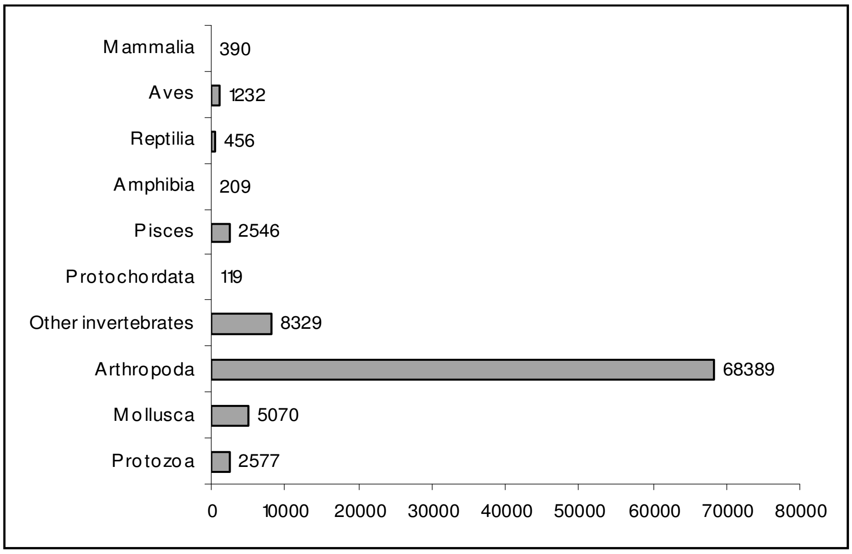
{Note – Know that all the three sample areas are represented by three kinds of species. (species richness is same). However they vary in species abundance varying number of individuals per species) and in taxonomic diversity. Observe that sample C has the highest species diversity as it is represented by taxonomically unrelated species}

At the global level, an estimated 1.7 million species of living organisms have been described to date and many more are yet to be discovered. It has been currently estimated that the total number of species may vary from 5 - 50 millions. Species diversity is not evenly distributed across the globe. The overall richness of species is concentrated in equatorial regions and tends to decrease as one moves from equatorial to polar regions. In addition, biodiversity in land ecosystems generally decreases with increasing altitude. The other factors that influence biodiversity are amount of rainfall and nutrient level in soil. In marine ecosystems, species richness tends to be much higher in continental shelves.

India is a country of vast diversity (Fig. 15.2) and it is among the 12 "mega-diversity" countries in the world.

Bacteria

*(a) Number of species of plants and bacteria*




*(b) Number of species of animals*

***Fig. 15.2:*** *Number of plant and animal species in different groups recorded in India*

### 15.1.3 Ecosystem diversity

It refers to the presence of different types of ecosystems. For instance, the tropical south India with rich species diversity will have altogether different structure compared to the desert ecosystem which has far less number of plant and animal species. Likewise, the marine ecosystem although has many types of fishes, yet it differs from the freshwater ecosystem of rivers and lakes in terms of its characteristics. So such variations at ecosystem level are termed as *ecosystem diversity*.

As stated above, ecosystem diversity encompasses the broad differences between ecosystem, and the diversity of the habitats and ecological processes occurring within each ecosystem type. India has very diverse terrestrial and aquatic ecosystems ranging from ice-capped Himalayas to deserts, from arid scrub to grassland to wetlands and tropical rainforests, from coral reefs to the deep sea. Each of these comprises a great variety of habitats and interactions between and within biotic and abiotic components. The most diversity-rich are western-ghats and the north-eastern region. A very large number of species found in these ecosystems are **endemic** or found in these areas only in India i.e. they are found no where else except in India. The endemics are concentrated mainly in north-east, western-ghats, north-west Himalaya, and Andaman and Nicobar Islands. About 33% of the flowering plants recorded in India are endemic to our country. Indian region is also notable for endemic fauna. For example, out of recorded vertebrates, 53% freshwater fish, 60% amphibians, 36% reptiles and 10% mammalian fauna are endemic.

### 15.1.4 Hot spots of biodiversity

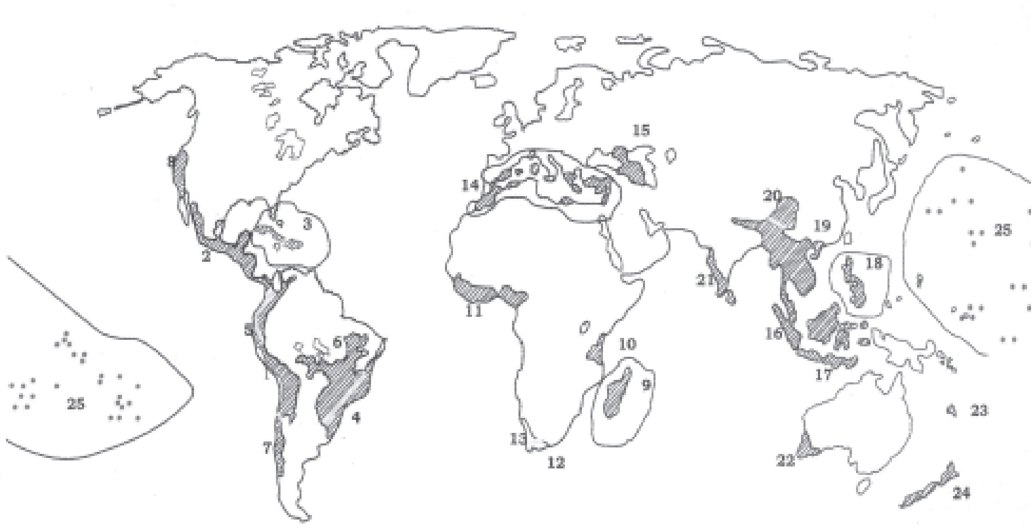
Biodiversity is not uniformly distributed across the geographical regions of the earth. Certain regions of the world are very rich in biodiversity. We call such areas as “mega diversity zones”. We also refer to them as “hot-spots”. For example, India accounts for only 2.4 % of the land area of the world; but it contributes approximately 8% species to the global diversity due to existence of such pockets.

Norman Myers, a British Ecologist, developed the concept of hot spots in 1988 to designate priority areas for *in situ* conservation. According to him, the hot spots are the richest and the most threatened reservoirs of biodiversity on the earth. The criteria for determining a hot spot are:

i) The area should support >1500 endemic species,

ii) It must have lost over 70 % of the original habitat

Twenty-five biodiversity hot spots have been identified in the world. These hot spots are characterized by posing exceptionally high biodiversity. For example the total area of these 25 hot spots cover 1.4% of the total land area, support 44% of plant and 35% terrestrial vertebrates. (Refer to the Fig. 15.3)



1. Tropical Andes, 2. Mesoamerica, 3. Caribbean, 4. Brazil's Atlantic Forests, 5. Choco/Darien/Western Ecuad
6. Brazil's Cerrado, 7. Central Chile, 8. California Floristic Province, 9. Madagascar, 10. Eastern Arc & Coastal Fores of Tanzania/Kenya, 11. West African Forests, 12. Cape Floristic Province, 13. Succulent Karoo, 14. Mediterrane Basin, 15. Caucasus, 16. Sundland, 17. Wallacea, 18. Philippines, 19. Indo-Burma, 20. South-Central Chir
21. Western Ghats/Sri Lanka, 22. Southwest Australia, 23. New Caledonia, 24. New Zealand, 25. Polynesia/Micrones

***Fig. 15.3:*** *The terrestrial biodiversity hot spots*

Among the 25 hot spots of the world, 2 are found in India namely western ghats and the eastern Himalayas. These two areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals.

The eastern Himalayan hot spot extends to the north – eastern India and Bhutan. The temperate forests are found at an altitude of 1780 to 3500 m. Many deep and semi-isolated valleys are exceptionally rich in endemic plant species.

The Western Ghat region lies parallel to the western coast of Indian peninsula for almost 1600 km, in Maharashtra, Karnataka, Tamil Nadu and Kerala. These forests at low elevation (500 m above mean sea level) are mostly evergreen, while those at 500- 1500 m height are generally semi-evergreen forests.

## INTEXT QUESTIONS 15.1

1. What do you understand by biological diversity?

2. List the various levels of biodiversity.

3. Name the two hot spots in India.

4. Name the most abundant (i) group of plants and (ii) group of animal recorded in India.

## 15.2 WHY IS BIOLOGICAL DIVERSITY IMPORTANT

Humans depend for their sustenance, health, wellbeing and cultural growth on nature. Biotic resources provide food, fruit, seed, fodder, medicines and a host of other goods and services. The enormous diversity of life is of immense value, imparting resilience to ecosystems and natural processes. Biodiversity also has enormous social and cultural importance.

**The value of biological diversity**

The various benefits of biological diversity can be grouped under three categories: a) ecosystem services, b) biological resources, and c) social benefits.

### 15.2.1 Ecosystem services

Living organisms provide many ecological services free of cost that are responsible for maintaining ecosystem health. Thus biodiversity is essential for the maintenance and sustainable utilization of goods and services from ecological system as well as from individual species.

i) **Protection of water resources:** Natural vegetation cover helps in maintaining hydrological cycles, regulating and stabilizing water run-off and acting as a buffer against extreme events such as floods and droughts. Vegetation removal results in siltation of dams and waterways. Wetlands and forests act as water purifying systems, while mangroves trap silt thereby reducing impacts on marine ecosystems.

ii) **Soil protection:** Biological diversity helps in the conservation of soil and retention of moisture and nutrients. Clearing large areas of vegetation cover has been often seen to accelerate soil erosion, reduce its productivity and often result in flash floods. Root systems allows penetration of water to the sub soil layer. Root system also brings mineral nutrients to the surface by nutrient uptake.

iii) **Nutrient storage and cycling:** Ecosystem perform the vital function of recycling nutrients found in the atmosphere as well as in the soil. Plants are able to take up nutrients, and these nutrients then can form the basis of food chains, to be used by a wide range of life forms. Nutrients in the soil, in turn, is replenished by dead or waste matter which is transformed by micro-organisms; this may then feed others such as earthworms which also mix and aerate the soil and make nutrients more readily available.

iv) **Pollution reduction:** Ecosystems and ecological processes play an important role in maintenance of gaseous composition of the atmosphere, breakdown of wastes and removal of pollutants. Some ecosystems, especially wetlands have the ability to breaking down and absorb pollutants. Natural and artificial wetlands are being used to filter effluents to remove nutrients, heavy metals, suspended solids; reduce the BOD (Biological Oxygen Demand) and destroy harmful micro-organisms. Excessive quantities of pollutants, however, can be detrimental to the integrity of ecosystems and their biota.

v) **Climate stability:** Vegetation influences climate at macro as well as micro levels. Growing evidence suggests that undisturbed forests help to maintain the rainfall in the vicinity by recycling water vapor at a steady rate back into the atmosphere. Vegetation also exerts moderating influence on micro climate. Cooling effect of vegetation is a common experience which makes living comfortable. Some organisms are dependent on such microclimates for their existence.

vi) **Maintenance of ecological processes:** Different species of birds and predators help to control insect pests, thus reduce the need and cost of artificial control measures. Birds and nectar–loving insects which roost and breed in natural habitats are important pollinating agents of crop and wild plants. Some habitats protect crucial life stages of wildlife populations such as spawning areas in mangroves and wetlands.

Without ecological services provided by biodiversity it would not be possible to get food, pure air to breathe and would be submerged in the waste produced.

### 15.2.2 Biological resources of economic importance

i) **Food, fibre, medicines, fuel wood and ornamental plants:** Five thousand plant species are known to have been used as food by humans. Presently about 20 species feed the majority of the world's population and just 3 or 4 only are the major staple crops to majority of population in the world.

A large number of plants and animals materials are used for the treatment of various ailments. The usage of medicinal plants in India has an ancient history, dating back to the pre-vedic culture, at least 4000 years B. C. The therapeutic values of herbal medicines led to evolution of *Ayurveda* which means "science of life". It is estimated that at least 70 % of the country's population rely on herbal medicines and over 7000 species of plants are used for medicinal purposes.

Wood is a basic commodity used worldwide for making furniture and for building purposes. Fire wood is the primary source of fuel widely used in third world countries. Wood and bamboo are used for making paper.

Plants are the traditional source of fibre such as coir, hemp, flax, cotton, jute.

ii) **Breeding material for crop improvement:** Wild relatives of cultivated crop plants contain valuable genes that are of immense genetic value in crop improvement programmes. Genetic material or genes of wild crop plants are used to develop new varieties of cultivated crop plants for restructuring of the existing ones for improving yield or resistance of crops plants. For example: rice grown in Asia is protected from four main diseases by genes contributed by a single wild rice variety.

iii) **Future resources:** There is a clear relationship between the conservation of biological diversity and the discovery of new biological resources. The relatively few developed plant species currently cultivated have had a large amount of research and selective breeding applied to them. Many presently under-utilised food crops have the potential to become important crops in the future. Knowledge of the uses of wild plants by the local people is often a source for ideas on developing new plant products.

### 15.2.3 Social benefits

i) **Recreation:** Forests, wildlife, national parks and sanctuaries, garden and aquaria have high entertainment and recreation value. Ecotourism, photography, painting, film making and literary activities are closely related.

ii) **Cultural values:** Plants and animals are important part of the cultural life of humans. Human cultures have co-evolved with their environment and biological diversity can be impart a distinct cultural identity to different communities.

The natural environment serves the inspirational, aesthetic, spiritual and educational needs of the people, of all cultures. In a majority of Indian villages and towns, plants like Tulsi (*Ocimum sanctum),* Peepal (*Ficus religiosa),* Khejri (*Prosopis cineraria)* are planted and considered sacred and worshipped.

### 15.2.4 Research, Education and Monitoring

There is still much to learn on how to get better use from biological resources, how to maintain the genetic base of harvested biological resources, and how to rehabilitate degraded ecosystems. Natural areas provide excellent living laboratories for such studies, for comparison with other areas under systems of use and for valuable research in ecology and evolution.

## INTEXT QUESTIONS 15.2

1. Name the three important categories under which the uses of biodiversity can be described.

______________________________

2. Mention two examples of ecosystem services.

______________________________

3. List any two ways by which biodiversity contributes towards cleaner environment.

______________________________

## 15.3 UNIQUENESS OF INDIAN BIODIVERSITY AND ASSOCIATED REGIONAL SPECIFICITY

India is uniquely rich in all aspects of biodiversity including ecosystem, species and genetic biodiversity. For any one country in the world, it has perhaps the largest array of environmental situations by virtue of its tropical location, varied physical features and climate types. India has the widest variety of ecosystems. With only 2.4% of the land area, India accounts for 7-8 % of the recorded species of the world. More than 45000 species of plants and 81,000 species of animals are found in India. India is also one of the eight primary centers of origin of cultivated plants and has a rich agricultural biodiversity.

The trans-Himalayan region with its sparse vegetation has the richest wild sheep and goat community in the world. The snow leopard (*Panthera uncia*) and Black-necked Crane (*Grus nigricollis)* are found here. The Great Indian Bustard (*Ardeotis nigriceps*) which is highly endangered bird, is found in (Gujrat) region, rich in extensive **grasslands.**

North-east India is one of the richest regions of biodiversity in the country. It is especially rich in orchids, bamboos, ferns, citrus, banana, mango and jute.

India is also rich in coral reefs. Major reef formations in Indian seas occur in the Gulf of Mannar, Palk Bay, Gulf of Kutch, the Andaman and Nicobar Islands and the Lakshadweep. The threat to mangroves trees (growing in marshy lands) and coral reefs comes from the biotic pressure such as extraction for market demands, fishing, land-use changes in surrounding areas, and from pollution of water etc.

## 15.4 CAUSES OF BIODIVERSITY DEPLETION

Loss of species is a serious cause of concern for human survival. It has been observed that 79 species of mammals, 44 of birds, 15 of reptiles and 3 of amphibians are threatened. Nearly 1500 species of plants are endangered in India. The threat to survival or loss may be caused in the following three ways:

- **Direct ways:** Deforestation, hunting, poaching, commercial exploitation.
- **Indirect ways:** Loss or modification of the natural habitats, introduction of exotic species, pollution, etc.
- **Natural causes** - Climate change.

Among these causes, habitat destruction and over-exploitation are the main.

i) **Habitat (natural home) destruction** may result from clearing and burning forests, draining and filling of wetlands, converting natural areas for agricultural or industrial uses, human settlements, mines, building of roads and other developmental projects. This way the natural habitats of organisms are changed or destroyed. These change either kill or force out may species from the area causing disruption of interactions among the species. Fragmentation of large forest tracts (eg. the corridores) affects the species occupying the deeper part of the forest and are first to disappear. Apart from the direct loss of species during the development activities, the new environment is unsuitable for the species to survive. Over exploitation reduces the size of the population of a species and may push it towards extinction.

ii) **Introduction of exotic species**: Seeds catch on people's clothes. Mice, rats and birds hitch-hike on ships. When such species land in new places, they breed extra fast due to absence of any enemy and often wipe out the native species already present there. **Exotic species** (new species entering geographical region) may wipe out the native ones. A few examples are-

(i) Parthenium hysterophorus (Congress grass- a tropical American weed) has invaded many of the vacant areas in cities, towns and villages in India leading to removal of the local plants and the dependent animals.

(ii) Nile perch, an exotic predatory fish introduced into Lake Victoria (South Africa) threatened the entire ecosystem of the lake by eliminating several native species of the small Cichlid fish that were endemic to this freshwater aquatic system.

(iii) Water hyacinth clogs lakes and riversides and threatens the survival of many aquatic species. This is common in Indian plains.

(iv) *Lantana camara* (an American weed) has invaded many forest lands in various parts of India and wiped out the native grass species.

iii) **Pollution:** Air pollution, acid rain destroy forests. Water pollution kills fishes and other aquatic plants and animals. Toxic and hazardous substances drained into waterways kill aquatic life. Oil spills kill coastal birds, plants and other marine animals. Plastic trash entangles wildlife. It is easy to see how pollution is a big threat to biodiversity.

iv) **Population growth and poverty:** Over six billion people live on the earth. Each year, 90 million more people are added. All these people use natural resources for food, water, medicine, clothes, shelter and fuel. Need of the poor and often greed of the rich generate continuous pressure resulting in over-exploitation and loss of biodiversity.

**The World Conservation Union (IUCN)** (formerly known as International Union for the Conservation of Nature and Natural Resources, IUCN) has recognized eight Red List categories according to the conservation status of species. These categories are defined below in Table 15.2.

***Table 15.2:** The IUCN Threat Categories*

| List Category | Definition |
|---|---|
| Extinct | A taxon is extinct when there is no reasonable doubt that the last individual has died. |
| Extinct in the wild | A taxon is extinct in the wild when exhaustive surveys in known and/or expected habitats have failed to record an individual. |
| Critically endangered | A taxon is critically endangered when it is facing high risk of extinction in the wild in immediate future. |
| Endangered | A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in near future. |
| Vulnerable | A taxon is vulnerable when it is not critically endangered or endangered but is facing high risk of extinction in the wild in the medium term future. |
| Lower risk | A taxon is lower risk when it has been evaluated and does not satisfy the criteria for critically endangered, endangered or vulnerable. |
| Data deficient | A taxon is data deficient when there is inadequate information to make any direct or indirect assessment of its risk of extinction. |
| Not evaluated | A taxon is not evaluated when it has not yet been assessed against the above criteria. |

### Status of threatened species

The IUCN Red List is an authentic source of information for this purpose. The 2000 Red List is the latest available. It uses a set of criteria, relevant to all species and all regions of the world, to evaluate the extinction risk of species. The 2000 Red List contains assessment of more than18,000 species; 11,000 of which are threatened (5,485 animals and 5611 plants). Out of these, 1,939 are listed as critically endangered (925 animals, and 1,014 plants).According to the Red List, in **India,** 44 plant species are critically endangered., 113 endangered and 87 vulnerable. Amongst animals, 18 are critically endangered, 54 endangered and 143 Vulnerable. A few examples of these plant and animals are given below :

***Table 15.3:** Examples of threatened species in India*

| Category | Plant species | Animal species |
|---|---|---|
| Critically endangered | *Berberis nilghiriensis* | *Sus salvanius*, (Pigmy hog) |
| Endangered | *Bentinckta nicobarica* | *Allurus fulgens* , (Red Panda) |
| Vulnerable | *Cupressus cashmeriana* | *Antilope cervicapra*, (Black buck) |

## 15.5 CONSERVATION OF BIODIVERSITY

Conservation is the planned management of natural resources, to retain the balance in nature and retain the diversity. It also includes wise use of natural resources in such a way that the needs of present generation are met and at the same time leaving enough for the future generations. Conservation of biodiversity is important to:-

- prevent the loss of genetic diversity of a species,
- save a species from becoming extinct, and
- protect ecosystems damage and degradation.

## INTEXT QUESTIONS 15.3

1. Which region in India has the richest wild sheep and goat community in the world?

2. List any three factors by virtue of which India has a rich and unique biodiversity.

3. Name the richest regions of biodiversity.

4. What are exotic species? What effect do they have on the local species?

5. List the three zones of a biosphere reserve and which one of them allow settlements etc.

6. List the three objectives of convention of biological diversity signed during the earth summit-1993.

7. Expand IUCN.

8. Howe many animals and how many plants in India are listed as critically endangered in red list.

## 15.6 CONSERVATION STRATEGIES

Conservation efforts can be grouped into the following two categories:

1. ***In-situ*** (on-site) conservation includes the protection of plants and animals within their natural habitats or in protected areas. Protected areas are land or sea dedicated to protect and maintain biodiversity.
2. ***Ex-situ*** (off-site) conservation of plants and animals outside their natural habitats. These include botanical gardens, zoo, gene banks, seek bank, tissue culture and cryopreservation.

### 15.6.1 In-situ methods

i) **Protection of habitat**: The main strategy for conservation of species is the protection of habitats in representative ecosystems. Currently, India has ninety six National Parks, five hundred Wildlife Sanctuaries, thirteen Biosphere Reserves, twenty seven Tiger Reserves and eleven Elephant Reserves covering an area of 15.67 million hectares or 4.7 % of the geographical area of the country. Twenty one wetlands, thirty mangrove areas and four coral reef areas have been identified for intensive conservation and management purposes by the Ministry of Environment and Forests, Govt. of India.

**• National parks and sanctuaries**

India is unique in the richness and diversity of its vegetation and wildlife. India's national parks and wildlife sanctuaries (including bird sanctuaries) are situated Ladakh in Himalayas to Southern tip of Tamil Nadu with its rich bio-diversity and heritage. Wildlife sanctuaries in India attract people from all over the world as the rarest of rare species are found here. With 96 national parks and over 500 wildlife sanctuaries, the range and diversity of India's wildlife heritage is unique. Some of the main sanctuaries in India are:

The Jim Corbett Tiger Reserve- Uttaranchal, Kanha National Park, Madhya Pradesh, Bandhavgarh National Park- Madhya Pradesh, Ranthambhor National Park-Sawai Madhopur, Gir National Park-Sasangir (Gujarat) etc.

Wildlife lovers eager to see magnificent Bird Sancturaty at Bharatpur, Rajasthan as it is the second habitat in the world that is visited by the Siberian Cranes in winter and it provides a vast breeding area for the native water birds, Great Indian bustard is found in the Indian deserts. In wesern Himalayas, one can see birds like Himalayan monal pheasant, western tragopanm koklass, white crested khalij pheasant, griffon vultures, lammergiers, choughs, ravens. In the Andaman and Nicobar region, about 250 species and subspecies of birds are found, such as rare Narcondum horn bill, Nicobar pigeon and megapode. While the national parks and sanctuaries in South India, too. For e.g. Madumalai in Tamil Nadu and Bandipur Tiger Reserve and Nagahole National Park in Karnataka.

Many National Parks and Sancturies have been established to preserve wildlife in their natural environment. Some of them are given below along with important species found there.

- Kaziranga sanctuary (Assam) – One-horned rhinoceros
- Manas sanctuary (Assam) – Wild buffaloes
- Gir forest (Gujarat) – Lions, chital, sambar, wild bears
- Kelameru bird sanctuary (Andhra Pradesh) – Pelicans and marine birds
- Dachigam sanctuary (Jammu and Kashmir) – Kashmir stags, Himalayan tahr, wild goats, sheep, antelopes.
- Bandipur sanctuary (Karnataka) – Indian bison, elephants, langurs
- Periyar sanctuary (Kerala) – Elephants, barking deer, sambhar
- Kanha National Park (Madhya Pradesh) – Tiger, leopards, wild dogs

- Simipal National Park (Orissa) – Mangroves, marine turtles lay eggs
- Bharatpur bird sanctuary (Rajasthan) – Ducks, herons
- Corbett National Park (Uttaranchal) –Tigers, barking deer, sambar, wild bear, rhesus monkey.
- Jaladpara sanctuary (West Bengal) – Rhinoceros

Wildlife Conservation Society (WCS) India in association with other NGO partners and tribal people, is making every possible effort to develop new models of wildlife conservation to preserve India's most treasured fauna and to protect the environment.

- **Biosphere Reserves**

These are representative parts of natural and cultural landscapes extending over large areas of terrestrial or coastal/marine ecosystems which are internationally recognized within UNESCO's Man and the Biosphere Programme **Thirteen biodiversity**- rich representative ecosystems , largely within the forest land ( total area – 53,000 sq. km. ), have been designated as Biosphere Reserves in India. shown in Figure 15.4.


***Fig. 15.4:*** *The Biosphere reserves in India*

The concept of Biosphere Reserves (BR) was launched in 1975 as a part of UNESCO's Man and Biosphere Programme, dealing with the conservation of ecosystems and the genetic material they contain**.** A Biosphere Reserve consists of core, buffer and transition zones. (a) The **core zone** is fully protected and natural area of the Biosphere Reserve least disturbed by human activities. It is legally protected ecosystem in which entry is not allowed except with permission for some special purpose. Destructive sampling for scientific investigations is prohibited. (b) The **buffer zone** surrounds the core zone and is managed to accommodate a greater variety of resource use strategies, and research and educational activities. (c) the **transition zone**, the outermost part of the Biosphere Reserve, is an area of active cooperation between the reserve management and the local people, wherein activities like settlements, cropping, forestry , recreation and other economic that are in harmony with the conservation goals. **Till date** there were 553 biosphere reserves located in 107 countries.

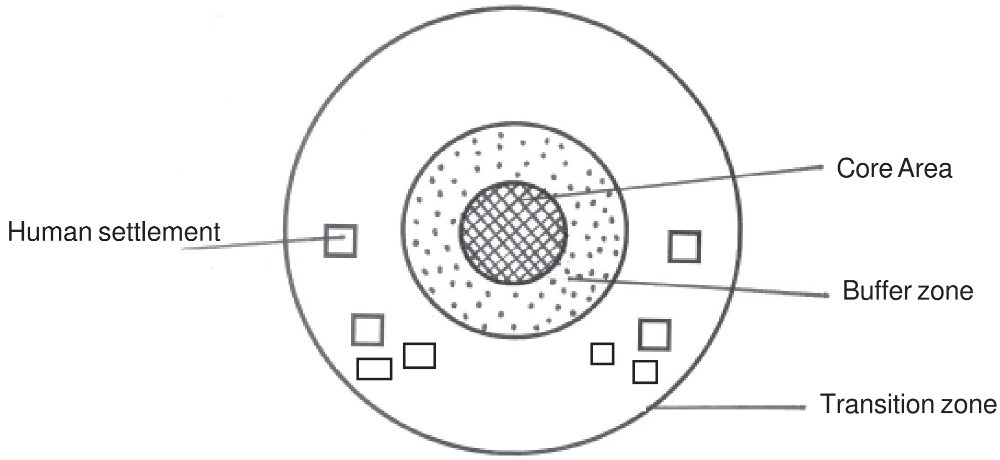



***Fig. 15.5:*** *Human Settlement (A terrestrial BR – Biosphere reserve)*

The main functions of the biosphere reserves are:

- **Conservation:** Long term conservation of representatives, landscapes and different types of ecosystems, along with all their species and genetic resources.
- **Development:** Encourages traditional resource use and promote economic development which is culturally, socially and ecologically sustainable.
- **Scientific research, monitoring and education-** Support conservation research, monitoring, education and information exchange related to local, national and global environmental and conservation issues.

**ii) Species-oriented projects:** Certain species have been identified as needing a concerted and specifically directed protection effort. Project Tiger, Project Elephant and Project crocodile are examples of focusing on single species through conserving their habitats.

- **Project Tiger – A success in species conservation**

Tigers which were once abundant in Indian forests have been hunted. As a result tiger population within the country declined drastically from estimate of 40,000 at the turn of century to 1200 by the 1970. This led to initiate the Project Tiger in 1973 with the objective of conserving and rescuing this species from extinction. In 2007, there were more than 40 Project Tiger wildlife reserves covering an area of 37,761 km². Project Tiger helped to increase the population of these tigers from 1,200 in the 1970s to 3,500 in 1990s. However, a 2008 census held by Government of India revealed that the tiger population had dropped to 1,411. A total ban has been imposed on hunting of tigers and trading in tiger products at the national and international levels. Elaborate management plans are made for each of the tiger reserves for tiger habitat improvement and anti -poaching measures.

- **Project Elephant**

Project Elephant was launched in February, 1992 to assist states having free ranging populations of wild elephants to ensure long-term survival of identified viable populations of elephants in their natural habitats. The project is being implemented in twelve states viz. Andhra Pradesh, Arunachal Pradesh, Assam, Jharkhand, Karnataka, Kerala, Meghalaya, Nagaland, Orissa, Tamil Nadu Uttaranchal and West Bengal.

- **Crocodile breeding and management project**

This project was started in 1976 with FAO - UNDP assistance to save three endangered crocodilian species, namely, the fresh water crocodile, salt water crocodile and the rare *gharial. The* project surveyed the crocodile habitats and facilitated their protection through declaration of sanctuaries and National Parks. Captive breeding and reintroduction or restocking programmes involved careful collection of eggs from the wild. Thousands of crocodiles of three species have been reared at sixteen centres and several of these have been released in the wild. Eleven sanctuaries have been declared specially for crocodile protection including the National Chambal Sanctuary in Madhya Pradesh.

(iii) **Sacred forests and sacred lakes:** A traditional strategy for the protection of biodiversity has been in practice in India and some other Asian countries in the form of sacred forests. These are small forest patches protected by tribal communities due to religious sanctity. These have been free from all disturbances. Sacred forests are located in several parts of India i.e. Karnataka, Maharashtra, Kerala, Meghalaya , Similarly, several water bodies for example, Khecheopalri lake in Sikkim, have been declared sacred by the people, leading to protection of aquatic flora and fauna.

### 15.6.2 Ex-situ Conservation

(i) **Botanical gardens, zoos, etc.** To complement *in-situ* conservation efforts, *ex-situ* conservation is being undertaken through setting up botanic gardens, zoos, medicinal plant parks, etc by various agencies. The Indian Botanical Garden in Howrah (West Bengal) is over 200 years old. Other important botanical gardens are in Ooty, Bangalore and Lucknow. The most recent one is The Botanical Garden of Indian Republic established at NOIDA, near Delhi in April, 2002. The main objectives of this garden are –

- *ex-situ* conservation and propagation of important threatened plant species,
- serve as a Centre of Excellence for conservation., research and training,
- build public awareness through education on plant diversity and need for conservation.

A number of zoos have been developed in the country. These zoological parks have been looked upon essentially as centres of education about animal species and recreation. They have also played an important role in the conservation of endangered animal species such as the Manipur Thamin Deer (*Cerus eldi eldi)* and the White winged Wood Duck (*Cairina scutulata).* Notable successful examples of captive breeding are those of Gangetic gharial (*Gavialis gangeticus),* turtles and the white tiger.

(ii) **Gene Banks :** *Ex-situ* collection and preservation of genetic resources is done through gene banks and seed banks. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi preserves seeds of wild relatives of crop plants as well as cultivated varieties; the National Bureau of Animal Genetic Resources at Karnal, Haryana maintains the genetic material for domesticated animals, and the National Bureau of Fish Genetic Resources, Lucknow for fishes.

(iii) **Cryopreservation:** (“freeze preservation”) is particularly useful for conserving vegetative propagated crops. Cryopreservation is the storage of material at ultra low temperature of liquid nitrogen ($-196^0$C) and essentially involves suspension of all metabolic processes and activities. Cryopreservation has been successfully applied to meristems, zygotic and somatic embryos, pollen, protoplasts cells and suspension cultures of a number of plant species.

(iv) **Conservation at molecular level (DNA level):** In addition to above, germplasm conservation at molecular level is now feasible and attracting attention. Cloned DNA and material having DNA in its native state can all be used for genetic conservation. Furthermore, non-viable material representing valuable genotypes stored in gene banks can all be used as sources of DNA libraries from where a relevant gene or a combination of genes can be recovered.

**Legal measures :** Market demand for some body parts like bones of tiger, rhino horns, furs, ivory, skins, musk, peacock feathers , etc results in killing the wild animals. **The Wildlife Protection Act (1972)** contain provisions for penalties or punishment to prevent poaching and illegal trade. India is also a signatory to the **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**. The Convention entered into force on 1$^{st}$ July, 1975. In addition to this, India is also a signatory to **Convention on Biological Diversity (CBD)**, which it signed on 29$^{th}$ December, 1993 at Rio de Janeiro during the Earth Summit. The Convention has three key objectives:

1. Conservation of biological diversity,
2 Sustainable use of biodiversity and
3. Fair and equitable sharing of benefits arising out of the utilization of genetic resources.

The CITES and the CBD are international initiatives. Government of India have also passed the Biological Diversity Act, 2002, the details of this acts is given in lesson 23.

**Biological Diversity Act, 2002**

- This Act provides for setting up of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBB) and Biodiversity Management Committees (BMC) in local bodies.
- All foreign nationals organizations require prior approval of NBA for obtaining biological resources and/or associated knowledge for any use.
- Similarly, Indian nationals or organizations will require to give prior intimation to the concerned SBB about any biological resources being imported for commercial use. The SBB may prohibit the import if found to violate the objectives of conservation, sustainable use and benefit sharing.
- However, local people and communities of the area, including *Vaids* and *Hakims* will have free access to use biological resources within the country for their own use, medicinal purposes and research.
- While granting approvals, NBA will impose terms and conditions to secure equitable sharing of benefits.
- There is a enabling provision for setting up a framework for protecting traditional knowledge.
- The monetary benefits, fees and royalties, as a result of approvals by NBA are to be deposited in National Biodiversity Fund which will be used for conservation and development of areas from where the resource has been accessed, in consultation with local self government.
- World Wide Fund for Nature (WWF) and World Conservation Union supports projects to promote conservation and appropriate development of Biosphere Reserves.

## INTEXT QUESTIONS 15.4

1. What are the main conservation strategies?

2. Name two important tiger reserves.

3. Expand WCS.

4. What are the main functions of biosphere reserve?

5. Expand the following:
   i. NBPGR ii. NBG, iii. CITES, iv. IUCN, v. CBD, vi. NBA.

## WHAT YOU HAVE LEARNT

- Biodiversity refers to the totality of genes, species, and ecosystems of plant, animals or micro-organisms in a region. Study of biodiversity has become very important recently after realising the value of biodiversity for our survival. It has many medicinal, commercial, economic and scientific uses.
- Wild relatives of cultivated crop plants are the source of genes for disease resistance and several other attributes required for crop improvement.
- Biodiversity also provides valuable services like water conservation, clean air, soil conservation and improvement of soil fertility, pollution break-down, aesthetic needs and so on.
- The total number of species on earth is estimated to range from 5-100 million, but only about 1.8 million species have so far been described.
- India is very rich in biodiversity and is one of 12 megadiversity countries globally recognized. In India, 70 % of the country's area has been surveyed and around 45,000 species of microorganisms and plants; and 81,000 species of animals have been described till date.
- Biodiversity has 3 levels - i) genetic, ii) species, and iii) community or ecosystem. Species are distinct units of diversity and each species plays a specific role in a ecosystem.
- The diversity within a species often increases with environmental variability. Species diversity refers to the variety of species within a region. In ecosystem biodiversity, the biodiversity increases from polar regions towards the equator, and from high elevations to low elevations.
- Habitat loss and fragmentation, over-exploitation, environmental pollution, climate change and introduction of exotic species pose major threat to biodiversity. It is estimated that 14,000-40,000species are being lost every year from the tropical forests alone.
- The IUCN Red list is the world's most comprehensive inventory of the global conservation status of threatened plant and animal species.
- It is important to ensure the conservation of landscapes, ecosystems, species and genetic resources failing which it will create survival crisis for mankind.
- Conservation strategies include *in-situ* (on-site)and *ex-situ (off-site)* approaches.
- Habitat protection is the main *in-situ* approach. The Protected Area Network for habitat protection includes national parks, wildlife sanctuaries, biosphere reserves, sacred groves or sacred forests.
- Ex-situ conservation is doen by setting up botanical gardens, zoos, gene banks and seed banks, cryopreservation and preservation of germplasm.

- Areas that need immediate protection for conservation of biodiversity are called Biodiversity Hot Spots. Twenty-five hot spots of biodiversity have been identified the world over, of which two are in India.
- Convention on Biodiversity is an important international instrument promoting biodiversity conservation globally.
- IUCN and WWF are among the leading international organizations concerned with biodiversity conservation. The Wildlife Protection Act (1972) and Biodiversity Act (2002) at the national level and The CITES and The Convention on Biodiversity at the international level regulate the trade in biodiversity and promote its conservation and sustainable use.

## TERMINAL EXERCISE

1. What is biodiversity? Why has it become important in recent years?
2. List different levels of biodiversity and explain what is meant by genetic diversity.
3. What are various *in-situ* methods of conservation?
4. Write short notes on : a) Cryopreservation, b). Protected areas, c) Biosphere Reserves, d) IUCN Red List, e) Gene banks, f) Hot spots of biodiversity , g) Biodiversity Act,2002.
5. Describe various causes of depletion of biodiversity.
6. How is biodiversity distributed along major environmental gradients?
7. Write a brief note on biodiversity conservation efforts in India.
8. Match the words in column I with those in Column II

| **Column I** | **Column II** |
|---|---|
| i) 13000 genes | (a) *Lantana camara* |
| *ii)* Exotic species | (b) *Drosophila melanogaster* |
| *iii)* Transition zone | (c) Red List |
| *iv)* Endangered | (d) Biosphere Reserve |

9. What is the resultant of the Earth Summit held at Rio de Janeiro in 1992?
10. What is an approximate percentage of endemic vascular plants in India?

## ANSWER TO INTEXT QUESTIONS

**15.1**

1. Sum total of all the variety of living organisms on earth constitute biological diversity.
2. Genetic, species and ecological biodiversity

3. Western ghats and eastern Himalayas
4. (i)Angiosperms (ii) Arthropods

**15.2**

1. Ecological services, biological resource, aesthetic and cultural values.
2. Pollination, protection of soil, climatic control.
3. Reduce pollutants, maintenance of gaseous composition of air, degradation of wastes.

**15.3**

1. Trans-Himalayan region
2. 
   - Its tropical location
   - Varied physical features and climatic situations
   - Meeting of three major biogeographical realm
3. North east India
4. New species entering a geographical region or exotic species and may cause disappearance of native species through changed biotic interaction.
5. Core zone, buffer zone and transition zone; transition zone.
6. Conservation of biological diversity; sustainable use of biodiversity and fair and equitable sharing of benefits arising out of the utilization of genetic resources.
7. International Union for Conservation of nature and Natural Resources
8. 18,44

**15.4**

1. Two strategies- i. In-situ and ii. Ex-situ
2. Jim Corbett National Park in Uttaranchal, Kanha National Park, Bandhavgarh National park.
3. Wildlife Conservation Society.
4. It consists of core, buffer and transition zone
5. 1. Conservation, 2. Development,
6. i. The National Bureau of Plant Genetic Resources, New Delhi

   ii. National Botanical Garden

   iii. Convention on International Trade inN Endanger Species of Wild Fauna and Flora

   iv. The international Union for the Conservation of Nature and Natural Resources.

   v. Convention on Biological Diversity

   vi. National Biodiversity Authority

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# 16

# CONSERVATION OF OTHER NATURAL RESOURCES

Resource is anything useful or can be made useful to humans to meet their needs. The resource that is directly available for use from nature is called **natural resource**, which includes air, water from rainfall in lakes, rivers and wells, soil, land, forest, biodiversity, minerals, fossil fuels etc. Thus natural resources are supplied by our environment. When human population was small and they lived a controlled and moderate life, the resource use was limited. But increasing population and economic activity resulted in excessive material consumption is putting heavy burden on natural resource base and that is causing severe damage to the environment.

Increasing growth of human population has led to deforestation, draining of wetlands and reclamation of coastal areas to build their homes, farms and factories. Huge amounts of fossil fuel are being used in industries and for transportation. Destruction of forests causes loss of biodiversity which will deprive the future generations from the treasure of biodiversity.

It is therefore, extremely important to prevent further degradation of natural resources and use them in a wise and judicious manner to ensure their sustainable utilization. Natural resource conservation involves wise use of natural resources so that they are not wasted, depleted or degraded and are available to both present and future generations.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the term resource and classify it giving examples;*
- *explain the primary energy sources and their consumptions;*
- *list various fossil fuels and their occurrence;*
- *list and describe various renewable resources;*
- *list and classify various types of mineral resources;*
- *classify minerals, give examples and their uses in Indian context;*
- *suggest ways to reduce their depletion.*

## 16.1 NATURAL RESOURCE AND THEIR CLASSIFICATION

The term resource means anything obtained from the living and non living environment to meet human needs and wants.

**Natural resources** are earth's natural material and processes that sustain life on earth and our economies. A classification of natural resources is given in the Fig. 16.1

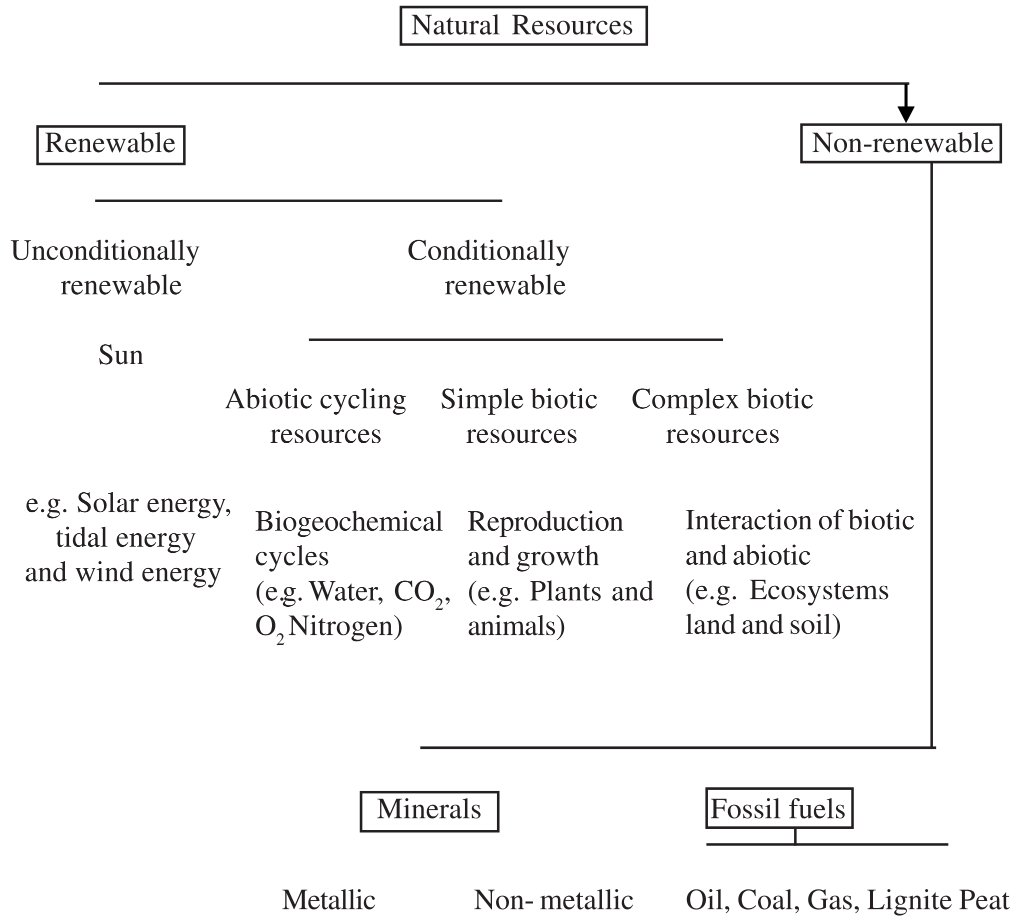


***Fig. 16.1:*** *The nature of natural resources and their classification*

## 16.2 PRIMARY ENERGY SOURCES AND THEIR CONSUMPTION

Fossil fuel includes all forms of stored solar energy including coal, lignite, peat, crude oil (petroleum) and natural gas. These are considered primary sources of energy. These energy resources are non-renewable and exhaustible because they are found in finite quantities cannot be renewed if exhausted during one's lifetime. Their renewal or formation may require millions of years, not within the human life scale, i.e., they are replaced slowly than they are used. Though coal, oil and natural gas are biotic in origin as they were produced from plants and plankton that lived millions of years ago, they cannot be renewed in practical terms; at least it cannot be reproduced in our times. Once these resources are consumed, they are practically gone forever.

**Consumption of oil**

The global consumption of oil has grown rapidly. Although the world is not yet running out of oil but like all other non-renewable resources, oil supplies are found to decline eventually. It is believed that at the present rate of consumption oil will reach its total depletion sometime during this century. It is hard to believe the amount of oil we consume.

> *Just for the world to keep using conventional oil at current rate, we must discover global oil reserves that are the equivalent to a new Saudi Arabian supply every ten years.*

**What do we do?**

We have three options (i) look for more oil, (ii) use or waste less oil (iii) use something else.

Rising oil prices when oil supply will fall short of oil demand will stimulate exploration of new reserves to meet future demand or new technology will allow to recover more oil from the existing oil wells.

> *China and India have started increasing their oil consumption. If everyone in the world consumed as much oil as the average American, the world's oil reserves would be gone in a decade!*

## 16.3 FOSSIL FUELS AND THEIR OCCURRENCES

Coal, oil and natural gas are three major fossil fuels that are conventional sources of energy. Coal is the world's most abundant energy resource (fossil fuel) that is burned most to produce electricity and steel. Coal is a solid fossil fuel that was formed in several stages as the buried remains of land plants, that lived 300-400 million years ago, were processed by geological forces.

Coal formation goes through the following stages:

| | | | | | | |
|---|---|---|---|---|---|---|
| **Peat**<br>Partially decayed plant matter in swamps and bags known a peat | Heat<br>Pressure | **Lignite**<br>(Brown coal) low cost and low sulphur content | Heat<br>Pressure | **Litminous**<br>(Soft coal) generally used as fuel | Heat<br>Pressure | **Anthracite**<br>(Hard coal) desirable fuel with low sulphur content |
| *Low heat content* | | *Low heat content* | | *High heat content* | | *High heat content* |

USA has one fourth of world's coal reserves, Russia has 16% and China 12%. China has enough coal reserves to last 300 years at its current rate of consumption. In India about one third of the country's coal reserves are distributed in Jharkhand coal fields like Jharia, Bokoro, Giridih, Daltonganj, Ramgarh etc. Mining and burning of coal has severe environmental impact on air, water and land and accounts for more than one third of the world's annual $CO_2$ emissions.

Petroleum or crude oil (oil as it comes out of the ground) is a thick liquid containing a complex mixture of hydrocarbons with sulphur, nitrogen and oxygen.

Deposits of crude oil and natural gas are tapped together within the earth crust or under the seafloor. The crude oil is dispersed in pores and cracks in underground rock-formations like water saturating a sponge. The oil drawn out of the rock pores and into the bottom of the well and from where it is pumped to the surface.

In India commercial oil production (extraction) is being carried out in four regions – (1) Assam Valley; (2) Gujarat region; (3) Mumbai High off shore region; (4) East coast in Krishna-Godavari and Kaveri basins. Mumbai high is the top petroleum producing region of India.

Recently petroleum has been found in Jasalmer district of Rajasthan.

*For exploration of petroleum, wells were drilled in Assam valley in 1866, just seven years after the discovery of petroleum in Pennsylvania in USA. Oil was discovered in 1890 in Digboi oil field in Assam. Only Assam produced petroleum in the country until 1959.*

**Natural gas**

Natural gas like coal, oil, was formed from fossil remains. The conditions needed for oil formation are same as those for natural gas. Natural gas is emerging as an important source of commercial energy. It is found in association of petroleum. India has a huge recoverable, reserve of natural gas. Natural gas contains methane and smaller amounts of propane and butane. When a natural gas field is tapped, propane and butane gases are liquefied and removed as liquefied petroleum gas (LPG). The rest of the gas (mostly methane) is dried to remove water vapour, cleansed of poisonous hydrogen sulphide and pumped into pressurized pipelines for distribution. At a very low temperature, natural gas can be converted into liquefied natural gas (LNG).

## INTEXT QUESTIONS 16.1

1. Define resources and natural resources.

2. Give five examples of natural resource.

3. Which are our primary energy sources? How are these formed in nature?

4. Name the top petroleum producing region of India.

5. What are lignite and anthracite? How do they differ?

## 16.4 MINERAL RESOURCES – CLASSIFICATION AND THEIR USES

India has extensive and rich deposits of industrially important minerals. Minerals like water and land are invaluable treasure of the earth. Minerals play a significant role in industrialization and economic development of a country. Like oil and petroleum, minerals are non-renewable resources, hence they must be used carefully and judiciously so that they are conserved for future.

**Classification of minerals**

Minerals are broadly divided into two groups- metallic and non-metallic minerals. Metallic minerals are further subdivided into ferrous and non-ferrous.

**Minerals**

- Metallic minerals
  - Ferrous metallic minerals
    (Iron, Mangnese, Chromite).
  - Non-ferrous metallic minerals
    Gold, Silver, Copper, Tin, Zinc,
    Aluminium (Bauxite ore)
- Non-metallic minerals
  Lime stone, Dolomite, Mica,
  Gypsum, Phosphate, Kyanite.

### 16.4.1 Ferrous metallic minerals

(i) **Iron-ore**

They constitute most important mineral group after fuel minerals (oil and gas). They include iron, manganese, chromite, pyrite etc. These minerals contain iron in substantial quantity. These minerals provide a strong base for the development of metallurgical industries, particularly iron, steel and alloys. Most iron ores found in the country are of three types – Haematite, magnetite and limonite. Haematite is red in colour, called 'red ore' and has 68% iron. Magnetite is dark brown in colour called 'black ore' and has 60% iron. Limonite is yellow in colour and has 35% iron.

India has large reserve of haematite and magnetite ores, inferior quality limonite is rarely used. India has 20 % of world's total reserves of iron ore. Almost 96% of the total iron reserves of the country are in Orissa, Jharkhand, Chattisgarh, Karnataka and Goa.

(ii) **Manganese ore**

India ranks third in the production of manganese ore in the world. One fourth of the total production of India is exported. Manganese is an important ingredient in the manufacture of iron and steel and ferro-manganese alloy. It is also used in the manufacture of dry batteries, in photography, leather and match industries. About 85% of total manganese consumption in India is used by metallurgical industries. Important areas of production are Orissa, Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka.

(iii) **Chromite**

Chromite is used in metallurgical refractory and chemical industries. Orissa alone has 98% of recoverable reserves.

### 16.4.2 Non-ferrous metallic minerals

These are minerals which do not contain iron. They include gold, silver, copper, tin, lead and zinc. These metals are very important in our daily life. India is deficient in all these minerals.

(i) **Bauxite**

Bauxite is a non-ferrous metallic mineral. It is the ore from which aluminum metal is produced. India has a rich reserve of bauxite. Aluminum extracted from the ore is used in making aeroplanes, electrical appliances and goods, household fittings, utensils etc. Bauxite is also used in the manufacture of white colour cement and certain chemicals. Major reserves of bauxite occur in Jharkhand, Maharastra, Madhya Pradesh, Chattisgarh, Gujarat, Karnataka, Tamilnadu, Goa and Uttar Pradesh.

(ii) **Copper**

Copper is a good conductor of electricity. It is extensively used in the manufacture of electrical cables, wires and electrical goods. Major copper ore deposits are found in Singhbhum of Jharkhand, Balaghat of Madhya Pradesh and Jhunjhunu and Alwar (Khetri mines) of Rajasthan.

(iii) **Zinc and lead**

Zinc and lead have very high industrial significance. Zinc is mainly used in tyre industry. It is also used in dye, casting, dry batteries, textile etc. Similarly lead is used in electrical cables, batteries, glass, ammunition, printing, rubber industry etc. Lead and zinc reserves occur in Rajasthan, Gujarat, Maharastra, West Bengal, Orissa, Madhya Pradesh and Uttar Pradesh.

(iv) **Gold**

Gold is a precious metal and is highly valued by people all over the world. It is one of the rare mineral. There are three important gold fields in the country namely- Kolar Gold Field and Hutti Gold Field both in Karnataka and Ramagiri Gold Field in Andhra Pradesh. Gold is obtained from sand deposits of rivers, is known as "placer deposits". Small quantity of gold is produced from placer deposits in Jharkhand.

### 16.4.3 Non-metallic minerals

India has deposits of several non-metallic minerals. These minerals are used as raw materials, a flux minerals (substance mixed with metal to help fusion) and as refractory mineral (resistant to treatment or heat).

Only a few of the non-metallic minerals are significant in the mining economy. Limestone, phosphorite, kaolin, gypsum and magnesite are significant non-metallic minerals.

(i) **Limestone**

Limestone is a key raw material for construction, chemical and metallurgical industries. Almost 76% of country's total consumption is used in cement industry, a large amount is used in iron and steel industry. Limestone is also used by sugar, paper, fertilizer and ferromanganese industries. Large deposits of limestone are available in our country.

(ii) **Dolomite**

Dolomite is a type of limestone. Deposits of dolomite are present in almost all parts of the country.

(iii) **Mica**

India is the leading producer of sheet mica. Bihar and Jharkhand produce the high quality ruby-mica. Mica mining was mainly done for export and USA being the principal importing country. It was one of the indispensable minerals used in electrical and electronic industries till recently. However, its synthetic substitute has reduced its export as well as production considerably.

(iv) **Phosphate minerals**

These are mainly used for manufacturing of phosphate fertilizers. Rajasthan is the leading producer followed by Uttaranchal, Madhya Pradesh and Uttar Pradesh.

### Ocean a source of minerals

Ocean mineral resources are found in sea water and on deep ocean floor. High cost of mineral extraction from sea water, where they occur in low concentration, is not economical. Only magnesium, bromine and sodium chloride are abundant enough to be extracted profitably using existing technologies.

Manganese rich nodules present on the deep ocean floor may be a future source of manganese and other important metals. They can be sucked up by giant vacuum pipes by mining ship. But because of high cost involved in the process and who owns them or the ocean have kept people away from this project. Rich deposits of gold, silver, zinc and copper are found as sulphide in the deep-ocean floor. But it costs too much to extract these minerals.

## 16.5 WAYS TO REDUCE DEPLETION OF MINERALS

A mineral becomes "economically depleted" when it costs more to find, extract, transport and process the remaining deposit than its worth.

- To check and reduce depletion of minerals, five choices are recycle or reuse existing supplies, wasteless, useless, find a substitute or do without.
- When a resource (mineral) becomes scarce, its price rises. This can encourage exploration of new deposits, stimulate development of better mining technology and make it profitable to mine lower-grade ores.
- It can also encourage a search for substitutes and promote resource conservation.
- Substitution of more abundant materials like plastic and glass, for scarce minerals is an important way to check depletion. The amount of lead and steel used in telecommunication have decreased with the use of plastic. Glass fibres have replaced copper wiring in telephone cables. Synthetic substitute of mica has reduced its export as well as production.
- One way to improve mining technology is to use microorganisms to extract metals from its ores known as "biomining" or 'ecological engineering', which may be an economical and environmentally preferable way to mine metals. Presently 30% of all copper produced worldwide, comes from such biomining. Biomining is economically feasible specially with low- grade ores.
- The science of nanotechnology have immense potential of using atoms in producing or manufacturing everything from medicines to solar cells to automobile bodies. Thus the job of many metals can be taken over by new materials produced by nanotechnology.

## INTEXT QUESTIONS 16.2

1. How do you classify minerals.

______________________________________________

2. What are haematite, magnetite and limonite?

______________________________________________

3. What is limestone? What are its uses?

______________________________________________

4. Which is the most important mica producing region of India?

______________________________________________

5. How can you check depletion of mineral resource?

______________________________________________

## 16.6 RENEWABLE RESOURCES

Renewable resources are those that can be formed or regenerated by natural processes. Air, water, soil, vegetation and animals renewable primary resources because they naturally recycle and reproduce themselves. Renewable resources can be perpetual or unconditional which will last forever on human time scale and conditional renewable resources which must reproduce and regenerate in order to last forever.

**(a) Perpetual resources or unconditionally renewable resources:**

Solar, winds and tidal energy are virtually inexhaustible resources on human time scale.

- **Solar energy** in the form of heat and light are delivered to the earth everyday whether we use it or not. Solar energy can be used in a regulated manner for space and water heating or it can be converted into electricity by producing steam.

- **Wind t**he greater heating of earth by sun at the equator than at the poles and the rotation of the earth set up flows of air called **wind**. Thus wind is an indirect form of solar energy and can be captured by wind turbines to generate electricity.

Coastal areas of India are particularly suitable for generating electricity from wind energy.

- **Tidal** energy can be generated from high tidal waves. In India, areas identified for generating tidal energy are located in Gulf of Kutch and Cambay in Gujarat.

**(b) Conditional renewable resources:**

(i) **Land and soil**

Land is a precious resource, which humans have used for agriculture, mining etc. The use of land results in changing in structure and function of the ecosystems. Human exploitation of land for various activities like agriculture, industry, housing, entertainment etc. ultimately results in the degradation of land. The degraded lands have reduced capacity to sustain healthy growth of crops and plants.

Soil formation is a natural process, so soil is a renewable resource. But formation of an inch of soil layer generally takes 200 to 1000 years and soil erosion occurs much faster as compared to the rate of soil formation, so it can become non-renewable resource as the top soil may be lost forever. Soil erosion is one of the greatest environmental problem. The main cause of soil erosion is land degradation. So, land protected by vegetation can be saved from soil erosion.

Land and soil degradation must be checked for the following reasons –

- to prevent soil erosion and land slides;
- to maintain soil fertility;
- for increasing biodiversity;
- for maintaining economic growth.(Details are given in lesson-17).

(ii) **Water**

Water is an invaluable resource which makes life possible on earth. We generally depend on fresh water resources for our survival which is finite in quantity. We use freshwater for drinking, irrigating the crops, and industrial uses, transportation, recreation and waste disposal. Availability of water is a powerful indicator of economic prosperity and ecological sustainability.

Fast depletion of fresh water resources must be checked and availability of water may be increased by:

- prevention of water wastage.
- increasing water use efficiency.
- recycling of water.
- capturing and storing more flood run off.
- harvesting rain water.
- desalinating seawater.

(iii) **Biodiversity**

Biodiversity is valuable renewable resource. Plant and animal are able to reproduce and maintain their healthy populations. Biodiversity is of great use to humans as they derive many direct and indirect benefits from the living world. It is the source of food crops, livestock, forestry and fisheries.

Biodiversity or biological diversity includes (i) genetic diversity, (ii) species diversity and (iii) and ecosystem diversity. These three levels of biodiversity are interrelated. You have already learnt about biodiversity in lesson 15.

Biodiversity is of great use to modern agriculture in three ways:

- as a source of new crops
- as a source of material for breeding improved varieties.
- as a source of new biodegradable pesticides.

Increasing growth of human population adversely affects rich and unique habitats and their biodiversity. Over exploitation of ecosystems (forest, grasslands, oceans), habitat destruction and pollution are major causes of biodiversity loss. Over exploitation of plants and animals may lead to extinction thus a renewable resource may be lost forever. The over exploitation of living resources must be checked and stopped to conserve and maintain healthy biodiversity for the over all benefit of present and future generations.

## INTEXT QUESTIONS 16.3

1. Write the difference between perpetual or unconditional natural resources and conditional natural resource?

   ______________________________

2. How can soil become a non-renewable resource?

   ______________________________

3. How is biodiversity of great significance in modern agriculture?

   ______________________________

4. Name the major ecosystems where species live and evolve.

   ______________________________

## WHAT YOU HAVE LEARNT

- Resource is anything useful or can be made useful to humans to meet their needs.
- Natural resources are earth's natural material and process that sustain life on earth.
- Petroleum, natural gas and coal are major non-renewable fossil fuel. They are gradually getting depleted with high rate of consumption.
- New energy sources must be found out so that the fossil fuels can be conserved for future.
- Minerals are important non-renewable resources and are extremely important for our industrial and economic growth.
- Iron, manganese and chromite are ferrous metallic minerals. India has rich iron resources in many states.
- Gold, silver, aluminium, copper, tin, lead, zinc are non-ferrous metallic minerals.
- India has rich deposits of several non-metallic minerals like limestone dolomite, mica.
- Ocean beds or floors are rich in mineral resources. Gold, silver, copper, zinc are present in ocean floors but their extraction is very costly.
- Depletion of metals and minerals can be checked by the following methods – reuse or recycle the existing supplies, wasteless, useless, find a substitute, extract by biomining.

## TERMINAL EXERCISE

1. Define natural resources. Name two unconditionally renewable natural resources.
2. How do you reduce the use of lead and steel in the communication?
3. What is the advantage of having synthetic substitute of mica?
4. Ocean floor is a rich manganese nodules but people are kept away from mining them. Give two reasons.
5. When does a mineral element become economically depleted?
6. Suggest any four ways to check and reduce depletion of minerals.
7. What is biomining and what is its advantage?
8. What are the main causes of land degradation? (Any three). Why should land degradation be checked? (Any three suggestions)

9. Which is an unconditionally renewable resource. Give two examples.
10. State any two methods to check depletion of fresh water resources.
11. Which are the three levels at which biodiversity occurs?
12. What is the major cause of biodiversity loss?

## ANSWER TO INTEXT QUESTIONS

**16.1**

1. Resource is anything useful or can be made useful to humans to meet their needs. Resource that is directly available for use from nature is called natural resource.
2. Examples of natural resources are – fresh air, fresh water, soil, forest, minerals and fossil fuels.
3. Our primary energy sources are crude oil (petroleum), natural gas and coal. They are formed in nature when plants and planktons get compressed under hard rocks for millions of years.
4. Mumbai high is the top petroleum producing region of India.
5. Lignite is brown coal with low heat content and anthracite is hard coal with high heat content.

**16.2**

1. See Chart (section16.1)
2. These are iron ores. Haematite and magnetite are rich iron ores and limonite is inferior quality ore.
3. Limestone is a non-metallic mineral. It is used in cement industry, iron and steel industry, sugar, paper, fertilizer and ferro manganese industries.
4. Bihar and Jharkhand are most important mica producing states of India.
5. Depletion of minerals can be checked by reuse, recycle of existing supplies, wasteless, useless, find a substitute.

**16.3**

1. Perpetual or unconditional renewable natural resources last forever on human time scale. Conditional renewable natural resources must reproduce or regenerate in order to last forever.

2. Formation of an inch of top soil takes 200 to 1000 years and soil erosion may occur faster than rate of soil formation, thus it can become a non-renewable resource as the top soil may be lost forever.

3. Biodiversity of great significance in modern agriculture in three ways-

   - as a source of new crops.
   - as a source of material for crop improvement
   - as a source of new biodegradable pesticide

# 17

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# CONSERVATION OF SOIL AND LAND

Soil erosion and land degradation together, constitute one of the major problems that disturb the ecological balance of the world. In this lesson, we will discuss the causes of soil erosion and land degradation. You will also learn about remedial measures that can be taken to reduce or prevent soil and land degradation.

## OBJECTIVES

After completing this lesson, you will be able to;

- *define soil erosion;*
- *describe the causes of soil erosion, its consequences and methods of control;*
- *explain the harmful effects of agrochemicals (chemical fertilizers and pesticides);*
- *describe various methods of soil conservation;*
- *define land degradation;*
- *list factors responsible for land degradation;*
- *describe the major consequences and control of land degradation.*

## 17.1 SOIL EROSION AND LAND DEGRADATION

Rapid increase in human population has placed a great strain on the land and soil resources resulting in land degradation and soil erosion. Fig. 17.1 shows the relative effect of soil degrading agents. Agents like air, wind and water erode the soil.

| |
|---|
| Soil is the uppermost layer of the earth's crust, which can be dug or ploughed, and in which plants grow. |

| |
|---|
| Land is a solid, substratum which supports human and many other organisms. |

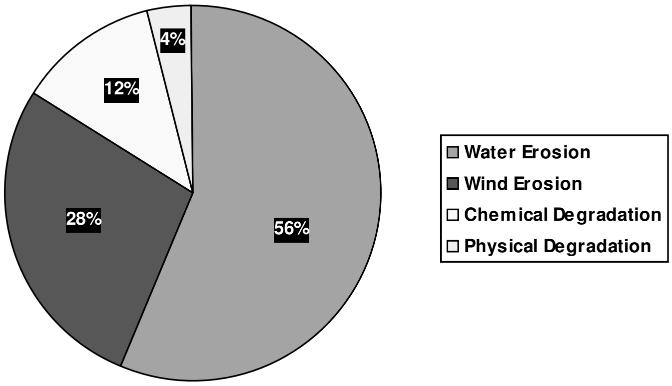


***Fig. 17.1:*** *A pie-chart showing percentage of world wide soil degradation agents. (Modified from 'World map of the Status of Human –induced soil degradation 1990)*

On a worldwide basis more than 4.85 billion acres (1.96 billion hectares) or 17% of the earth under vegetation has been degraded by humans to various extent. Fig 17.2 shows that the soil of certain regions of the earth are in the danger of being degraded.

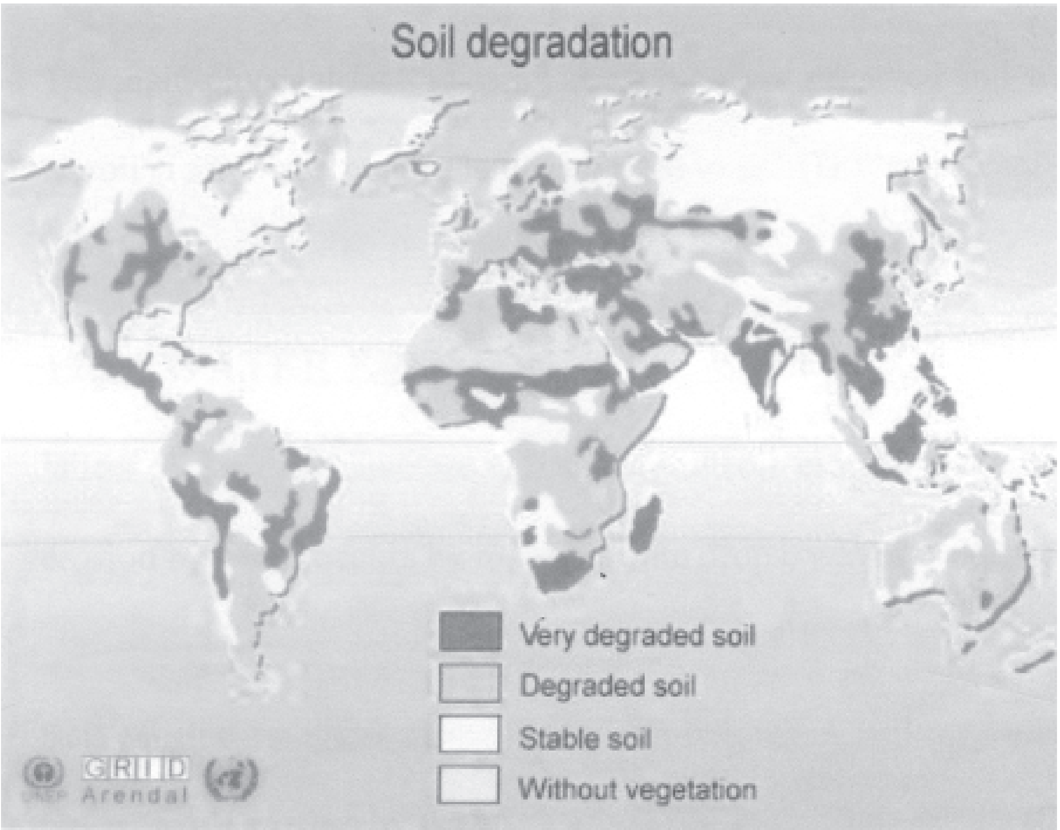


***Fig. 17.2:*** *World map showing areas of concern for soil degradation (Source- World Resources 1992-1993-New York, Oxford University Press)*

**Soil erosion**

Soil erosion is the loosening and displacement of topsoil particles from the land. Soil erosion is a natural process that occurs on all lands. Soil erosion may occur at a slow or fast rate.

**Land degradation**

Land degradation is the deterioration in the quality of land. Degradation of land results in loss of crop production capacity of the land.

## 17.2 PACE OF SOIL EROSION

Soil erosion in nature may be (a) a slow process (or geological erosion) or (b) a fast process promoted by deforestation, floods, tornadoes or other human activities. These two processes are explained below:

(a) **Geological erosion**

Geological erosion (Geo: earth) is a slow process that continues relatively unnoticed and has been occurring for millions of years. The first phase of this soil forming process is called weathering which is a physico- chemical process that leads to the break down of rocks by wind and water into small fragments and formation of soil particles.

(b) **Accelerated (Speeded up) erosion**

Accelerated soil erosion occurs when the protective vegetation cover is destroyed. This may occur due to natural causes like flooding or due to human activities. One of the main human activitiy responsible for accelerated soil erosion is cultivation of land. Land under cultivation is more vulnerable to natural agencies like wind and water. Human activities accelerate removal of surface soil by wind and /or water at a faster rate. The rate and extent of accelerated soil erosion is much higher as compared to natural geological soil erosion.

## 17.3 TYPES OF SOIL EROSION

Soil erosion is classified on the basis of the physical agent responsible for erosion. The various types of soil erosion are consequently referred to as: (a) Water erosion (b) Wind erosion.

(a) **Water erosion**

Running water is one of the main agents, which carries away soil particles. Soil erosion by water occurs by means of raindrops, waves or ice.

Soil erosion by water is termed differently according to the intensity and nature of erosion.

(i) Raindrop erosion
(ii) Sheet erosion
(iii) Rill erosion
(iv) Steam banks erosion
(v) Erosion due to land slides
(vi) Coastal erosion.

(i) **Raindrop erosion**

Raindrops falling on land surface cause detachment of the soil particles. The loose soil particles are washed away by flowing water. Raindrops thus initiate water erosion. An average size of raindrop is approximately 5 mm in diameter falling through the air hits the soil at a velocity of 32 km/hr. Larger raindrops and gusts of wind hit the soil surface even at higher velocities. Raindrops behave like tiny bombs when falling on exposed soil, displace soil particles and destroy soil structure. Presence of vegetation on land prevents raindrops from falling directly on the soil thus erosion of soil in areas covered by vegetation is prevented.

With continued rainfall the displaced soil particles fill in the spaces between soil particles and so prevent water form seeping into the soil. After some time this result in accumulation of water called 'ponding' on the land. This water begins to flow. This flowing water is called **runoff** and is muddy due to the displaced soil particles in it. As the water moves in further erodes the soil surface. (Fig 17.3) Similarly, the melting snowdrops cause soil erosion.

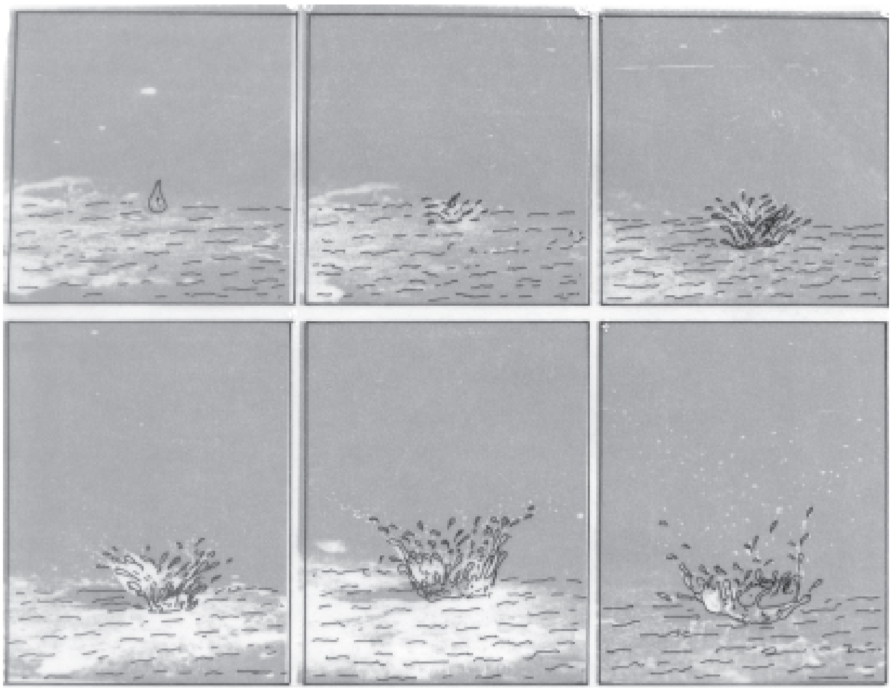

***Fig. 17.3:*** *Process of soil erosion caused by rain drops*

(ii) **Sheet erosion**

The detachment and transportation of soil particles by flowing rainwater is called sheet or wash off erosion. This is very slow process and often remain not noticed (Fig. 17.4).

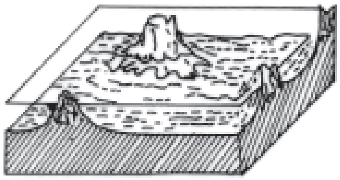

***Fig. 17.4:*** *Sheet erosion*

(iii) **Rill erosion**

In rill erosion finger like **rills** appear on the cultivated land after it has undergone sheet erosion (Fig 17.5a). These rills are usually smoothened out every year while forming. Each year the rills slowly increase in number become wider and deeper. When rills increase in size they are called **gullies** (Fig. 17.5b). Ravines are deep gullies.

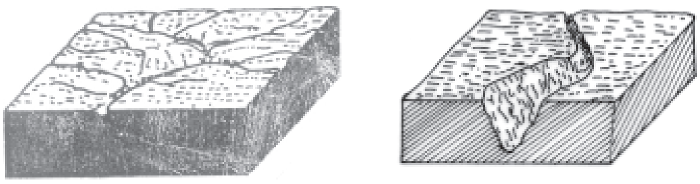

***Fig. 17.5:*** *(a) Rill erosion, (b) Gully erosion*

(iv) **Stream bank erosion**

The erosion of soil from the banks (shores) of the streams or rivers due to the flowing water is called bank erosion. In certain areas where river changes its course, the river banks get eroded at a rapid rate. Stream bank erosion damages the adjoining agricultural lands, highways and bridges. Fig 17.6 shows the after effects of stream bank erosion.

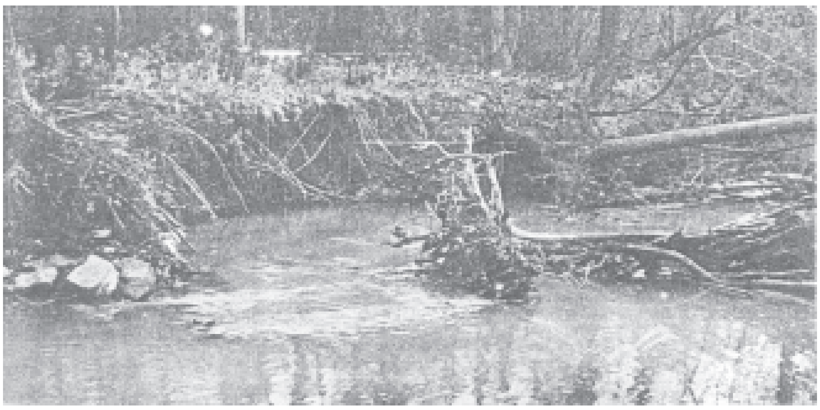

***Fig. 17.6:*** *Stream bank erosion*

(v) **Landslide:**

Sudden mass movement of soil is called landslide. Landslides occur due to instability or loss of balance of land mass with respect to gravity. Loss in balance occurred mainly due to excessive water or moisture in the earth mass. Gravity acts on such an unstable landmass and causes the large chunks of surface materials such as soil and rocks slide down rapidly.

(vi) **Coastal erosion:**

Coastal erosion of soil occurs along sea shores. It is caused by the wave action of the sea and the inward movement of the sea into the land (Fig. 17.7).

***Fig. 17.7:*** *Coastal erosion due to wave action*

**Consequences of soil erosion:**

1. The fine particles of the topsoil which contain the bulk of nutrients and organic matter needed by the plants are lost from soil erosion. Erosion removes the most fertile part of soil. The less fertile subsoil is left.
2. Erosion may result in removal of seeds or seedlings so that the soil becomes bare. Bare soil is more vulnerable to erosion both by wind and water (Fig. 17.8).
3. Removal of seeds and seedlings reduces the ability of soil to store water.
4. Sheet, rill, gully and stream bank erosion also cause siltation of rivers, streams and fields. Deposition of silt results in damage of crops and pastures, and sedimentation of water bodies like streams, dams, reservoirs etc.
5. Sedimentation of water bodies deteriorate water quality and damage aquatic habitats and organisms.
6. Gully erosion also results in loss of large volumes of soil. Wider deep gullies sometimes reach 30 m and thus severely limit land use.
7. Large gullies disrupt normal farm operation.

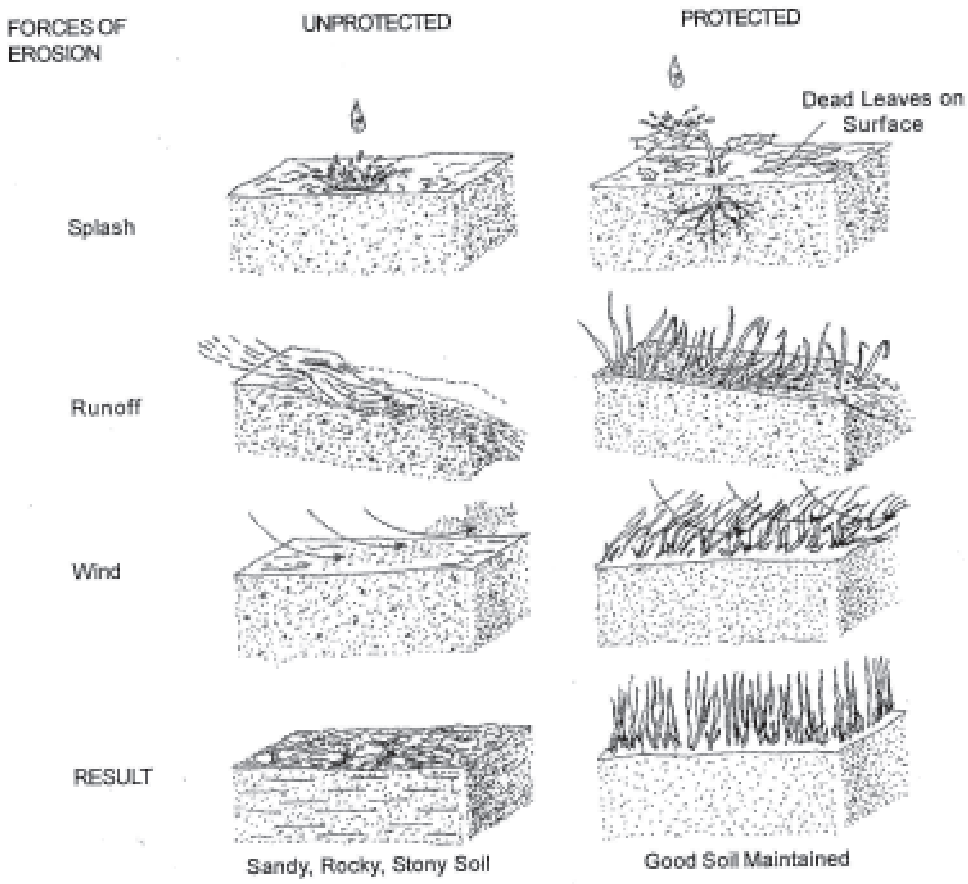


***Fig. 17.8:*** *Vegetation protects soil from all forms of erosion*

8. Stream bank erosion not only causes loss of land, but also changes the course of a river or stream.
9. Stream banks erosion also damage public roads.
10. Mass movement of land or landslides also inhibits farm production and land use.
11. It also causes mortality in animals and humans.
12. Coastal erosion causes the adjourning land to become covered by sand.

**Prevention of soil erosion**

1. It is essential to retain vegetation cover that soil is not exposed to rain. Refer again to Fig. 17.8 vegetation cover is important because roots of plants hold soil particles together. Plants intercept rainfall and protect soil from direct impact of raindrops.
2. Cattle grazing should be controlled.
3. Crop rotation and keeping the land fallow (not planting anything in the soil for sometime) should be adopted.

4. Vegetation and soil management should be improved in order to increase soil organic matter.
5. To prevent stream bank erosion runoff water should be stored in the catchment for as possible by maintaining vegetation cover and as by constructing dams for storing water.
6. For prevention or reduction of coastal erosion, protective vegetation along the beaches should be re-established. The best method of controlling coastal dune erosion is not to disturb the dunes and the coastal system. Further, construction of buildings and other development should be located behind the dune system.

### 17.3.2 Wind erosion

Soil erosion by wind is more common in areas where the natural vegetation has been destroyed. Such conditions occur mainly in arid and dry areas along the sandy shores of oceans, lakes and rivers. The loose soil particles are blown and transported from wind by following three ways:

(i) **Siltation:** blown by wind in a series of short bounces.

(ii) **Suspension:** transported over long distances in the form of suspended particles.

(iii) **Surface creep:** transported at ground level by high velocity winds.

**Consequences of wind erosion**

1. Wind erosion removes the finer soil material including organic matter, clay and slit, in a suspension (colloidal) form and leaving behind coarser, less fertile material. See once again (Fig. 17.8).
2. Productive capacity of the soil is lost as most of the plant nutrients which remain attached smaller colloidal soil fraction are lost.
3. Wind erosion also damages roads and fertile agricultural fields by depositing large quantities of air blown soil particles.

**Remedial strategies for prevention of soil erosion**

1. The vegetation cover over sandy soils should be kept above 30%. Access of wind to the soil should be controlled by leaving the stubble or mulch on the soil. (Stubble is the remains of crop left after harvesting).
2. Wind speed can be broken or controlled by planting trees in form of a shelter belt.
3. The practice of leaving the land fallow (i.e. not planting anything in the field) and use of machinery should be modified. This can be done by using direct- drilling techniques (ploughing the field) and by using direct-drilling techniques.
4. Over grazing by cattle should be avoided.

## INTEXT QUESTIONS 17.1

1. Define soil.

_______________________________________________

2. Name two natural agencies which cause soil erosion.

_______________________________________________

3. What is coastal erosion?

_______________________________________________

4. What is surface creep?

_______________________________________________

5. How wind erosion is damaged roads and agricultural fields?

_______________________________________________

## 17.4 SOIL EROSION CAUSED BY HUMAN ACTIVITIES

Certain human activities accelerate soil erosion.

- Deforestation
- Farming
- Mining
- Developmental work, human settlements and transport.

### 17.4.1 Deforestation

Deforestation includes cutting and felling of trees, removal of forest litter. Browsing and trampling by livestock, forest fires, also leads to cause deforestation etc. Deforestation leads to erosion. Deforestation further leads to land degradation, nutrient and the disruption of the delicate soil plant relationship.

### 17.4.2 Farming

Agriculture is a major human activity that causes soil erosion. Crops are grown, harvested, land reploughed, exposed to wind and rain intermittently. All this prevents replenishment of moisture. Agriculture also causes the worst type of soil erosion on farmland in the form of wash-off or sheet erosion. On the arid and semiarid areas, sand blows and sand shifts act in a similar fashion as sheet erosion does, where water is the chief agent. Consequently, a creeping effect of desertification sets in and the fertility of the land is lost progressively.

The following agricultural practices can lead to accelerated soil erosion:

1. **Tilling or ploughing** increases the chances of erosion because it disturbs the natural soil surface and protective vegetation.
2. **Continuous cropping:** Continuous cropping of the same land and extending of cultivation of marginal and sub-marginal lands encourages soil erosion.
3. **Cultivation on mountain slopes:** Cultivation on mountain slopes without appropriate land treatment measures such as bounding, terracing and trenching cause soil erosion and loss of soil nutrients.
4. **Monoculture:** Monoculture refers to the practice of planting of the same variety of crop in the field. Monoculture practices can lead to soil erosion in three ways.
   (i) A monoculture crop is harvested all at one time, which leaves the entire fields bare exposing it to both water and wind.
   (ii) Without vegetation natural rainfall is not retained by the soil and flows rapidly over the surface rather than into the ground. It also carries away the top soil which results in soil erosion and degradation.
   (iii) In the event any disease or pest invades the field , the entire crop is usually wiped out leaving the bare soil susceptible to water and wind.
5. **Overgrazing:** It means too many animals are allowed to feed on a piece of grassland. Trampling and grazing by cattle destroys the vegetation of the area. See Fig. 17.9. In the absence of adequate vegetative cover the land becomes highly susceptible to both wind and water erosion.

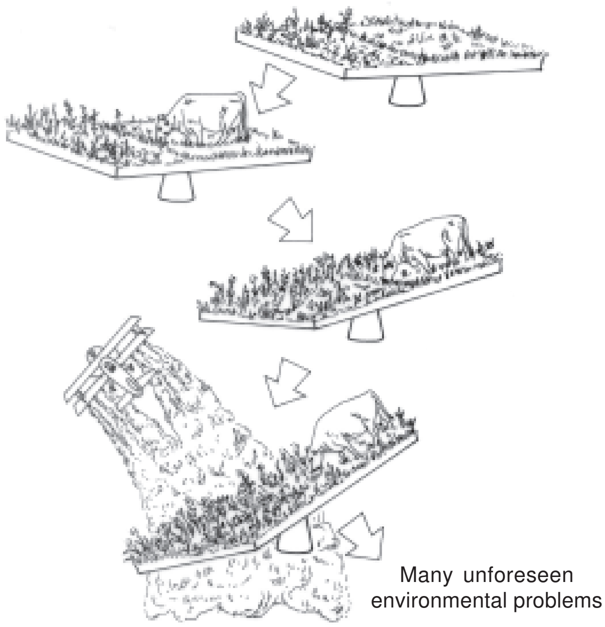


***Fig. 17.9:*** *Effects of over grazing*

6. **Economic activities:** Soil erosion also occurs due to economic activities. The extraction of useful natural resources such as metals, minerals and fossil fuels etc., from the land causes serious disturbance to the land leading to soil erosion and drastic changes in the landscape.

7. **Developmental activities:** Soil erosion may also occur because of various developmental activities such as housing, transport, communication, recreation, etc. Building construction also promotes soil erosion because accelerated soil erosion takes place during construction of houses, roads, rail tracks etc.

The construction of such facilities causes massive disturbance to land, resulting in soil erosion and disruption of natural drainage system.

## INTEXT QUESTIONS 17.2

1. Name any three human activities which cause soil erosion.

2. What is monoculture?

3. Why monoculture may lead to soil erosion? State one reason.

3. How does building construction soil erosion?

## 17.5 LAND DEGRADATION

Degraded land is classified on the basis of productive capacity of the land. Slight degradation refers to the condition that where crop yield potential is reduced by 10%. Moderate degradation refers to 10-50% reduction in yield potential and in severely degradation means that the land has yield potential is lost more than 50% of its potential yield capacity (productive capacity).

Some causes of land degradation are:

- use of agrochemical (chemical fertilizers and pesticides)
- excessive irrigation
- cultivation of high yielding plant varieties.

### 17.5.1 Agrochemical and their harmful effects on land

Agrochemicals are applied to the soil for two main reasons namely to:

(i) replenish or replace soil nutrients by using chemical fertilisers.

(ii) destroy plant pests by using toxic chemicals called pesticides.

(i) **The adverse effect of use of chemical fertilizer**

Plants take up nutrients from soil. Repeated crop cultivation depletes nutrients in the soil removed from it. Therefore, nutrients in soil have to be augmented periodically by applying chemical fertilizers. However, excess use of chemical fertilizers and pesticides leads to the following problems:

- **Widespread imbalance in the soil nutrients:** Most of the chemical fertilizers used in modern agriculture contains macronutrients like nitrogen, phosphorus and potassium (NPK). Excessive addition of NPK to the soil however causes the plants to absorb more micronutrients from the soil. As a result soil becomes deficient in micronutrients like zinc, iron, copper etc, and the soil productivity decreases.
- **Eutrophication of water bodies**: Fertilizer which is not used by plants is washed down with rainwater and carried into water bodies, resulting in eutrophication or algal bloom leading to death of aquatic life.
- **Health problems:** About one fourth of the applied fertilizer is not used by the crop plants and is leached down into the soil and underground water aquifer. The chemical which usually leaches down is nitrate whose increased concentration in the drinking water may cause serious health problems. Excess nitrates in water is harmful especially in bottle-fed infants in whom cause the disease, **methaemoglobinaemia.**

(ii) **The adverse affects of the use of plant protection chemicals**

Toxic chemical used to kill pests of cultivated crops (Fig. 17.10). Toxic chemicals like insecticides, herbicides, fungicides, rodenticides are generally used to kill insects, weeds, fungi and rodents in order to protect crop plants from their attack. These poisonous chemicals are collectively called biocides (agents that kill organism) they are not selective i.e., they not only kill the target pests but may also kill other non/not target and other useful organisms. Moreover, Biocides tend to remain active long after destroying the target organisms i.e. pests, weeds, fungi or rodents. It is persistence that makes these chemicals harmful to us.

Continued application of biocides cause various problems which are as follows:

1. They contaminate food materials and drinking water.

2. They disrupt the balance of the natural ecosystem by killing non-target often-useful organisms.
3. The continuous use of biocides results in a gradual increase of the immunity of the pest to these chemicals. The biocides after a period of time become ineffective against the pest leading to excessive multiplication of the pests.
4. Most of these chemicals are persistent and not biodegradable and so they persist in the plant or animal body once they enter the food chain. Their concentration in the organisms multiplies progressively through the food chain due to **biological magnification.**

***Fig 17.10:*** *All organisms are natural part of the ecosystem, but any of them interfering with human needs is called a pest*

### 17.5.2 Problems due to excessive irrigation

Excessive irrigation of soil may leads to water logging and accumulation of salt in the soil. Both these degrade the soil.

(i) **Water logging:** Excessive irrigation of land without proper drainage raises the water table. This causes the soil to become drenched with water or water logged. This waterlogged soil cannot support good plant growth due to lack of air particularly oxygen in the soil, which is essential for respiration of plant roots. Water logged soils lack mechanical strength and cannot support the weight of plants which fell down and gets logged thus become submerged in the mud. This result in loss of productivity of the soil.

**ii) Salt affectation:** In areas of high temperature, excessive irrigation of land usually causes the accumulation of salt in the soil. This is because water evaporates fast leaving behind traces of salt in the soil. As cycles of irrigation are repeated the left over salt accumulated and forms a thick layer of grey or white effervescence on the surface. (Fig 17.11)

The productivity of salt affected soil is low. Plants in saline soil are unable to absorb nutrients and so face water stress (lack of water) even when moisture is abundant in the soil.

***Fig 17.11:*** *Accumulation of salt on the soil surface*

### 17.5.3 Impact of high yielding plant varieties on leads to soil degradation

High Yielding Varieties (HYV) have helped to increase food production but at the same time they have greatly impacted to the environment are man made varieties of agricultural plants, fodder plants, forest trees, livestock and fishes. This means that the HYV have been raised and modified by us by means various breeding techniques in order to increase productivity. The HYVs require adequate irrigation and extensive use of fertilizers, pesticides to be successful. You have already learnt in 17.5.1, about land degradation due to agrochemical.

## INTEXT QUESTIONS 17.3

Give one to three words for the following:

1. The loosening and displacement of top soil particles from land.__________
2. The deterioration in quality of land resulting in reduction of crops productivity.______________
3. The first phase of soil formation which is a physio-chemical process that leads to the breakdown of rocks into its mineral constituents.________________
4. The erosion of soil from banks of rivers due to flowing water. Stream bank erosion.____________________
5. Man-made varieties of agricultural plants, fodder plants, forest trees, livestock and fishes that have been raised and modified by us by means of various breeding techniques in order to increase productivity.________________

6. Toxic chemicals used to kill organisms that are pests.________________

7. The progressively increased concentration of chemical in organisms through the food chain.___________

## 17.6 AGRICULTURE TECHNOLOGIES FOR PREVENTING SOIL DEGRADATION

Conservation of cultivable land cause can be achieved not only through preventive and remedial measures in order to control land erosion and degradation about which you will read in section 17.7 but also by using innovative agricultural technologies which involve use of:

(i) organic farming or green manures

(ii) biofertilisers

(iii) biological pest control

### 17.6.1 Organic farming or green manures

Instead of applying chemical fertilizer for supplementing the nitrogen content of soil, we can use the natural process that involves the use of nitrogen fixing bacteria in the legume root nodules (Fig. 17.12). In addition to this, the use of organic forms of fertilizers such as cow dung, agricultural wastes also improves the nutrients status of soils. This may also help to reduce the excessive and prolonged use of chemical fertilizers and thus minimize their toxic effects.

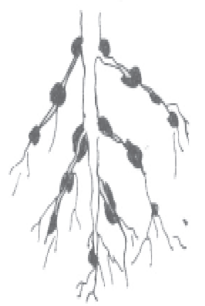

***Fig 17.12:*** *Root nodule*

### 17.6.2 Bio fertilizers

Micro-organisms are important constituents of fertile soils. They participate in the development of soil structure, add to the available nutritional elements and improve the physical conditions of soil. A large variety of micro-organisms are being used as biofertilisers for improving the nutritional status of crop fields.

### 17.6.3 Biological pest control (biological control)

The natural predators and parasites of pests play a significant role in controlling plant pests and pathogens. They are nowadays used by farmers to control or eliminate plant pests.

> The biological control agents of pests do not enter in the food chain or poison animals and so are not likely to harm mankind. Biological control of pests is an ecologically sound alternative to chemical pest control.

The cottony cushion scale pest (*Icerya purcahsi*) (Fig. 17.13a) is controlled biologically on a large scale by its predator, the lady bird beetle (Fig. 17.13b). At present some 15,000 naturally occurring micro-organisms or microbial byproducts have been identified as potentially useful biological pesticides.

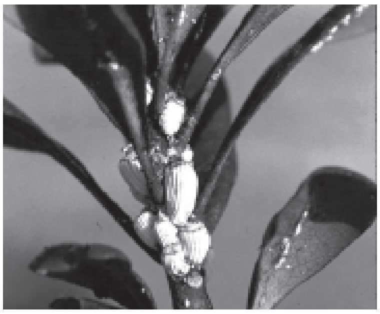

***Fig. 17.13:*** *(a) Cottony cushion scale pest (b) the lady bird beetle*

## 17.7 MEASURES FOR PREVENTING SOIL EROSION AND LAND DEGRADATION

**(a) Tree planting**

To prevent wind erosion, trees should be planted in such a way so that they break the force of the wind. The trees not only cover soil from the sun, wind and water, they also help to hold the soil particles.

**(b) Cultivation and farming techniques**

Certain cultivation and farming techniques also reduce soil erosion. These include:

(i) Cultivation of land at the right angles to the direction of wind helps to reduce soil erosion by wind.

(ii) **Ploughing style:** The ploughing style substantially reduces the amount of erosion. (Fig. 17.14) Tilling the field at right angles to the slope called counter ploughing in soil of the land helps prevent or reduce soil erosion. The ridges that are created act like tiny dams and hold the water and helps its seepage into the soil instead of let it run down freely the slopes causing soil pollution. Contour ploughing can reduce soil erosion by upto 50%.

(iii) **Strip Farming:** This method is another method of soil erosion. This involves planting the main crops in widely spaced rows and filling in the spaces with another crop to ensure complete ground cover. The ground is completely covered so it retards water flow which thus soaks down into the soil, consequently reducing erosion problems (Fig. 17.14)

***Fig. 17.14:*** *Strip and contour farming combined. Strip of corn are separated by strips of grass for hay in photograph (SDA- Soil Conservation Service)*

(iv) **Terracing**: It is another method of reducing or preventing soil erosion on mountain slopes. In this method, terraces are created on the steep slopes. This is another way of preparing the fields for planting and preventing soil erosion. Terracing is usually done on slopes, by leveling off areas on the slope to prevent the flow of water down it. There are disadvantages to terracing however, in that the terraces themselves can be easily eroded and they generally require a lot of maintenance and repair.

(v) The time or season at which a field is tilled can also have a major effect on the amount of erosion that takes place during the year. If a field is ploughed in the fall, erosion can take place all winter long, however if the ground cover remains until spring, there is not as much time for the erosion to take place.

(vi) No-till cultivation is also used as a preventive method for soil erosion. Specialized machinery are available that can loosen the soil, plant seeds and take care of weed control all at once with minimum disturbance to the soil. Since all of these aspects are taken care of at one time there is less time for erosion to occur (Fig. 17.15). However there is an adverse effect due to this practice as weed and insect populations can increase since they are not continuously being removed and so can compete or destroy crops.

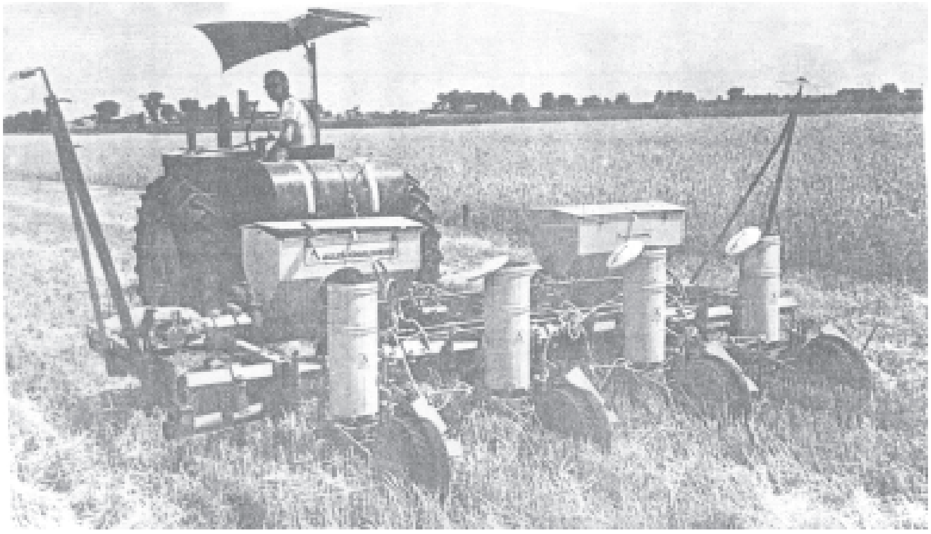

***Fig 17.15:*** *No till farming*

(vii) Polyvarietal cultivation also helps in controlling soil erosion. In this method the field is planted with several varieties of the same crop. As the harvest time vary for different varieties of the crops they are selectively harvested at different time. As the entire field is not harvested at one time and so it is not bare or exposed all at once and the land remains protected from erosion.

(viii) Addition of organic matter to the soil is also an important method for reducing soil erosion. This is achieved by ploughing in crop residues or entire the crop grown specifically for being ploughed into the ground. Microbes in the soil decompose the organic matter and produce polysaccharides which are sticky and act in gluing in the soil particles together and thus help the soil to resist erosion.

## INTEXT QUESTIONS 17.4

1. How does polyvarietal cultivation prevent soil erosion?

2. Out of the lady bird beetle and the cottony cushion scale (*Icerya purcahsi*), which is the pest and which the predator?

3. How do microbes resist soil erosion?

## WHAT YOU HAVE LEARNT

- Land degradation is the deterioration in quality of land.
- Soil erosion is a natural process in which loosening and displacement of top soil particles occurs.
- Slow rate of erosion is generally a natural phenomenon and is termed as geological erosion.
- Fast or accelerated soil erosion may be due to (i) natural calamities like floods or tornados or (ii) human activities.
- Water and wind are natural agents that are responsible for soil erosion.
- Soil erosion by water is due to running water that carries away soil.
- Erosion of soil by water is due to (i) raindrop erosion, (ii) sheet erosion, (iii) rill erosion, (iv) stream bank erosion, (v) erosion due to shifting lands—land slides and (vi) coastal erosion.
- Erosion of soil due to water can be prevented by (i) retaining vegetation cover of soil, (ii) crop rotation and leaving the land fallow, (iii) controlling cattle grazing, (iv) improving organic matter content of soil.
- Erosion of soil by wind generally takes place when vegetation is inadequate and is unable to cover and hold the soil—this type of erosion thus occurs in dry and arid regions.
- Wind transports or removes soil and causes erosion by (i) siltation, (ii) suspension, and (iii) surface creep.
- Wind erosion can be prevented or reduced by (i) keeping ground vegetation cover of sandy soil above 30% and by not removing remains of cut crops from soil surface, (ii) controlled tree planting which from a shelter bed and thus help in breaking the wind speed, (iii) the practice of keeping the land fallow should be modified and (iv) grazing by cattle should be reduced.
- Land degradation is classified on the basis of land productivity and is termed: (i) **slightly degraded** when crop yield is reduced by 10%, (ii) **moderately degraded** when crop yield potential is reduced by 10-50%, (iii) **severely degraded** when land loses more than 50% of its potential yield.
- Agrochemicals are used for replacing lost micronutrients in the soil and plant protection chemicals collectively called biocides lead to various problems in the soil including land degradation.
- Excessive use of fertilisers cause: (i) depletion in the micronutrient of the soil and (ii) accumulation of nitrates in ground water and eutrophication of fresh water bodies including lakes and rivers.

- Application of biocides causes death of useful non-target organisms along with pests.
- Excessive irrigation of agricultural fields especially in regions where temperature is high, results in water logging and salinisation. Excessive irrigation also depletes ground water resources and raises the water table.
- Soil degradation can be prevented or controlled by innovative agricultural techniques
- Soil condition can be improved by remedial measures that include: (i) planting tree cover for reducing wind speed, (ii) adopting certain cultivation and farming techniques like cultivation at right angles to direction of wind, contour farming, strip farming, terrace farming, (iii) ensuring that field is covered with vegetation for as long as possible (iv) not tilling the field, (v) polyvarietal crop cultivation in fields and (vi) addition of organic matter to soil.

## TERMINAL EXERCISE

1. Define soil erosion.
2. State the difference between geological and accelerated erosion with respect to (i) rate and (ii) cause.
3. What are the various ways by which water erosion takes place? Give details of any of three.
4. How can soil erosion by water be prevented?
5. What are the consequences of soil erosion due to wind?
6. Describe the several causes of soil erosion due to human activities.
7. In way does land get degraded by use of agrochemicals.
8. What are HYV? How do they degrade land.
9. How can soil erosion and land degradation be prevented?
10. Give an account of innovative agricultural techniques which prevent land degradation.

## ANSWER TO INTEXT QUESTIONS

**17.1**

1. Soil is the uppermost layer of earth's crust in which plants grow.
2. Water and wind.
3. Erosion at sea shores.

4. Caused by high velocity winds.
5. Deposits soil on roads.

**17.2**

1. Deforestation / agriculture or farming/ mining/ transport/ human settlements (any three)
2. Raising one plant variety only on a piece of land.
3. Barren land left after harvest/rainfall does not seep into soil after harvest/ water or wind erodes soil of damaged by a pest.
4. Large chunks of earth mass dug out.

**17.3**

1. Soil erosion
2. Land degradation
3. Weathering
4. Sheet/ wash off erosion
5. High yielding varieties/ HYV
6. Biocides
7. Biomagnification

**17.4**

1. Entire field does not become bare as different varieties harvested at different times.
2. *Icerya purchasi*- pest

   Lady bird beetle- predator
3. Microbes decompose organic matter to produce polysaccharides which bind soil particles together and thus prevent from erosion.

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# 18

# WATER AND ENERGY CONSERVATION

You have already learnt in the previous lesson 16 that water and energy are required for survival of all organisms. You have also learnt that there is growing shortage of water and energy which limits growth and development. Human beings, through overexploitation of water resources have made water scarce. Pollution of natural water bodies such as sea, rivers, lakes etc., have made their water unusable. The problem of growing shortages of two essential resources namely water and energy can be solved only through their wise use and effective conservation. In this lesson, you shall learn about water and energy conservation.

## OBJECTIVES

After completing this lesson, you will be able to :

- *list the factors responsible for increasing water demand;*
- *describe the various methods for conservation of water;*
- *explain the need and importance of water conservation and sustainable management;*
- *describe national river conservation plan;*
- *define energy and explain the use of energy for human society; list various conventional and non-conventional sources of energy;*
- *explain how to improve energy efficiency in home, place of work, transport and industry;*
- *learn about various energy conservation programmes being carried out in the country.*

## 18.1 WATER AS A NATURAL RESOURCE

Water is an indispensable, natural resource as no life can exist without water. It is also renewable and reusable. Scientists estimate that nearly three fourths of earth is covered with water of the ocean, seas, rivers, lakes, snow, glaciers and ground water as you have already learnt in lesson 8 of the module-3. However, only less than 1% of this water is fresh water and usable for living organisms including humans. Though water cycle ((Fig. 18.1) throughout the year, everywhere, it is being overused and some of it is even wasted. Hence, water conservation has become very necessary. At present, one-third of the global population is facing acute water shortage. In the villages, women have to walk long distances to fetch water. In certain hilly areas, women may have to walk as much as ten kilometers uphill to reach a well. According to UN estimates, by 2025, almost two-third of the world will face shortage of potable (fit for drinking) water. We have to be cautious about using water and devise methods of conserving it. But first let us understand as to what made water scarce.

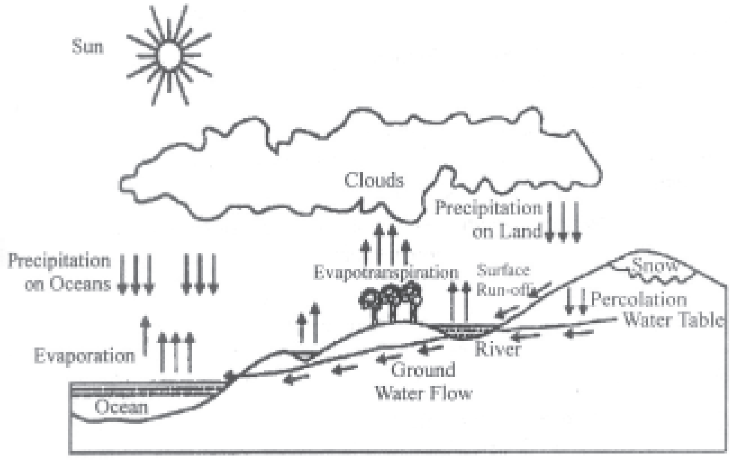


***Fig. 18.1:*** *Water cycle*

## 18.2 FACTORS RESPONSIBLE FOR INCREASING WATER DEMAND

Following factors for responsible for increasing water demand are as follows:

a. Expansion of irrigation

b. Increasing demand by industry

c. Rising demand due to growing population

d. Increasing water use due to changing life style

(a) **Expansion of irrigation**

India is an agricultural country hence plenty of water is needed for irrigation. 5.36 billion cubic meter water was used for irrigation in the year 2000. It is 81% of the total water used. The remaining percentage (19%) of water was used for domestic, industrial and other purposes mentioned above. There has been a rapid increase in the irrigated area in

India since independence. Thus the demand for irrigation in India has been increasing continuously. The reasons for the increasing demand of irrigation are:

- regional and seasonal variation in the distribution of rainfall.
- uncertainty of rainy season.
- growing demand of water for commercial crops.
- changing cropping pattern.

More efficient and environmentally sound irrigation technologies can greatly reduce water demands and waste on fields by delivering water more precisely to crops. For example, low pressure sprinklers (allows 80% of water to reach crops)and microirrigation (delivers small amounts of water precisely to crops). Israel now treats and reuses 30% of its municipal sewage water for crop production and plans to increase their percentage to 80% by 2025.

However, many of the world's poor farmers cannot afford most of the modern technological methods for increasing irrigation and irrigation efficiency. Instead, they use low cost traditional technologies which use up huge amount of water.

(b) **Industrial use of water**

Most industries require water at various stages of production of goods and products. Water is used in industries in both consumptive and non-consumptive ways. Be it agro-based industries (cotton, textile, jute, sugar and paper) or mineral based industries (iron, steel, chemical and cement). Water is needed in large amounts during the production process or as heat exchanger for cooling various machine parts which get heated up during the production process.

In power plants water is used as a power source as well as a cooling agent. The ore and oil refining industries use water in various chemical processes.

(c) **Rising demand for growing population**

Population of India has been increasing continuously and it has increased three times since independence. Due to this increase in population, the demand for water has increased. We need water for drinking, for flushing or draining sewage or human waste, domestic use, irrigation, industries.

- Rising demand for water due to growing population is a single most important factor leading to water scarcity in our country and elsewhere.
- It is becoming impossible for the state to supply clean drinking water to its people.
- Most other human activities like washing, cleaning, cooking, flushing of waste etc. require water.

- More the number of people more is the demand for water to carry out day to day work.

(d) **Changing life style**

Industrial development led to economic development. Purchasing capacity of individuals has increased. Thus the life style of people changed and the standard of living has gone up.

Large number of attractive appliances, gadgets and fittings for kitchen and bathroom are available in the market and people are generally tempted to use them, for example taps and showers are designed in such a way that large amounts of water come out when they are turned on. Washing machines and dishwashers use large amounts of water but are convenient and suit the present day life style.

Lot of water is used for recreational purposes like 'water parks' are becoming extremely favorite place for people to enjoy holidays. Most of the sports or games here require huge quantity of water.Although much of the water used in various water games are actually recycled and reused.

Water in the reservoirs are used for recreational purposes –boating, swimming and angling etc. Golf is becoming a very favorite sport and many golf courses are coming up at various places. Golf courses use excessive amount of water for its maintenance. Private and public gardens too require water for their maintenance.

> We receive the second highest rainfall in the world, first being Brazil, but much less rain water infiltrates the soil or is retained to increase water table. A sizeable amount of water is drained as run off (moving out from the soil surface) draining into the sea.

Public and private swimming pools require water supply and sanitation.

## 18.2 VARIOUS METHODS FOR CONSERVATION OF WATER

You must have realized that it is crucial to conserve water. You may do your bit (1) by making people aware of water scarcity so that they may use it judiciously. (2) never waste water. Get leaking pipes and taps required. Use only as much as water needed. (3) Close taps between brushing your teeth, bathing and shaving. It hardly required efforts to open and closed taps. (4) collect rain water and use for domestic use. Remember it is clean water.

We can do conservation of water by using various methods such as reforestation, re-use, recycle, increase water use efficiency, water harvesting and ground water recharge.

(i) **Reforestation**

There is a continuous interchange of moisture between earth and atmosphere, constituting the hydrological cycle. The movement of water through the hydrological cycle has a major influence on rainfall distribution and temperature modification. Plants play an important role in hydrological cycle through the process of transpiration. In tropical forests, 75% of the annual precipitation is returned to the atmosphere by the plants. Thus forests play a very important role in maintaining water balance of the soil and atmosphere. Forests play a protective function and conserve soil and water.

Forests provide major ecological services like-

- support energy flow and chemical cycling.
- reduce soil erosion.
- absorb and release water.
- purify water.
- purify air.
- influence local and regional climate.
- store atmospheric carbon.

Cutting down of large areas of forest reduces the ecological services provided by the forest and it can lead to regional and global climate change.

Deforestation is the temporary or permanent removal of large areas of forest for agriculture or other uses.

Reforestation is the process of planting of trees on the deforested area or of increased tree cover from regrowth and planting of trees (plantations). Reforestation increases soil fertility by preventing soil erosion, prevents run-off of eroded soil into aquatic systems and prevents flooding. Thus reforestation plays a major role in conservation of water.

(ii) **Recycling of water**

The wastewater from industrial or domestic sources can be used after proper treatment for irrigation, recharging ground water and even for industrial and municipal use.

Agricultural lands close to cities can be irrigated with municipal wastewater. Household level recycled ‘grey water’ (untreated household water which does not come in contact with toilet waste) can be used for various purposes.

Grey water from shower, bath, washbasins, laundry troughs and washing machines can be put to various uses to reduce pure water requirement. Pure water after used in bath and shower can be used for watering plants.

(iii) **Reuse of wastewater**

Wastewater containing lots of nutrients. These nutrients may help the growth of plants when such water is used in irrigation.

Reuse of wastewater occurs most effectively with on-site or small treatment system. The reuse option in the local context at the community level must be seriously considered.

(iv) **Water harvesting**

Water harvesting is collecting rainwater that falls on a house or on and around any building and then putting it to use later on or simply replenishing the ground water by allowing the water to reach underground.

Time has come when we should work on our ancient methods of water management including capturing of water from swollen streams and rivers during monsoon season and storing it in various forms of water bodies.

**(v) Recharging of groundwater**

The available groundwater is about 13-20 times as much as water available on surface. The groundwater consists of water contained in the soil or aquifers (underground natural water reservoir).

- Flood water may be injected into aquifers through series of deep pits or ditches.
- Small reservoirs and percolation tanks can be dug to hold runoff water recharging ground water.
- Storm water, used water (municipal and domestic), domestic drains can be fed into pits, trenches, depressions to be filtered and percolated through the soil for recharging ground water.
- Desiltation of canals and tanks should be done regularly.
- Premonsoon tillage of fields help to conserve soil moisture.

## INTEXT QUESTIONS 18.1

1. State any three factors responsible for increase in water demand.

______________________________________________

2. Name two environmentally effective systems of irrigation.

______________________________________________

3. Why should water be conserved?

______________________________________________

4. Mention any two ways an individual can help in conserving water.

______________________________________________

5. Mention one important cause of water scarcity in our country.

______________________________________________

## 18.3 MANAGEMENT OF WATER RESOURCES

The total amount of water available for use by humans is limited. In view of the variability of rainfall in our country, this precious resource needs to be effectively managed and conserved. Due to the unwise use of water resources by our enormously large population and poor distribution and maintenance practices, the existing system has resulted in serious shortages.

Effective management and conservation of water has to incorporate the following two strategies:

(1) Reduction in loss and wastage of water.

(2) Harvesting, collection and improved storage of water.

### 18.3.1 Reduction in wastage of water

Reduction in wastage of water can be best achieved by launching awareness campaigns to involve all sections of the society for the conservation of water. Such awareness is possible through different media such as newspapers, radio and TV. Other ways would be to organize short plays, street plays or lectures.

- Any agency either government or otherwise responsible for water meters and charging for water use should make it a point to install efficient meters and decide to charge a rate which will force the public to reduce use of municipal water.
- Tap, shower flow restrictors and low volume toilet flushes can help in reducing water use.
- Any leak in water pipes and faucets should be detected and repaired immediately.
- Lawns and gardens should be watered in the early morning or late in the evening so that water evaporation losses are minimized.
- Rain water is the major source of water for irrigation of agricultural fields in the country and for recharging the ground water. Rain fall is restricted to three months in a year therefore rain water should be stored and use of ground water well planned as ground water is a renewable water source and gets replenished by natural process of recharge. Loss of water through seepage and evaporation, water wasted on weeds, cost of bringing water from ponds to place of use should be minimized.

### 18.3.2 Harvesting, collecting, recharging of ground water and water storage

1. **Recharging of ground water**

- Flood waters may be injected into aquifers (underground water reservoirs) through series of deep pits or ditches.

- Small reservoirs and percolation tanks can be dug to hold run off water recharging ground water. (Fig. 18.2)
- Rain water harvesting carried out by building power for recharging ground water.
- Storm water, used water, domestic drains can be fed into pits, trenches, depressions to be filtered and percolated through the soil for recharging ground water.
- Desiltation of canals and tanks should be done regularly.
- Pre-monsoon tillage of fields helps to conserve soil moisture.

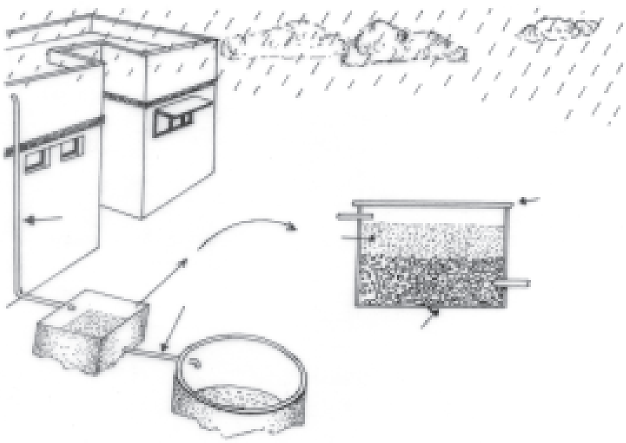

***Fig. 18.2:** Collection of rain water*

2. **Removal of pollutants to transform polluted water into usable form**

- Proper treatment of domestic and municipal waste water which is rich in organic matter and pathogens material also helps to conserve water. Treatment ensures the removal of pollutants, germs and toxic elements.
- Growing algae or floating masses of water hyacinth also helps in cleaning the water polluted by absorbing phosphates, nitrates and other nutrients. These aquatic plants can be harvested for producing biogas.

## 18.4 NATIONAL RIVER CONSERVATION PLAN

There are several small and large rivers in India such as Ganga, Yamuna, Brahmaputra, Sutlej, Krishna, Narmada, Kaveri, Godavari etc.

Many of the Indian rivers are polluted and their waters over large stretches are unfit for human use. River pollution is mostly from discharge of effluents by industries, and cities developed along river courses.

To clean up the rivers, massive action plans have been launched by the Government of India.

Two important action plans are:

1. Ganga Action Plan
2. Yamuna Action Plan

**Ganga Action Plan or GAP:** Ganga is the largest and most important Indian river. It is 2,525 Km long. The watershed of river Ganga spreads over ten Indian states. The major cause of Ganga water pollution is unrestricted discharge of untreated sewage and industrial effluents all along its course. Ganga Action Plan (GAP) is an ambitious and first of its kind river cleaning project. Ganga Action Plan(GAP) has been launched by the Government of India to clean the river Ganga.

The first phase of the project was completed in 1993.

**Yamuna Action Plan (YAP)** was implemented in April, 1993 under the banner-

''यमुना को स्वच्छ बनाना है।
हम सबको हाथ बटाना है।''

Yamuna is a major tributary of the river Ganga.

Yamuna Action Plan (YAP) aims at cleaning and conserving water of the river Yamuna by removing pollutants from it.

## INTEXT QUESTIONS 18.2

1. State in a sentence how TV can help in spreading awareness regarding water conservation.

______________________________________________

2. Why is it more sensible to irrigate plants and lawns in early morning or late evening?

______________________________________________

3. In your opinion what can be done to motivate people to reduce wastage of water?

______________________________________________

4. State one method of recharging ground water.

______________________________________________

5. What is the role of algae or aquatic plants like water hyacinth in removing pollutants from waste water?

______________________________________________

6. What are GAP and YAP?

______________________________________________

7. Why is such action plans undertaken?

8. Name two more important rivers of our country?

## 18.6 ENERGY CONSERVATION

**What is energy?**

Energy may be defined as the capacity to do work. Energy can be transformed from one form to another form. Energy gets used up? When used and accordingly energy cannot be recycled like nutrients. You have already learnt in earlier lessons that the sources of energy may be (i) renewable or (ii) non-renewable. However, energy can neither be created nor destroyed and can not be recycled.

### 18.6.1 Use of energy by society

Human beings and all other living organisms require energy for their activity and physiological functions. Living organisms obtain this energy required by them from food and is in the form of a chemical compound adenosine –tri –phosphate (ATP). This compound is synthesized mainly during the oxidation of food which occurs during cellular respiration.

You already know that in nature, transfer of energy takes place through the food chains (refers Fig. 5.2, lesson-5) the ultimate source of energy is the sun. Plants use solar energy for photosynthesis and they are called producers. Herbivores eat plants. They are the consumers. Carnivores eat herbivores. In this way, energy is transferred from one organism to another. Some energy is, however, always lost as heat.

Apart from energy required for one's own body processes, humans need energy for carrying out various kinds of activities.

- Heat or electrical energy is required for cooking and heating
- Electricity is required for lighting bulbs and tube lights, running fans, coolers and air conditioners.
- Fuel such as petrol or diesel or compressed natural gas (CNG) is required in vehicles such as cars, buses, trains, trucks, aeroplanes which are responsible for transporting human beings and goods from one place to another.
- Energy (electricity) is required for pumping water up the multi-storied buildings.
- Energy is required for the various industrial processes that ultimately result in the manufacture of different kinds of goods.

- Energy is required in agriculture, for irrigation, tractors and other farm machines, spraying pesticides.
- Energy is required in power generation e.g. rotating the turbines in hydro-electrical power generations.

Thus energy is a very important resource for human beings.

## INTEXT QUESTIONS 18.3

1. Define energy.

   ______________________________

2. List four human activities for which energy is required.

   ______________________________

3. Name the energy compound synthesized by human beings.

   ______________________________

## 18.7 CONVENTIONAL AND NON-CONVENTIONAL SOURCES OF ENERGY

The **conventional sources** of energy are the **fossil fuels**. It took millions of years for the formation of fossil fuels, hence they are **limited** and **non-renewable.** Fossils are remains of organisms that lived in the past and fossil fuels are plants that got buried under earth that became rock over years. Fossil fuels have to be unearthed from mines.

Most fossil fuels release energy as heat. The types of fossil fuels are:

1. **Coal** is solid. It is mined and then transported in trucks and trains. In our country coal mines are found in Raniganj, Jharia and Dhanbad in Bihar.
2. **Oil** is liquid which is pumped out from the ground after drilling a well. It is sent to far away places in oil tankers or pipe lines. Oil (petroleum) is used in automobiles and aeroplanes. In India oil is found along the west coast and in Digboi oil fields, Assam.
3. Natural gas is a mixture of gases. The gas we use for cooking which comes in cylinders is LPG or **Liquefied Petroleum Gas. Compressed Natural gas** or **CNG** is used in the public transport vehicles (buses, scooters, auto-rickshaws and taxi).

Oil and natural gas are fossils of phytoplankton (floating algae) which lived millions of years ago and sank to ocean bottom when they died. Over years, under pressure and heat, they became petroleum and filled reservoirs underneath the sea bed.

Till about five decades ago, human beings were not worried about the exhaustion of fossil fuel. But as population increased and consumption of fossil fuels became enormous, environmentalists began to talk about fossil fuels as non-renewable and limited (last for limited period of time) and scientists began to think and discuss about other sources of energy (non-conventional), which were till then used by humans to some extent only.

Non-conventional sources of energy are:

- solar energy
- wind energy
- hydel power
- tidal energy
- geothermal power
- energy from biomass.

These resources are **renewable** and almost **inexhaustible**. Of these solar energy or energy from the sun is very important. It is widespread in nature is non-polluting and available free of cost. **Solar energy** is now harnessed through "solar panels" directly which heat homes by solar radiations, solar photovoltaic cells used in solar TVs and solar thermal energy is used to cook food in solar cookers (Fig. 18.5). Solar energy is also used in industries.

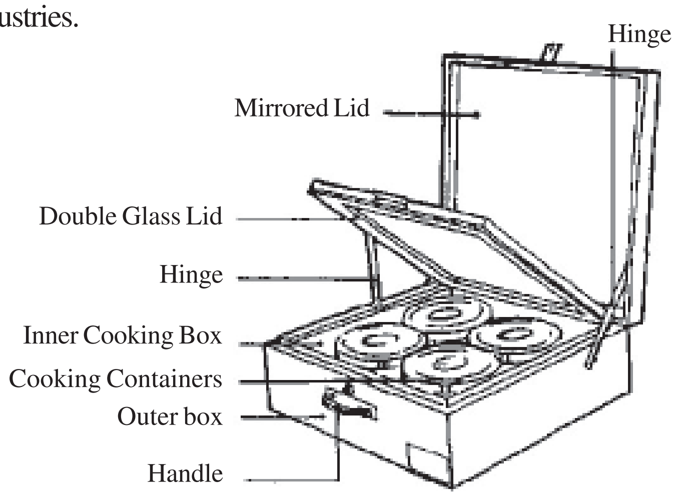


***Fig. 18.5:*** Solar cooker

**Wind energy**

Wind energy has been traditionally used to lift water for domestic purposes and irrigation of fields. Kinetic energy of wind is converted into electrical energy and used.

**Hydro-power (Hydel power)**

Many dams have been built on rivers to store water at a height and then potential energy of the stored mass of water is converted to kinetic energy by letting the massive water flow over **turbines**. Thus electrical energy is obtained converting potential energy of the mass of water.

### Tidal energy

Tidal energy is the energy of ocean or sea waves which derive energy from wind which in turn is driven by solar energy. Tidal energy can be transformed into electrical energy.

### Geothermal power

Geothermal power is the heat energy or thermal energy present in the earth's crust. The heat in the uppermost part of earth is readily accessible and can be used to generate electricity.

### Energy from biomass

Biomass is plant matter produced as a result of photosynthesis. Some of it can be burnt to provide heat, for example wood, agricultural waste. Biomass can also be used for power generation or converted into alcohol (liquid or methane gas) to be used as fuel. Since these are obtained from plant material, they are called **bio-fuels**.

Biomass is renewable energy and shall be available as long as plants grow on earth. Thus for supplying fuel wood, fast growing trees like oil palm, species such as *Euphorbia, Jatropha* etc. are planted. Another use of biomass as fuel is to collect agricultural waste and crop residues and animal manure.

Organic wastes, sewage and any other solid biomass can be converted by bacteria into **biofuels** such as **biogas**. Biogas digesters (Fig. 18.6) are large vessels in which organic wastes (plants and animals waste) are made to undergo bacterial fermentation and produce biogas which can be used for heating and cooking. Biogas is a mixture of methane and carbon-di-oxide. Methane can be obtained by anaerobic (in absence of air) digestion of manure and sludge of sewage treatment units by means of anaerobic bacteria.

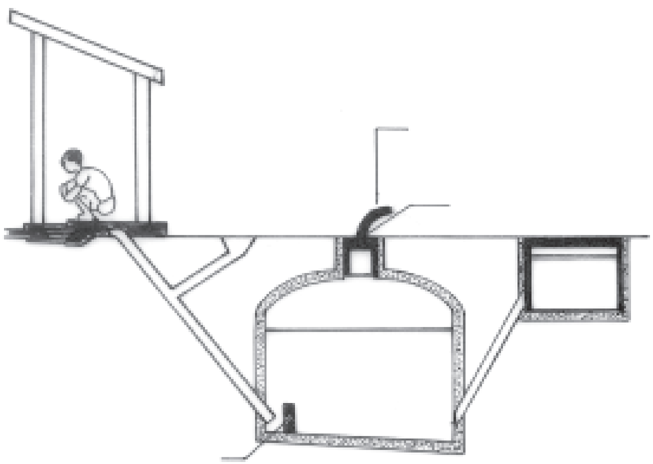

***Fig. 18.6:*** *Biogas digester*

Recently, the idea of using ethanol as car fuel is doing the rounds. It is made from sugar cane, sorghum, corn or beet root by fermentation and distillation. Pure ethanol may be used and there is no need to change the engine for using ethanol in place of petrol.

**Biodiesel**

India has many varieties of oilseed plants. Biodiesel may be get from vegetable oils. Some oil yielding trees that can give biodiesel are (1) Ratanjot or *Jatropha curcas* (2) Nagchampa or *Callophyllum ionophyllum* (3) Rubber seeds or *Hevea braziliensis.* Biodiesel does not contain any petroleum but it substitutes for petroleum in the same conventional engines.

## INTEXT QUESTIONS 18.4

1. Distinguish between non-renewable and renewable sources of energy.

   ______________________________

2. Name one conventional and one non-conventional sources of energy.

   ______________________________

3. Name three fossil fuels.

   ______________________________

4. Name one biodiesel yielding plant.

   ______________________________

5. What do you mean by (a) biomass and (b) biogas?

   ______________________________

6. Name two chemical compounds which can be called biofuel.

   ______________________________

7. Why are they termed biofuels?

   ______________________________

## 18.8 IMPROVING ENERGY EFFICIENCY

**At home**

- Do not waste electricity. Switch off lights and fans when not in use, minimize use by sharing to sit and work at one place.

- Use fuel efficient hearths (chulhas) for cooking. Do not use smoking stoves.
- Cut only dry branches of trees for burning.
- Use the gas at simmer level. it saves cooking gas and makes cooked item healthier and tastier.
- Keep material ready for cooking before lighting the gas so that it does not burn unnecessarily.
- Use solar cookers for heating and cooking.

**At work place**

- Use car pool to reach office – share the transport vehicles.
- Switch off lights and fan when not used. Does not matter if somebody else is paying bills. It is not about saving money so much as it is about saving power.
- Computer to be switched off when not in use.

**In transport**

- To use public transport system as much as possible instead of using personally owned vehicles.
- Car speed should be maintained as far as possible 50 to 60km/hr. Moderate driving; driving at lower speeds.
- Do not use choke unless necessary. When choke is used, put it off as soon as engine is warmed up, if there is a starting trouble, depress clutch to start the engine.
- Take care to check and mend leak if fuel tanks and exhausts of vehicles.
- Turning off a vehicles engine at stops rather than idling.

## 18.9 PROMOTION OF SOLAR ENERGY(POWER) IN INDIA

India is both densely populated and has high solar insolation, providing an ideal combination for using solar power in India.

- The Ministry of New and Renewable Energy (MNRE) have initiated schemes and incentives-like subsidy, easy loan, concessional duty on raw material imports, excise duty exemption on certain devices/systems etc. to encourage and use of solar energy systems.
- The Indian Renewable Energy Development Agency (IREDA) provides financial helps for the purchase of PV (Photovoltaic) systems.

- Government is planning to set up 10 million square meter solar collector area by 2022. This will conserve electricity equivalent to that generated from a 500 MW power plant.
- The state of West Bengal has initiated to make the use of solar power mandatory in new multi-storied buildings.
- Rajasthan government has set aside a 35,000 km$^2$ areas of the Thar desert for solar power.
- Rural electrification can be done for about 2700 village by using SPV (Solar photovoltaic) systems.
- Currently many companies in India are engaged in manufacturing PVs.
- Australian government has come forward to train next generation solar energy engineers specially from India and China as a part of the Asia-Pacific partnership (APP) on Clean Development and Climate. Many programmes have been designed under this for rural solar energy usuage.
- In the agriculture sector, solar PV water pumping systems are used for irrigation and drinking water. Solar driers are used to dry harvests before storage.
- Solar cookers, solar energy used for supply of hot water in hospitals, hotels and large kitchens have solved the problem of electricity to some extent and if needs to be extended.

**(i) Promotion of CFLs (Compact Fluorscent Light Bulbs)**

- Mercury is an essential element in the operation of fluorescent lighting. It allows the bulbs to be an efficient light source.
- CFLs use less electricity than traditional light bulbs (75%) less), they reduce demand for electricity.
- CFLs contain very small amount of mercury-an average of 4 milligrams in each bulb.
- No mercury is released when bulbs are intact or in use, however, it is important to be careful in the disposal of these products.
- Most people have started using CFLs at home to cut down their electricity bill.
- Government offices and institutions have replaced traditional light bulbs with CFLs.

**(ii) Use of star rating of electrical equipments**

Bureau of Energy Efficiency (BEE) is an agency of the Government of India, under the Ministry of Power created in March, 2002 under the provision of Energy Conservation

Act. The agency's function is to develop programs which will increase the conservation and efficient uses of energy in India.

- The government has proposed to make it mandatory or compulsory for appliances in India to have ratings by the BEE starting in January 2010.
- The BEE Star Energy Efficiency Labels have been created to standardize the energy efficiency ratings of different electrical appliances and indicate energy consumption under standard test conditions.
- These labels indicate the energy efficiency levels through the number of stars highlighted in colour on the label.
- Star rating system ranges from one star (least energy efficient thus least money saved) to five stars (most energy efficient, thus most money saved).

Refrigerators, Air conditioners, washing machines, lighting systems etc. will bear the star levels to indicate their energy efficiency.

**(iii) Transport and energy**

The transport sector is the fastest growing source of green house gases (carbondioxide ($CO_2$), Methane ($CH_4$) Nitrous oxides ($N_2O$)). Of the total green house gas emissions from transport, over 85% are due to $CO_2$ emissions from road transport vehicles.

Reducing energy waste requires improving energy efficiency by using less energy to do more useful work. Reducing such energy waste has numerous economic and environmental advantages.

- The best way to save energy in transportation is to increase the fuel efficiency of motor vehicles.
- Fuel efficient vehicles powered by a hybrid gas-electric engine and electric vehicles powered by fuel cells running on hydrogen are being developed.
- Fuel cells are about twice as efficient as internal combustion engines, have no moving parts, require little maintenance and produce little or no pollution.
- Reva is a small electric car developed in our country. Use of small sized cars instead of big cars and using two wheelers can go a long way in saving energy.
- Large reductions in energy costs can be done by using vehicles with efficient engine that reduces consumption of petroleum (i.e. petroleum electric hybrid vehicle) or preferably that uses renewable energy sources throughout its working life.
- Using biofuels instead of petroleum fuels is a new field where government of India is giving a lot of attention at the moment.

## INTEXT QUESTIONS 18.5

1. Mention how you improve energy efficient at home, at work place and in transport sector. Give two points in each.

2. Expand the following:

   MNRE, IREDA, CFL

3. Why have people started using CFL at homes?

4. What does BEE stand for? What is its function?

5. What is the difference between 'one star' and 'five star' refrigerators?

## WHAT YOU HAVE LEARNT

- Water is an indispensable natural resource.
- Sources of usable water are rivers, lakes, ponds, tanks and groundwater
- Several factors responsible for water scarcity are –
  - (i) Increased demand of an increasing population.
  - (ii) Increasing demand by expansion of irrigation and its demand.
  - (iii) Increasing water use due to changing in lifestyle.
  - (iv) Silting of rivers
  - (v) Bad management of water resources.
- Since water is needed for domestic purposes, in industries, irrigation and rearing livestock, its conservation is absolutely necessary.
- Water may be conserved by proper management of water resource. this can be in four directions:(i) Reducing wastage of water, (ii) Storage, (iii)Recharging and (iv) Harvesting of water.

- Water wastage is best reduced by generating public awareness through the media, enforcement by the government and by individual efforts.
- Water harvesting is through collection of rainwater, regular desiltation of canals and ponds, injecting flood waters into aquifers.
- Another way of obtaining usable water is by removing pollutants from freshwater bodies.
- Our rivers Ganges and Yamuna had been polluted and are being cleaned through the river action plans.
- Energy is defined as the capacity to do work.Energy is renewable and non-renewable.
- Conventional sources of energy are fossil fuels whereas non conventional sources are solar, wind, hydel power, tidal, geothermal and biomass energies.
- Biofuels are obtained from plants and plant products and may be in the form of liquid (Bioethanol) may be obtained as gases $CO_2$ and $CH_4$ (bio gas). Oil seeds of plants like Jatropha, Hevea and Callophyllum yield biodiesel.
- Certain careful actions at home and place of work can save energy.
- India has a well chalked out electricity conservation programme.
- Promotion of solar energy power in India and promotion of CFL.
- Star rating of electrical equipments by BEE, an agency of Government of India under Energy Conservation Act.
- Development of fuel efficient vehicles to reduce emission of green house gaese as well as to reduce energy waste.

## TERMINAL EXERCISE

1. State the factors responsible for water scarcity.
2. Mention the strategies for water conservation.
3. What is water harvesting? In what ways can it be done?
4. Write short notes on: Ganga Action and Yamuna Action Plan.
5. What are conventional and non-conventional energy resources? Explain with examples.
6. What are bio fuels?
7. Write notes on (i) Biogas digesters (ii) Biodiesel (iii) Fossil fuels
8. What are the ways of conserving energy as an individual?

9. What is the need for making electrical gadgets/equipments with star rating?
10. How can transport vehicles be made energy efficient?
11. Mention three ways of using solar energy as an energy resource.

## ANSWER TO INTEXT QUESTIONS

**18.1**

1. Increasing demand by industry, Rising demand due to growing population, Expansion of irrigation, Increasing water use due to changing life style (any two).
2. Low pressure sprinklers and micro irrigation.
3. To overcome the problem of scarcity of water, we need to judicious use of water and conserved it for use of future generations.
4. Use water very judiciously. To repair leaking pipes and taps to collect rain water for domestic use.
5. Growing population.

**18.2**

1. Awareness programmes in the form of small skits or conversation or cartoons can reach a large population.
2. Because transpiration is low so water loss is reduced.
3. Change an appropriate amount on water consumption.
4. Divert supply from region of surplus to that of scarcity. Feed used water into pits/ inject flood waters into aquifers / desilt canals/ hold runoff water/ till fields before monsoon/ harvest rain water (any two)
5. They take up phosphates and nitrates from water bodies.
6. Ganga Action Plan and Yamuna action plan.
7. Because the rivers Yamuna and Ganga got badly polluted.
8. Krishna/ Kaveri/ Godavari/ Rabi / Brahmaputra/ Narmada (any other)

**18.3**

1. Capacity to do work
2. Cooking, using electrical gadgets, fuel for vehicles in industries and agriculture
3. ATP or Adenosine trphosphate.

**18.4**

1. Non renewable is limited in supply; Renewable energy is available in an unlimited amount.
2. Conventional- coal or petroleum: Non-conventional-solar/hydel/ tidal/ biomass
3. Coal, natural gas, Petroleum (oil).
4. Jatropha/ Callophyllum/ Hevea (Rubber).
5. Biomass = plant matter.

   Biogas = Gas used as fuel, containing $CH_4$ and made by action of anaerobic bacteria on organic waste.
6. Ethanol, Methane.
7. Because they are obtained from plants or by bacteria both of which are biological organisms.

**18.5**

1. i. Switch of light, fan and AC when not in use, use gas at simmer level, it saves cooking gas.

   ii. Switch off light, fan and AC when not in use, use car pool to reach office, use CFL, computer to be switch off when not in use.

   iii. Car speed should be maintained at 50-60 km/h, turn off a vehicle engine at stops rather than idling. (Any other)
2. MNRE- Ministry of New and Renewable Energy; IREDA- The Indian Renewable Energy Development Agency; CFL- Compact Fluorescent Light Bulbs
3. Energy consumption is low hence cuts down electricity bill.
4. Bureau of Energy Efficiency – the function of BEE is to develop programme to increase conservation and efficient uses of energy in India.

# 19

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# CONCEPT OF SUSTAINABLE DEVELOPMENT

Humans have made a very impressive economic progress, specially during the past two centuries, in creating material and luxuries of life style. This progress has been achieved at a tremendous cost to the environment. Ever increasing exploitation of natural resources coupled with environmental degradation has reached a point that now threatens the well being and future of mankind. Environmentalist and even the common man around the world are seeking answers to these question like - can we keep up industrial and economic development without depleting or degrading our natural resources? Can forests be cleared endlessly for cultivation and habitation? Can agricultural land be regularly used up for building, cities, factories and shopping malls? Can intensive farming be carried out through the year? Can fossil fuels be pumped out in a never-ending manner? How long can our natural resources last at the increasing rate of exploitation and consumption? The answer to these questions will explain the "concept of sustainable development". In this lesson we shall learn about the concept of sustainable development.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the origin and concept of sustainable development;*
- *explain the concept of carrying capacity;*
- *distinguish between common and private resources;*
- *bring out the relationship between population growth and resource availability;*
- *describe the consequence of inequitable and exhortative use of resources;*
- *justify the need to conserve and manage resources for posterity;*
- *explain the need for just equitable sharing of resources; and*
- *justify the need for development without destruction.*

## 19.1 ORIGIN OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT

In United Nations Conference on Environment and Development (the "Earth Summit") held in Rio de Janerio in year 1992, the world leaders signed Framework Convention on Climate Change and Biological Diversity. The "Rio Summit" adopted *Rio Declaration* for achieving *Sustainable Development* in the 21$^{st}$ Century. It is here that the concept originated.

## 19.2 CARRYING CAPACITY CONCEPT

Development requires resources for the production of goods and services. The resources are basically provided by nature and thus known as natural resources. We must learn to respect nature and use the resources in a judicious and responsible manner, failing which we will deprive our future generations from these natural resources thereby endangering their life on this planet.

Population growth coupled with unplanned and ruthless exploitation of natural resources in the name of development is the root cause of our present state of environment.

Economic development is absolutely necessary for the welfare of people even though it causes damage and destruction of our environment. With economic development increasing use of natural resources is inevitable. Also with the increasing population these are bound to be tremendous increase in the use of resources. But the million dollar question is how do we use our resources? Can we use them so efficiently that we are able to conserve them, save them, use alternate and non-conventional resources and allow them (resources) to regenerate so that we do not run out of their stock? We have to hand over the earth with its environment clean and intact to our future generations. We owe this responsibility to them. So it is binding in us not to exploit our environment beyond its **carrying capacity**.

The concept of carrying capacity will become clear, by using the familiar example of any transport vehicle like a car or a bus. What is the carrying capacity of a car? It is the maximum number of people, it can carry without breaking down in the middle of a journey. If the number of passenger or people travelling in a car become more than its capacity to carry, then it would run slowly and may even break down in the middle of the road. Thus carrying capacity is the maximum pressure or load that a system can with stand before breaking down.

Similarly environment also has a capacity to bear the pressure of continual use. Its carrying capacity would be in terms of maximum amount of natural resources drawn from it and maximum amount of pollution discharged into it. If too much resources are extracted or used up than it can afford to give or too much pollutants are discharged into it than it can absorb, then it is severely damaged. Once damaged and destroyed beyond repair, it loses its ability to get back to its pure or usable or harmless state. Thus the carrying capacity of the environment may be defined as maximum load or pressure or use that the environment can withstand by economic or other human activities. Nature is finite and we have almost reached a critical point beyond which ecological decline would lead to disaster.

## 19.3 SUSTAINABLE DEVELOPMENT

Human greed must be controlled and human wants and needs must be restricted. We must treat our environment and resources with respect and stop their reckless exploitation of natural resources.

Sustainable development emphasizes that rate of consumption and use of natural resources must balance. The rate at which these resources can be either substituted or replaced. Economic and industrial development must go on in such a way that no irreparable damage be done to the environment. The World Commission on Environment and development defined sustainable development as **"Development that meets the needs of the present without compromising the ability of the future generations to meet their own needs."**

This definition emphasizes two important points. **One**, the natural resources are important for our present day survival as for the survival of our future generations. **Two**, any present developmental activity or programme must take into account, its future consequences. The main cause of unsustainability is in ever increasing human population and over exploitation of resources. In developing countries, resource exploitation occurs mainly to meet the needs of human population for food, fodder, fuel, wood and shelter. Human activities affect the sustainability of biosphere. The various human activities meant to improve the quality of life are usually accompanied by environmental degradation. Such activities as overfishing, agriculture, over use of fresh water supply, deforestation and industrialization cause environmental degradation and social stress because of negative changes in the ecosystem.

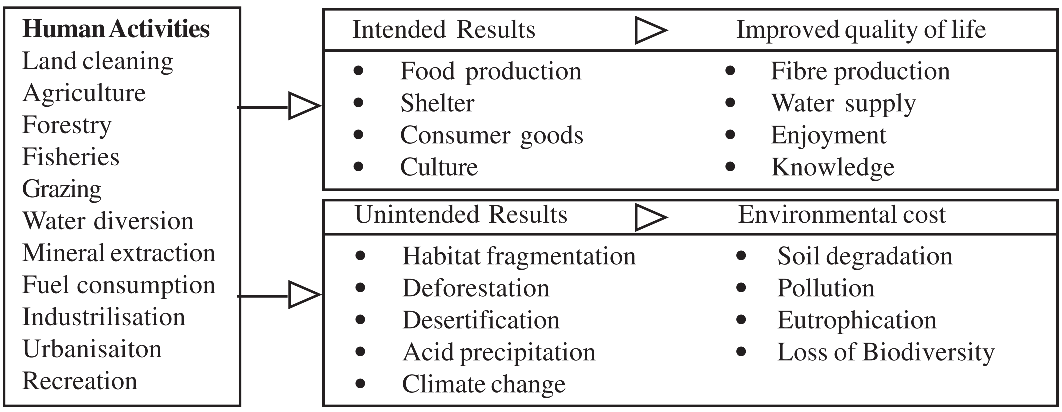


***Fig. 19.1:*** *Human activities affecting sustainability of the biosphere (based on Lubchenco et. al. 1991)*

Mahatma Gandhi's principle of "enoughness" in his saying "the earth provides enough to satisfy every persons need but not for every person's greed" is perhaps more relevant at present time than when it was said. We have been bitten by the bug "consumerisms". We desperately want to possess all the goods and services, no matter what environmental price we have to pay for that. We must check our personal greed at some stage in life and promote a "community greed of providing a beautiful life for our posterity".

An environmentally sustainable society meets the current needs of its people for food, clean air, clean water, shelter and other basic resources without compromising the ability of future generation to meet their needs.

**A Case Study**

A brazilian named Chico (born in 1944) lived happily in the rainforest of Amazon basin. His main income was from a hundred wild rubber trees, which he inherited from his father. He used to slash the trees carefully to collect the latex (rubber) taking care not to damage the trees. He used to collect nuts, fruits and other natural products from the forest. Soon land speculators and big ranching companies came in and made a quick profit by cutting down valuable trees to convert the forest to cattle pasture. Without any tree cover, the pasture land became vulnerable and heavy rains washed away nutrients from the soil making the soil so poor in nutrients that grasses stopped growing and could not support even a single cow. Brazil government came in and built highway in the cleared forest area with the help of international funds. Chico and other resisted this, went to higher government bodies and made the government declare this part of the forest as reserved and protected. But ultimately Chico was shot dead in 1988 by people of the ranch owners. Politics, economics and world trade played a role.

## INTEXT QUESTIONS 19.1

1. Define sustainable development.

2. What are the two important factors or points that sustainable development should consider?

3. What did Mahatma Gandhi say about 'enoughness'?

4. What do you understand about the 'carrying capacity' of the environment?

## 19.3 RELATIONSHIP BETWEEN POPULATION GROWTH AND RESOURCE AVAILABILITY

Rapid population growth coupled with demand of man for material comforts has put tremendous pressure on mother earth and its environment. In India human population has already crossed one billion. In a very short history of earth, humans and their activities are having significant impact on the natural dynamics of the earth system.

The various human activities such as food production, industrial development, international commerce, energy production and urbanization are transforming the earth system at various scales ranging from local to global. The destructive influence of some agricultural and animal husbandry practices on unsuitable land, the destruction of tropical rain forests and destruction of some ocean fisheries are all caused directly and indirectly, by human population growth pressure.

Human population and economic wealth of people (especially in the developed countries) have significantly increased the degradation of natural resources and threatened biodiversity. Thus the main cause of unsustainability is ever increasing human population which naturally leads to over exploitation of resources. With increasing human population leading to human domination on earth's ecosystem, natural resources are declining both in quantity and quality on global scale.

- Nearly half of the earth's surface has been transformed by human activities such as agriculture, industry, housing and commerce.
- Recent studies indicate that nearly 50% of natural vegetation on land has been transformed for developing crop lands, pastures, plantations and urban areas.
- Presently, all accessible fresh water and underground water resources are in a state of depletion in many areas.
- The aquatic environment and its productivity are also on the decline. Marine fisheries are being over exploited, world's coral reefs and fisheries are at risk from the adverse impact of human activities.
- During the last 15 years, the global ocean has lost more than 90% of predatory fishes due to intensive fishing technologies.
- Land is a precious resource which humans have used to produce various goods and services. There are diverse ways in which land has been exploited and altered. Land is being used for urban industrial purposes and for building houses, agricultural land for crops and grazing. Even pure and primitive remote forest areas have been changed by humans interference and exploitation of human beings.
- The most dangerous consequence of population explosion is poverty. Poverty is a major threat to human health and environment. Many of world's poor do not have access to the basic necessities, and lack of health, education facilities, productive and decent life (Fig 19.2 harmful results of poverty).

Their daily lives are focused on getting enough food, water and fuel to survive. Desperate for land to grow enough food and degrade forests, soil, grasslands and wildlife for short term survival. Poverty and environmental pollution are interlinked. Poor people often have many children as a form of economic security.

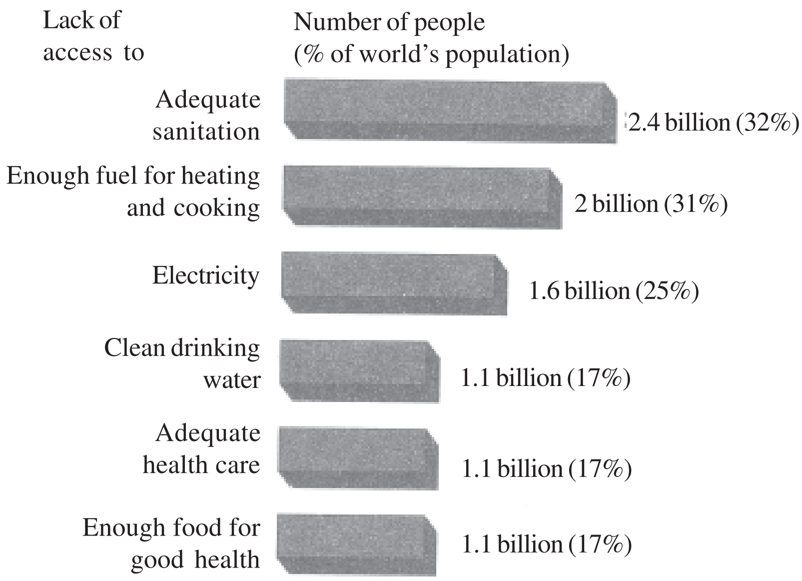


***Fig. 19.2:** Natural capital degradations. Some harmful result of poverty (data from United Nations, World Bank and World Health Organization)*

## 19.4 COMMON AND PRIVATE RESOURCES

Resource is anything useful or can be made useful to humans to meet their needs and wants. Resources that are freely available to everyone and belongs to no one in particular that is every body's property is no body's property and hence one feels that it can be damaged and degraded. Thus common properties are prone to over exploitation. One of the major causes of environmental degradation is the over use of common property or free access to resources. No one owns these resources and they are available to users at little or no charge. Examples include, air, water, land, forests, oceans, rivers, mountains, migratory birds and wild life. Similarly roads, streets, gardens, parks, our heritage monuments are also public properties and we are generally apathetic and careless towards them or for their maintenance.

Privately owned industries, agricultural land, houses, buildings, offices, gardens etc. are cared for and looked after by the owners. Most of them are beautifully maintained. A change of mindset is needed to care for natural resources. Some examples will illustrate the problems faced by some of our common and public resources.

- Air is a precious resource and no one holds its ownership. As a result we have given ourselves the liberty to pollute the air in various ways like burning of wood, coal, garbage and dry leaves, emission of diesel and petrol fumes from automobile exhausts and release of harmful emission from industries.
- Nobody owns a sea and thus everybody has a right to harvest deep sea animals including fishes. One can send any number of trawlers for deep sea fishing which lead to over exploitation of endangering precious marine life like coral reefs, turtles etc. Common ownership of oceans makes it inexpensive for cities freely dump their waste in oceans and nobody feels responsible for polluting the oceans.
- Rivers are common property resource and they belong to no one in particular. All kinds of wastes including municipal wastes and industrial effluents are poured into them; hundreds of idols are immerged into the river after worshipping them. Many years of abuse has converted many rivers into dirty drains.
- Forests are our common property. Economics and politics are main causes of tropical deforestation and degradation. Poverty drives landless poor to tropical forests, where they try to grow enough food to survive. Government of Indonesia, Mexico and Brazil encourage the poor to colonize tropical forests by giving them ownership of land that they clear. This practice can help to reduce poverty but may lead to environmental degradation, unless the new settlers are taught how to use such forests more sustainable. Common ownership properties such as parks, roads and streets are littered and misused without any remorse. Degradation of common resources undermines the quality of life and affects all of us.

Thus apathetic and careless attitude towards resources which are available to all free of cost, must change. Each one of us must care for the common resources as much one cares for his own possions.

## INTEXT QUESTIONS 19.2

1. Name one major cause of environmental degradation and name six such common resources.

   ______________________________

2. What is the most dangerous result of population explosion?

   ______________________________

3. Name an important common property of your locality, state or city which has been completely damaged leading to water crisis to its people.

   ______________________________

## 19.5 CONSEQUENCES OF INEQUITABLE (UNFAIR, UNJUST) AND EXHORTATIVE USE OF RESOURCES

These resources can be broadly classified into three categories namely perpetual (sunlight, winds and flowing water), renewable (such as fresh air and water, soils, forest products and food crops) and non- renewable (such as fossil fuel, metals and sand).

Solar energy, fresh air, wind, fresh surface water, fertile soil and wild edible plants are directly available for use. Solar energy represents perpetual resource, winds and flowing water indirect form of solar energy is renewed continuously. The solar energy is expected to last as long as the sun remains shining.

Other resources such as petroleum (oil), iron, ground water (water found underground) and cultivated crops are not directly available. These types of resources can be derived only after making considerable efforts and use of appropriate technology. For example, petroleum has to be drilled out, refined and processed then only the petroleum products can be made available for distribution in the market. In such cases, resources are obtained by an interaction between natural capital (natural resource) and human capital.

Renewable resources can be replenished fairly rapidly (hours to several decades) through natural processes as long they are not used up faster than they are replaced. Examples include forests, grasslands, wild animals, fresh water, fresh air and fertile soil. Our ecological foot prints –the amount of biologically productive area of the earth needed to produce the required resources as well as to absorb the wastes produced from such resources use.

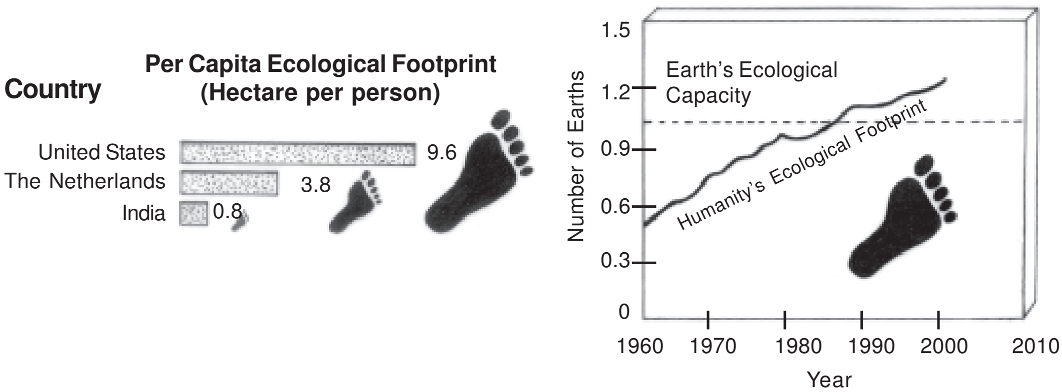


*Fig. 19.3: Natural capital use and degradation: Relative per capita ecological footprints of the United States, Netherlands and, India. (Left) By 2001, Humanity's ecological footprint was about 21% higher than the earth's ecological capacity.(right) (Data from World Wide Fund for Nature, UN Environmental Programme, and Global Footprint Network)*

The numbers shown in the Fig. 19.3 show relative differences in resource use and waste production by different countries and geographical areas.

Humanity's ecological footprint exceeds the earth's ecological capacity to replenish its renewable resources and absorbs the waste. Humanity is consuming the renewable resources faster than the earth can renew them.

The ecological footprint of most people in developed countries is large because of their significantly high consumption of renewable resources.

According to the developers of ecological foot print concept- it would take the land area of about "four more planet earths" for the rest of the world to reach U.S. levels of consumption with existing technology.

### 19.5.1 Sharing of resources

There is a big scope of equitable (fair and just) sharing of resources. Ecological foot print data (Fig.19.3) as well as the above description clearly demonstrate, the fact that there is inequitable sharing of resources in the world today. The result is that the developing and under developed parts of the world live in a state of deprivation and poverty.

When the resources are available in plenty one tends to use them generously without any consideration for others. Resources must be used wisely and judiciously. Responsibility lies with the have to make sure that enough resources are available to the have nots.

> It is found that 20% of world population of developed countries use 80% resources of the world.

## 19.6 NEED TO CONSERVE AND MANAGE RESOURCES FOR POSTERITY

Natural resources are goods and services supplied by our environment. Earlier when people lived at subsistence level the exploitation of resources was limited to local scale but now spatial scale have become much larger, much beyond the local scale.

Tree bark (e.g. Taxus), forest fruits, resin, plant dyes, pulp for hand made papers, roots of many inconspicuous species of a region, lichens, all being commercially harvested and are marketed at distant places. Human beings have begun to degrade all kinds of natural resources because of increasing demand of the growing population, use of technology for resource use as well as increase in per capita resource consumption.

According to a world report, the global consumer class, mostly living in developing countries also increasing at a very high rate. Consumer and consumerisms is increasing at a very high rate therefore it becomes all the more necessary to conserve resources for posterity.

For the survival and well being of the human race biodiversity plays a very important role in controlling the stability and functioning of the ecosystem. Human activities and environmental degradation is resulting in fast depletion of biodiversity which is a matter of great worry and concern because we do not know what wealth we have and what we are losing biodiversity because it represents potential source of wealth in the form of (a) new crops; (b) medicinal plant; (c) petroleum substitutes (d) biocides and other products.

Organisms are required for proper functioning of the earth's ecosystems. Loss of biodiversity would check or stop the process of evolution and production of newer types of organisms cope up with the changed environmental situation.

Biologically rich unique habitats are being destroyed and degraded due to by increasing human population, resource consumption and pollution. Biodiversity loss is new world's most disturbing concern. May be we are losing plants which would give us relief from diseases like cancer and HIV. We need to save biodiversity for our posterity so that they are able to derive countless direct and indirect benefits from the living world. The ecosystems like forest, deserts, grasslands, oceans, seas must be kept intact and health for our future generations. They should have a chance to use the biodiversity as a source of food, medicine, fibres, timber which are already in use and also have a chance to get newer plants and animals which came continuously evolving for meeting their demands for survival.

Wild varieties of cultivated or commercial species have many good genes which can be used to improve the crops for cultivating in different areas for different uses e.g. wild plants have in them natural defense mechanisms (genes for killing diseases, germs and pests) i.e. disease resistant genes. Degradation of soil, air and water by human activities lead to damage of these resources which ultimately affect the various ecosystems. Which form the habitat of all organisms on earth including humans. We are not saving the habitats for other organisms on earth, let us not forget we are part of this ecosystem and it is our responsibility to check our activities to save the earth.

Environmental degradation means depletion or destruction of potentially renewable resource such as soil, grassland, forest or wildlife that is used faster than it is naturally replenished. If such use continues, the resource becomes non renewable (at least in our life time) or non existent (extinct). Thus our effort should be to use potentially renewable resources without reducing its available supply throughout the world or a in a particular area.

We must work towards development of a sustainable society that manages its economy and population size without doing irreparable environmental harm or damage by overloading, earth's ability to absorb environmental in and outs, replenish its resources and sustain human and other form of life for a long period of life (hundreds to thousands of years) During this period, the society should satisfy the needs of its people without depleting natural resources and thereby endangering the prospects of current and future generations of humans and other species.

We are ethically and morally responsible to care and manage the earth. Actually the earth does not need us managing it to go on where we do need the earth to survive.

We wrongly assume that we now have or can gain enough knowledge to become effective managers of the earth. We do not know how many species live on the earth, much less what their roles are and how they interact with one another their nonliving environment.

When we use the earth's natural resources we are borrowing from the earth and from future generation and have a moral responsibility to pay the debt by leavingg the earth in atleast as good a condition as we now enjoy. Infact in all our activities we must consider the impact or effect of our decisions on the next seven generations.

## 19.7 DEVELOPMENT WITHOUT DESTRUCTION

The damage and destruction of the environment is so clearly visible now as never before. We see bald and barren slopes of mountains once covered by green forests, we find rivers choked with muddy water and garbage, we grasp for breath in the polluted air, we are incapable of handling our wastes and pay the price through our health.

In short we have damaged and destroyed our environment in the name of development. There is very little time left for talking and discussing the matter, we have to do and act now to recover the lost environment and conserve the natural resources.

**Some steps in that direction are:**

- adoption of energy and resource saving methods;
- new technology for minimization of wastes and toxins;
- biodegradable, renewable and recyclable products;
- education and awareness about environment in people.

**Environmental problems must be approached at all three levels**:

- Immediate local problems like water pollution and waste management can be taken up at community level.
- Regional problems like acid rain, floods, air pollution and deforestation can be dealt with at national or regional level.
- Global issues like climate change, depletion of ozone layer and the associated problems should involve world bodies for the participating of the nation around the world.

**Think globally and act locally**

Any environmental problem either local or regional can become a gigantic global issue if not addressed in time. If communities address their local problem (issues) then bigger problems get solved. Thus our motto should be think globally and act locally.

### The least we can do

Each one of us can play our role, as a responsible member of the society to conserve the resources and protect or save the environment.

### Conserve fossil fuels

- Switch off fans and lights when not needed.
- Let the breeze in by switching off the air-conditioning.
- Avoid the use of electrical gadgets as much as possible.

### Conserve water

- Use only as much as you need.
- Repair leaking taps and pipes.
- Do not pollute water bodies like rivers, lakes, canals etc.
- Do not wash your cars everyday.
- Harvest rain water.
- Join river cleaning programmes like "Yamuna Bachao Andolan".

### Save the trees

- Reduce use of paper and paper products.
- Recycle used papers.
- Make full use of writing papers.
- Plant trees and care for trees.

### Keep the air clean

- Stop smoking.
- Do not burn papers, dry leaves and other wastes.
- Drive vehicles with a catalytic converter.
- Keep your vehicle well maintained.
- Implement pollution control and treatment facilities in your factory.

### Reduce garbage

- Buy goods with less/recyclable packaging.
- Reuse/recycle paper, metal, glass, plastic items.
- Carry your own shopping bag and say not to plastic bags.

- Convert kitchen and garden waste into compost.
- Use natural products for cleaning, fertilizing and getting rid of bugs and insects.

**Spread awareness**

- Show your family and friends how to be eco-friendly or environment friendly.
- Support environmental issues like cleaning of rivers, cleaning of air etc.
- Write to government representatives demanding action on environmental issues.
- Set an example by following eco-friendly life style.

## INTEXT QUESTIONS 19.3

1. How does biodiversity represent potential source of health?
2. "Biodiversity loss is world's most disturbing concern". Because we do not know what we are losing" briefly explain the statement.
3. What are the main causes of biodiversity destruction? Mention any two.

## WHAT YOU HAVE LEARNT

- Economic development is necessary for the welfare of people but it should not be at the cost of environmental degradation.
- Carrying capacity is the maximum pressure or load that a system can withstand or take up before breaking down.
- Carrying capacity of the environment may be defined as maximum use of human activities that the environment can tolerate.
- Sustainable development is "development that meets the needs of the present taking care of the needs of future generations".
- Human activities like agriculture, industrialization etc. affect sustainability of biosphere.
- Human activities meant to improve the quality of life are usually accompanied by environmental degradation.
- Rapid growth of population coupled with demand and needs of man for material comforts has put tremendous pressure on earth and its environment.

- Most dangerous consequence of population is poverty. Poverty is a major threat to human health and environment.
- One method of eliminating poverty is by taking care of equitable i.e. far and just distribution of resources.
- Resource is anything useful or can be made useful to humans to meet their needs and wants.
- Resources that belong to no one in particular become common property. Examples air, water, rivers, forest, oceans, mountains etc.
- People are apathetic and careless for them or their maintenance.
- Each of us must treat the common natural resources with same amount of care as one treats the personal things.
- Privately owned industries, agricultural land, houses, building, offices, gardens etc. are cared for and looked after by the owners.
- Ecological foot print is a measure of area of earth required per person (to produce resources) and waste production.
- Ecological foot print of most people in developed countries is large because of the half amount of consumption of natural resources.
- There is need to conserve and manage the resources for posterity.
- In order to improve the environment it is important to act and encourage other for conservation of natural resources.

## TERMINAL EXERCISE

1. Define and explain carrying capacity of environment.
2. "Economic and industrial development without damage and destruction of the environment." What do you call this type of development?
3. What did Mahatma Gandhi say about the use of earth's resources by its people?
4. Increase in human population is causing decline in natural resources on a global scale. Mention any three causes.
5. What is the difference between common and private properties? Give two examples for each.
6. Define a resource. Name one perpetual resource, a renewable resource and one non-renewable resource.
7. What is ecological foot-print?

8. Name three major environmental damages that have already occurred in our country.
9. Suggest any three methods to record damaged environment.
10. Suggest any five methods to conserve water.

## ANSWER TO INTEXT QUESTIONS

**19.1**

1. Development that meets the needs of the present without compromising the ability of the future generations to meet their own needs.
2. The two factors are :

   i. the natural resources are important for our present day survival as far as the survival of future generations;

   ii. any present developmental programme must take into account, its future consequences.
3. The earth provides enough for every person's need but not for every person's greed.
4. Environment has a capacity to bear the pressure of continual use, that is the maximum amount of natural resource drawn from it and the maximum amount of pollution discharged into it.

**19.2**

1. Over use or over exploitation of common property or free access of resources like air, water, land, forest, rivers, mountains.
2. Poverty is the most dangerous result of population explosion.
3. River Yamuna has been exploited in such a way that it has ceased to exist. It has turned into a dirty drain.

**19.3**

1. Wealth in the form of (a) new crops (b) medicinal plants (c) petroleum substitute or any other (any two)
2. May be we are losing useful plants, animals or other organisms, which would have provided us medicine against HIV and cancer etc.
3. Main causes of degradation are- increasing human resource consumption and pollution.

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# 20

# MODERN AGRICULTURE

Modern agriculture has made impressive contribution in increasing food grain production in the country. The country could achieve self-sufficiency in food grain production by using modern methods of agriculture using better quality of seed, proper irrigation and adequate supply of plant nutrients by using chemical fertilizers and control of pests and diseases in crop plants by using pesticides. It has also involved modern cultivation practices using tractors, combine harvesters and tube wells for irrigation. Rapid growth in food grain production from using seeds of high yielding variety is termed as Green Revolution. Protection of air, water, soil and human health while producing bumper crops should be the prime concern of modern agriculture.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define green revolution;*
- *know about the introduction of high yielding varieties (HYV) in India;*
- *understand the significance of the need for pesticides and fertilizers;*
- *emphasize the need of superior quality seeds, agricultural implements and irrigation;*
- *learn about newer agricultural practices like mushroom cultivation, poultry farming and fisheries;*
- *define animal husbandry;*
- *mention management of livestock with respect to shelter, feed and care;*
- *mention names of common diseases of livestock;*
- *relate disposal of dead livestock with environmental degradation;*
- *emphasize the detrimental effects of indiscriminate use of hormones on livestock and poultry;*
- *discuss the consequences of aquaculture.*

## 20.1 WHAT IS GREEN REVOLUTION

The term "Green revolution" refers to substantial increase in grain yield obtained by plant breeders by developing new crop varieties. The high yielding varieties (HYVs) of wheat and rice have been the key elements in green revolution. It was in March 1968 that the director of the US Agency for International Development (USAID), William Gand, first used the phrase "green revolution", to describe the great gains in yields of rice, wheat, maize and other crops through the use of high yielding varieties (HYVs). Specifically the term "green revolution" refers to wheat and rice but some agricultural scientists even include maize, soyabean and sugarcane where spectacular gains in yield have occurred.

The factors which have helped to bring about the green revolution are:

- introduction of high yielding varieties of crops.
- multiple cropping, better irrigation and sufficient supply of fertilizers.
- use of crop protection measures against disease and pest.
- transfer of the technology of scientific farming from research farms to village farmers.
- better arrangements for transporting farm produce from fields to the market.

Spectacular increase in the yield of crops, particularly cereals, through the application of modern techniques in agriculture is called green revolution.

A cross between semi-dwarf Mexican wheat (high yielding and responded to fertilizer and irrigation) and Indian, wheat (disease resistant and good grain quality) resulted in high yielding and disease resistant varieties of wheat. Some important revolutionary varieties are 'Kalyan Sona', 'Sonalika' and 'Sharbati Sonora' etc.

### 20.1.1 Introduction of High Yielding Varieties (HYV) in India

The average national yield of wheat has remained at 800 kg/ha which was very low as compared to the wheat yields of agriculturally advanced countries. MS Swaminathan former Director General of ICAR (Indian Council of Agricultural Research) made a theoretical analysis of the factors responsible for the yield stagnation as well as instability in crop production. He stressed the need for reorientation of the entire breeding programme as the very morphological and physiological structure of tall varieties prevented any type of break through in the yield.

Through extensive wheat breeding programmes carried out during 1970-80, new amber seeded, high yielding dwarf wheat varieties were developed. The important high yielding varieties include 'Kalyan Sona', 'Sharbati, Sonara', 'Sonalika' were released. These varieties responded favourably to fertilizer and irrigation.

On the request of Indian breeders Prof. Norman E. Borlaug was invited from Mexico in 1963 by the Government of India to assess the possibilities of using dwarf varieties in India. After travelling through major wheat growing areas in India, he recommended the feasibility of using semi dwarf wheats of Mexican origin as the agro-climatic condition prevailing in India are similar to Mexico. On his recommendation two semi dwarf varieties namely Lerma Rajo and Sonora-64 were chosen and were released for cultivation in irrigated fields. These varieties gave very high yield and brought in revolution in wheat production.

Dr. Borlaug joined the Rockefeller Foundation Cooperative project with Mexican Ministry of Agriculture as the head of Wheat Research and Improvement Programme. In 1966 his "Quiet Revolution in Wheat Improvement" created worldwide interest and International Wheat and Maize Improvement centre was established in Mexico. In 1970 he was awarded Nobel prize for "Green Revolution" which helped India.

Dr. M.S. Swaminathan an outstanding mutation geneticist produced 'Sharbati Sonara' and released it for cultivation in 1967. This ambar coloured mutant variety was produced in a mutation breeding programme by subjecting Sonara 64 to gamma and ultraviolet radiations. 'Sharbati Sonara' had bold, amber, and lustrous grains and was found to contain 15-25% more protein than the parent Sonara 64.

## 20.2 FERTILIZERS AND PESTICIDES

- **Fertilizers**

Fertilizers are substances that are generally applied to soil to promote healthy growth of plants. Fertilizers restore the lost plant nutrients in the soil. Farmers use both organic fertilizers produced from plant and animal wastes as well as commercial chemical fertilizers produced from various inorganic compounds.

Fertilizers are mainly applied through the soil to be absorbed by plant roots; it can also be applied as foliar spray to be absorbed by leaves.Chemical fertilizers are generally of the following types:

(a) **Nitrogenous fertilizers**: Nitrogen containing fertilizers e.g. ammonium sulphate, ammonium nitrate and urea.

(b) **Phosphate fertilizers**: Phosphate containing fertilizers e.g. ammonium phosphate, calcium dihydrogen phosphate (superphosphate)

(c) **Potassium fertilizers**: Potassium containing fertilizers e.g. potassium sulphate and potassium nitrate.

Nitrogenous fertilizers promote plant growth and are essential for food production. But they should be used judiciously. Inefficient absorption by crops and wasteful application of fertilizers are the main causes of environment pollution. The unused fertilizers then enter surface water (rivers, lakes, ponds) and ground water. Fertilizers cause environmental pollution when used indiscriminately and cost us money.

**• Organic fertilizers**

Organic fertilizer is produced from plants and animal waste matter by biological degradation by microorganisms. This is known as manure or compost and is produced from cattle dung and other animal wastes or from fallen leaves, twigs and other vegetable wastes by biodegradation by microorganisms. Organic fertilizers or manure or compost are environment friendly as it does not cause any type of pollution either to the soil or to water. Organic fertilizers enrich the soil with nutrients and improves the overall quality of the soil like soil texture, soil aeration and water holding capacity.

**• Pesticides**

Pesticides are chemicals which have been developed to kill or control organisms called pests which are unwanted by man especially in agriculture.

Modern pesticides increase food supplies, increase profits for farmers and are safe if used properly. Pesticides control most pests quickly and have a long shelf life and are easily shipped and applied. When genetic resistance occurs farmers can use stronger doses or switch to other pesticides. Pesticides, when used in the approved regulatory manner, pose no risk to either farm workers or consumers.

Level of DDT (chlorinated hydrocarbon) in the body of tissues of people living in New Delhi is the highest in the world.

## INTEXT QUESTIONS 20.1

1. Define “green revolution”.

2. How was “Sharbati Sonora” produced by Dr. Swaminathan?

3. Define fertilizer.

4. What are the advantages of using organic fertilizers or manure?.

## 20.3 NEED FOR USE OF SUPERIOR QUALITY SEEDS

Increasing production in limited land area requires the use of superior quality seeds. Improving the quality of seeds by applying knowledge of genetics and plant breeding are being done in a routine manner. By applying the knowledge of biotechnology, superior quality seeds are being produced.

Seeds are being improved to produce:

- high yielding varieties;
- seeds of better and higher nutritional quality like protein quality in pulses, baking quality in wheat, preserving quality in fruits and vegetables, oil quality and quantity in oil producing plants;
- Varieties for disease resistance and pest resistance;
- Varieties for resistance against factors like heat, cold, salinity, frost, draught and water logging.

Disease resistant and pest resistant seeds will not require so much pesticide which will save environmental pollution also will save money which would have gone in the purchase of pesticides.

Plants can be grown under various difficult situations; thereby extending the area of cultivation e.g. dry or saline or water logged areas can be utilized for cultivation.

## 20.4 MECHANISATION OF AGRICULTURE

Increase in productivity on large areas of land brought the idea of farm mechanization. All the activities associated with agriculture became possible within a short period of time over large acerage of land so that the produce or the harvest reaches the market as quickly as possible with the help of various types of machines. In developing countries agriculture used to be labour intensive but with the increasing migration of rural population to the cities and agricultural labour is gradually became scarce in most areas. To cope up with the shortage of agricultural labour, farm mechanization was the obvious choice for completing agricultural operations. The machines which perform various jobs at the farm are water pump, ploughs, combine harvesters, land levelers, cultivators, power operated tractor sprays, reapers, threshers, trolleys and mechanical pickers etc.

- **Combine harvester** – They are also known as "combine". It is a large farm machine that both cuts the corn and separates the grains from the ear of the plant. It does the job of cutting or harvesting and threshing, i.e. separating the grains from the ears right in the field.
- **Ploughs** – Plough or till the soil mechanically, turning the soil over there are various types of ploughs available.

- **Land levelers** – Level the soil after breaking big chunks of soil or clay, and prepare the soil for sowing.
- **Box drill** – Attachment on tractors are used for sowing seeds.
- **Power operated tractor sprays** – They run through the rows of crops, spraying insecticides or pesticides on crops present on either side.
- **Pumps** are simple electrically operated water pumps to supply irrigation water to fields.
- **Threshers** are machines which separate the grains of corn, rice, wheat from the ears or the rest of the plant.
- **Mechanical pickers** which works on the principle of suction, designed to harvest or pick cotton. For picking cotton, plants are defoliated using chemicals.

## 20.5 NEWER AGRICULTURAL PRACTICES

Modern agriculture includes animal husbandry, poultry farming, apiculture, fisheries and mushroom culture etc. to provide additional food supplements like milk, meat, fish, egg, mushroom etc. In addition to provide nutritional food for the masses, they also reduce load on the comsumption of cereals and pulses. Thus modern farmers take up some of these above operations, over and above cultivation of plants.

(a) **Poultry farming**

Poultry farming is a term used for rearing and keeping of birds such as fowl, duck and hen for egg and meat. Poultry farming has become popular because this is comparatively easy to start and maintain. It gives quick return within one to six month of investments, is easily manageable and required less space and labour. Poultry birds and their eggs are rich source of nutrients.

Indian poultry birds provide good quality meat but produces small sized eggs. They have natural immunity against common diseases as compared to exotic varieties bred abroad.

Common exotic birds are Leg horn, Rhode Island Red, Cornish.

Common Indian breeds are Aseel, Chittagong, Busra.

(b) **Mushroom culture**

Mushroom culture has became a lucrative method of earning money as well as it provides a nutritious food supplement. Mushrooms are kind of fungus which appear as white tiny balls consisting of a short stem and a cap which opens like an umbrella later. They lack chlorophyll and grow on organic matter or waste materials from farms or factories, useless by-products can be recycled as medium to grow mushrooms for human consumption. Out of the large number of mushroom species only some are edible. Some of the edible ones found in India are white button mushroom (*Agaricus bisporus*), paddy straw mushroom and oyster mushroom.

Mushrooms are good source of high quality proteins and are rich in vitamins and minerals. Like fruits and vegetables mushrooms are perishables and require a great deal of attention during storage, marketing and processing.

(c) **Apiculture**

Apiculture is also known as bee-keeping. 'Apis' means bee. Apiculture or bee-keeping is the art of caring for and controlling colonies of honey bee in large quantity for commercial production of honey. Earlier bee-keeping used to be done by people to produce honey for home consumption but now it has become an important industry.

There are three major advantages of bee-keeping:

(i) provides honey- a valuable food

(ii) provides bee wax- which has many uses in industry

(iii) honey bees are excellent pollinating agents which increase agricultural yields.

Bees produce honey and wax, both of which are valuable marketable commodities but their function as pollinating agents are of great significance in agriculture. Nectar and pollen from flowers form the raw material for honey. Nectar is the sweet secretion of the flowers. It is the raw material for honey. Pollen provides the raw material necessary for the major food of the brood (fertilized egg).

(d) **Fish culture and aquaculture**

Fishes form an important protein rich diet in many areas of the world. The development of fisheries is therefore one of the most promising industry.

India has a long coastline which is a great producer of marine fish.

Areas where fish are reared commercially are known as artificial fisheries. The fishes are bred, reared and later harvested. The fishery may be a natural water body or an artificial one. A variety of fish may be reared together.

Depending on the nature of water in which fish is reared fisheries can be:

1. **Marine fisheries-** fishing operations along the coastline, e.g. Mackerels, Sardines, Catfish.
2. **Fresh water or inland fisheries-** fish found in rivers, irrigation canals, reservoirs, lakes, tanks, ponds etc. e.g. Rohu, Catla, Mystus.

3. **Estuarine or brackish water fisheries-** estuaries are where river water and sea water get mixed like backwaters, lagoons, coastal lakes, delta channels. They are more common in Bengal and Kerala. E.g. Mullet, Milkfish, Pearlspot.

There are several other aquatic resources such as molluscs (oyster, mussels, squids, octopus, cuttlefish etc.) and seaweeds which have been exploited for aquaculture. Sea weeds are used for human consumption, as cattle and poultry feed, as manure and for industrial purpose as a source of agar-agar and algin. Thus these newer agricultural practices can became lucrative or profitable business as well as create employment.

## INTEXT QUESTIONS 20.2

1. What are the advantages of using disease resistant varieties of seeds?

______________________________________________

2. What are the functions of combine harvesters, ploughs and land levellers?

______________________________________________

3. Of what significance is the production of seed varieties resistant to salinity, dry or waterlogged conditions?

______________________________________________

4. Name three important newer agricultural practices of great value and their advantages

______________________________________________

## 20.6 ANIMAL HUSBANDRY

The branch of agriculture that deals with breeding, feeding and care of domestic animals is called **animal husbandry.**

Animal husbandry is an integral part of modern agriculture as animal sources provide us important food materials like milk, egg, meat etc.

Cows and buffaloes are our chief sources of milk. Milk producing animals are called **milch animals**.

Hens are egg laying animals. Fishes, pigs, hens and goats are our major sources of meat.

Protein intake of our food have increased because people are consuming more animal food resources, yield of animal food products (milk, fish, eggs) have steadily increased in the last four decades.

Animal husbandry plays a prominent role in the rural economy in supplementing the income of rural households.

There are large number of organizations, cooperative societies, universities and national institutes which are involved in research processes resulting in steep increase in the total yield of various animal food resources like milk, fish and eggs.

Breeding of domestic animals is also one of the key elements of animal husbandry.

## 20.7 MANAGEMENT OF LIVESTOCK

Management of livestock includes proper care of animals, providing them feed and water, shelter and protection against diseases.

(a) **Feed for livestock**

The food consumed by animals is called **feed**. Cattle feed must be rich in all required nutrients. It should be given according to the age, nature of work and health of the animals. For example a growing calf needs more food than an old cow. Animals require food to produce enough milk and maintain good health.

The feed of the cattle must be rich in food nutrients like carbohydrates, proteins, fats, minerals and vitamins. Cattle feed are grouped into two types of substances:

(i) roughage and (ii) concentrates

(i) **Roughage** includes coarse and fibrous low nutrient materials rich in cellulose. Like hay, fodder (jowar, bajra, ragi, maize) and legumes (berseem, cowpea etc.) constitute the roughage.

(ii) **Concentrates** includes food rich in one or more nutrients. Oilseeds (Binola), oil cakes (khal), cereals, millets, gram and bran.

A large amount of water, roughage and concentrate should be included in an ideal cattle feed.

Leguminous green fodder like barseem, lucern, cowpea etc. are highly nutritious and preferred by cattle and given to them in winter. Some nutritious fodder grasses are elephant grass, Rhodes grass, Sudan grass, Napier grass.

An average cow needs the following feed daily:

1. Green fodder and dry grasses (roughage) : 15 to 20 kg
2. Grain mixture (concentrate) : 4 to 5 kg
3. Water : 32 litres

Cattle population in India constitutes 25% of the world cattle population but the total milk production is about 5% of the world's total milk production. In our country a cow on an average gives about 1.5 litre of milk per day and a buffalo 2.5 litres per day whereas a cow in some developed countries produces 8-11 litres of milk per day. Low milk yield in our country is due to:

- poor quality feed
- shortage of feed and fodder
- low milk yielding indigenous breeds

However, milk production in our country has improved in recent years because of improved breeds of cattle and better feeds. Some important indigenous breeds of cows are – Sahiwal, Gir, Tharparkar, Red Sindhi. High milk yielding cows in India developed through cross breeding with exotic (foreign breeds) breeds to produce high milk yielding Jersey, Karan and Swiss (Brown Swiss and Sahiwal), Karan and Fries, (Tharparkar and Holstein) Frieswal (Friesian and Sahiwal), Holstein –Friesian.

Jersey is a breed of the Island of Jersey, USA

Brown Swiss is an original breed from Switzerland

Holstein –Friesian is a breed of Holland

Some important Indian breeds of buffaloes are Murrah, Mehsana, Surti and Jaffarabadi.

**(b) Breeding and lactation**

A female calf after a certain age is mature enough for reproductive life. For breeding, she is allowed to mate naturally or is inseminated artificially and she gives birth to a calf in ten months. This is the period she enters into a period of lactation and begins to give milk. After 4-6 months, the milk yield is lowered. High yield can be increased by increasing the lactation period. But indiscriminate use of hormones for increasing lactation period. But indiscriminate use of hormones supplied from outside can be harmful for the animal as well as the quality of milk.

## 20.8 SHELTER MANAGEMENT

Domestic animals must be provided with proper shelter to protect them from rain, heat, cold and disease causing organisms and predators. Animals in good shelters lead a comfortable life which increases their yield or productivity.

An ideal shelter is one, which is:

- clean, dry and well ventilated.
- not crowded.
- provided with clean drinking water and adequate sunlight.
- provided with proper arrangement for disposal of excreta.
- hygienic to prevent outbreak of diseases.
- protected against predators.

### 20.8.1 Diseases of livestock

Domestic animals are prone to many bacterial, fungal and viral diseases. A weak and diseased animal produces less milk or meat. However, the meat and the milk may be contaminated by disease causing organisms. Some common diseases of livestock have been tabulated below:

| Disease | Causal organism | Animal affected | Symptoms |
|---|---|---|---|
| Foot and mouth disease | Virus | Cattle | Blisters on the mouth and foot, excessive production of saliva, loss of appetite, high body temperature, shivering. |
| Pox | Virus | Cow, buffalo, sheep, goat | Appearance of small nodules and fever. |
| Dermatitis | Virus | Goat and sheep | Irritation, blisters and eruptions on the skin. |
| Tuberculosis | Bacteria | Cattle | Infection of udders, lungs, intestine and other parts, swelling of lungs and fever. |
| Rinderpest | Bacteria | Cattle | Discharge from eyes, nostrils, loss of appetite, constipation followed by severe diarrhoea. |
| Anthrax | Bacteria | Cattle, sheep, goat, pigs | Swelling of body, fever, reduction in milk secretion. |
| Salmonellosis | Bacteria | Cattle | Diarrhoea with blood clots and fever |
| Mastitis | Bacteria | Cattle | Swallow udders, fever, milk becomes watery . |

## INTEXT QUESTIONS 20.3

1. Name three indigenous and three foreign breeds of cows.

2. What are the main reasons of low milk yield per day a cow in our country?

3. Mention the causal organisms and the symptoms of the diseases like (i) foot and mouth diseases, (ii) Rinderpest and (iii) Anthrax.

## 20.9 DISPOSAL OF DEAD LIVESTOCK

The foot and mouth disease of cattle is very common, dangerous and contagious disease. The affected animals are slaughtered and the dead ones are buried deep or burned so as to stop the disease from spreading.

Another dreaded disease is anthrax which spreads easily. Such animals after death must be burnt and disposed off completely. If the bodies are left at a place or allowed to rot, foul smell will pollute the air. The dead bodies may cause danger to other animals and man.

Disease causing organisms after the death of the animals may stay in air, water, and soil. When the animal dies a natural death, its skin, horn, hooves and bones can be used in various useful ways.

**Detrimental effect of hormones on livestock and poultry**

- Indiscriminate use of hormones used orally or injected may be harmful for the animal as well for the milk it produces.
- Hormone increases amount of milk but their udder enlarge abnormally, so much so that the cows have difficulty in movement and they develop an abnormal goit.
- It also affects their normal physiology of reproduction.
- Oxytocin causes milk ejection from mammary glands in nursing mothers. This hormone also causes uterine contraction, so injection of this hormone for milk release can cause pain and discomfort to the animal.

## 20.11 CONSEQUENCES OF AQUACULTURE

World's third major food-producing system consists of fisheries. The world's commercial marine fishing industry is dominated by industrial fishing fleets (large factory ships) many latest technologies to catch maximum amount of fish. In fact over fishing take place to such an extent that very little breeding stock (fish population) is left to maintain the special number. Prolonged over fishing leads to commercial extinction when the population of the species becomes so low that it is no longer profitable to hunt them.

Fishing methods such as trawling and drift nets capture everything in their way indiscriminately. Sometimes 70% of the catch is thrown away. This commercial fish catching disturbs non-target marine animals annually. Dredges and trawls also adversely affect the marine habitats. Thus fish populations in the oceans of the world suffer from:

- over exploitation
- habitat destruction
- incidental mortality of non-target species
- pollution

Humans have failed to conserve marine fisheries management to date and focused to maximize the catch of a single target species, disregarding or not caring about the marine ecosystem.

Aquaculture offers a potential solution to the depleted ocean fisheries as well as meeting the demand for sea food. Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Basically aquaculture or fish farming involves cultivating fish in a controlled environment (coastal or inland pond, lake, reservoir) and harvesting them when they reach the desired size. Aquaculture provides protein rich diversified diet for people.

It is fastest growing sector of world food economy and increasing by 10% per year. The vast majority of aquaculture takes place in Asia. However, China is the world leader in this field.

The current "blue revolution" of aquaculture has taken up the shape of an industry with intensive use of resources and has adverse environmental impacts.

Ecological aquaculture (Eco-aquaculture) need to be promoted with a focus on developing aquatic farming system that preserve the environment in which they are suited and can be harvested in a suitable manner. Thus it should be a sustainable fisheries management.

Also aquaculture can provide an important source of livelihood for rural poor, generating income through direct sales of products and employment in fish production, services and processing.

## INTEXT QUESTIONS 20.4

1. Mention the harmful effects of infecting hormones in order to increase milk production in cows.

   ______________________________

2. Define aquaculture?

   ______________________________

3. Which are the main dangers the fish population suffer from?

   ______________________________

4. What is the advantage of the system of eco-aquaculture?

   ______________________________

## WHAT YOU HAVE LEARNT

- 'Green revolution' is substantial increase in yield of crop using high yielding varieties of seeds, and providing enough fertilizer and pesticides and good irrigation.

- Prof. Norman Borlaug helped India in bringing in 'Green revolution'.
- Dr. M.S. Swaminathan, internationally renowned Indian Agricultural Scientist and the father of "Green Revolution" in India, made India a food surplus country.
- Indiscriminate and wasteful use of fertilizer causes environmental pollution and cost us money.
- Modern agriculture is an industry, hence it is highly mechanized. Various types of machines are used for managing crops in large acreage of land. Combine harvesters, disc ploughs, threshers, water pumps are very common.
- Poultry farming, apiculture, mushroom culture and fisheries are newer agricultural practices which bring money and employment to the farmers.
- Animal husbandry is a branch of agriculture which deals with proper care and breeding of domestic animals.
- Milk producing animals are called milch animals. The two most popular milch animals are cows and buffaloes.
- Some indigenous (Indian) breeds of dairy cows are Sahiwal, Red Sindhi, Tharparkar, Gir. Some exotic (foreign) breeds of cows are Jersey, Brown Swiss, Holstein Friesian. Some cross breeds of dairy cows are Frieswal, Karan Fries and Karan Swiss.
- High milk yielding breeds of buffaloes are Murrah, Surti, Mehsana.
- Feed of cattle should be rich in carbohydrates, protein, fats, minerals, vitamins and water. It must include large amount of roughage and some concentrates.
- Roughage the low nutrient, fibrous, coarse material rich in cellulose. Concentrates are generally rich in one or more nutrients, provided by cotton seeds, oil cakes, gram, cereals and millets.
- It is very important to provide proper shelter to the domestic animals to keep them in a healthy condition (disease free) so that the milk yield is high.
- Animals are also attacked by diseases causing organisms (Pathogens) like bacteria, virus and fungi. Common diseases of cattle are (i) foot and mouth disease, (ii) anthrax, (iii) rinderpest and (iv) cow pox and (v) tuberculosis.
- Proper disposal of dead livestock is a serious matter especially when the animals die of high infections diseases like anthrax, tuberculosis.
- Indiscriminate use of hormones for increasing milk production causes lot of discomfort and to pain the animals making it difficult for her to even walk.
- Aquaculture (Blue revolution) is a sustainable way of harvesting aquatic edible, crustaceans (lobsters and prawns). It helps to save the oceans or marine ecosystem from getting damaged.

## TERMINAL EXERCISE

1. Define green revolution. Which were the two crops specially involved with 'Green Revolution' in the beginning?
2. Which was the wheat variety production by Dr. M.S. Swaminathan and how?
3. What do the farmers do when the pests develop genetic resistance to certain pesticide?
4. Define pesticides. Mention two advantages of using pesticides.
5. Write brief notes on combined harvester, plough, land levelers, box drill.
6. Name four new areas of agricultural practices. Write a short note on poultry farming.
7. How do you define animal husbandry? Mention the food items that are provided by these animals.
8. Write the names of causal organism and animals affected with the following diseases

   Foot and mouth disease

   Pox

   Tuberculosis

   Anthrax

   Rinderpest

## ANSWER TO INTEXT QUESTIONS

**20.1**

1. Substantial increase of new crop varieties of wheat and rice using large quantities of fertilizers, pesticides and good irrigation.
2. 'Sarbati Sonora' a very desirable variety of wheat produced by mutation Sonara-64 by radiations of x-rays and gamma rays.
3. Fertilizers are substances that are generally applied to the soil to promote healthy growth of plants.
4. Organic fertilizers are environmental friendly and improves and enriches the soil.

**20.2**

1. Disease resistant plants variety do not require pesticides thus the environment is saved from pollution, also money spent on purchase of pesticides is saved.

2. Combine harvesters – It harvests the crops as well as separates the grains from the ears (threshing)

   Ploughs- Turn the soil over which is very important to make the soil healthy and airy before sowing is done.

   Land levelers – After ploughing the soil is leveled before sowing is done.
3. Plants can be grown under different situations thereby extending the area of cultivation.
4. Mushroom culture, bee-keeping or apiculture, poultry farming are newer practices which bring money and creates employment.

**20.3**

1. The indigenous breeds of cows are Sahiwal, Tharparkar, Red Sindhi, Foreign breed are Jersey, Brown Swiss, Holstein-Friesian.
2. Low milk yield in our country is due to: poor quality feed, shortage of feed and fodder, low milk yielding indigenous breeds.
3. Foot and mouth causal organisms virus- Blisters on the mouth, foot, excessive production of saliva, loss of appetite, high temperature, shivering.

   Rinderpest causal organism Bacteria- Discharge from eyes, nostrils, loss of appetite, constipation followed by sever diarrhea.

   Anthrax causal organism Bacteria- Swelling of body, fever, reduction in milk secretion.

**20.4**

1. Indiscriminate use of hormones to increase milk production causes extreme enlargement of udders of the animals which results in difficulty of movement and discomfort to the animals.
2. Aquaculture is the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants. It is fish farming that is cultivating fish in a controlled environment (coastal or inland pond, lake, and reservoir) and harvesting when they reach desired size.
3. Over exploitation, habitat destruction, incidental mortality of non-target species, pollution.
4. Ecological aquaculture focuses on adequate farming system that preserves the aquatic environment in which they are suited and can be harvested in a sustainable manner.

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# 21

# CONCEPT OF SUSTAINABLE AGRICULTURE

Agriculture is the process of producing food, feed, fibre and other desired products by cultivation of certain plants and raising of domesticated animals. Agriculture has changed dramatically, especially since the end of World War II. Food and fibre productivity has increased by using new technologies, mechanization, increased use of fertilizers and pesticides and expansion of irrigation facilities. These changes allowed farmers with reduced labour demands to produce the majority of the food and fibre. Although these changes have had the positive effect of these practices have also caused some serious environmental and social problems such as erosion of top soil depletion and pollution of groundwater contamination, unemployment of farm labourers due to their replacement by increasing use of farm machinery in agriculture operations.

A growing movement has emerged during the past two decades to question the role of the agricultural establishment in promoting practices that contribute to these social problems. In view of the growing negative consequences of modern agriculture there is growing demand to promote "sustainable agriculture". Sustainable agriculture incorporates address many environmentally safe agricultural practices and offers innovative and economically viable opportunities for farmers, labourers, consumers etc., policymakers and many others in the entire food system.

## OBJECTIVES

After completing this lesson, you will be able to:

- *relate changing human needs with over use of environment;*
- *need for enhancing quality of environment;*
- *define sustainable agriculture and justify its need;*
- *describe concepts and methods of sustainable agriculture;*
- *explain about organic farming and its benefit;*

- *describe the method of preparing vermicompost;*
- *explain biofertilizers and their use in agriculture;*
- *explain Integrated Pest Management (IPM);*
- *explain GMOs and its related issues.*

## 21.1 HUMAN NEEDS AND OVER USE OF ENVIRONMENT

Urban populations are growing rapidly throughout the world and many cities in developing countries have become centres of poverty. Almost half of the world's people live in densely populated urban areas. Rural people migrate to urban areas in search of jobs, food, housing, a better life style, entertainment etc. Others move to cities because of poverty, lack of land to grow food and declining agricultural jobs etc. The proportion of global population living in urban areas is increasing and urban population is increasing rapidly in developing countries and poverty is becoming one of the major problem in urban areas as more poor people migrate to cities from villages. Biggest human need is, need for survival.

## 21.2 NEED FOR ENHANCING QUALITY OF ENVIRONMENT

The huge population puts a tremendous pressure on resources. The high rate of consumption of resources and high waste output. Large areas of forests and agricultural land are disturbed and degraded to provide urban dwellers with houses, food, water, energy for transport, minerals and other resources. As cities expand, they destroy rural crop land, fertile soil, forests, wet land and wild life habitats. At the same time, they provide little of the food they use. From the point of view of environment, the cities are like giant vacuum cleaners, sucking up all the resources and giving out pollution, wastes and heat.

There is great need to improve the situation so that human beings enjoy a good quality environment. We do deserve a healthy environment to survive and lead a good life.

## 21.3 SUSTAINABLE AGRICULTURE

Sustainable agriculture is that form of agriculture which attempts to produce sufficient food to meet the needs of present day population without exhausting soil fertility and irreversibly damaging the environment. Sustainable farming systems are those that are least toxic and least energy intensive and yet maintain productivity and profitability i.e. low input agriculture or organic farming.

Thus, sustainable agriculture is one that,

- supports profitable production;
- protects environmental quality;
- uses natural resources efficiently;
- provides consumers with affordable, high-quality products;
- decreases dependency on non-renewable resources;
- enhances the quality of life for farmers and rural communities;
- and will last for generations to come.

## INTEXT QUESTIONS 21.1

1. Define sustainable agriculture.

_____

2. Mention three advantages of sustainable agriculture.

_____

## 21.4 METHODS OF SUSTAINABLE AGRICULTURE

Sustainable production practices involve a variety of approaches. At the planning level one must take into account the local geography (topography), soil condition and nature, local climate, pests, local inputs and the farmer's goals. The grower (farmer) must then select appropriate practices. Several methods adopted in sustainable agriculture are:

- cultivation practices to increase biological and economic stability.
- selection of improved varieties to suit the need.
- soil management by proper method of tillage.

Many farmers in India and other developing countries follow the traditional practice of mixed cropping or diverse cropping and crop rotation.

(a) **Mixed cropping or diverse cropping**

It is an old practice in our country. Two or more crops are grown all at the same time in a field. If by chance one crop fails, the others crops cover the risk of total crop failure. Usually a long duration crop is grown with a short duration one so that both get sufficient nutrition at the time of maturity. Then water and nutrient requirement are also different.

Generally a leguminous crop is grown alongwith the main crop. Legumes helps to increase soil fertility by fixing atmospheric nitrogen. This saving the cost of chemical fertilizers.

The various plans followed in diverse or mixed cropping practices are-

- polyvarietal cultivation where several genetic varieties of the same crop are planted.
- intercropping where two or more different crops are grown at the same time on a plot like carbohydrate rich cereal that uses soil nitrogen and nitrogen fixing legume that puts back the nitrogen in the soil.
- polyculture, in which different plants maturing at various times are planted together. This practice has many advantages because fertilizer and water requirement of plants are different so there is less need of these inputs. Pests are controlled naturally because their natural predators find multiple habitats to survive. It has been found that this practice produces much higher yield per hectare compared to monoculture.

Large scale mechanization lead to the spread of *monoculture* i.e. only one crop variety is sown in the entire area when only one cultivator is planted in a large area. This system uses lot of fertilizer, pesticide, water. This practice may be productive for sometime but causes environmental and economic problems.

(b) **Crop rotation**

It is practice of growing different crops in regular succession in the same field. This practice controls insects and diseases, increases soil fertility and decreases soil erosion. Generally soil cannot sustain continuous cropping with high yielding single crop because certain nutrients required by the crop get exhausted totally while others remain unutilized leading to serious nutrients imbalance in soil and encouraging certain diseases and pests. Sowing a leguminous crops (eg. green gram) as a rotational crop is very useful because legumes enhance nitrogen level in the soil due to their ability to fix atmospheric nitrogen, reduces the need for chemical nitrogen fertilizer. Thereby cutting the cost and saving the soil from the harmful effects of using high yielding varieties alongwith the application of large amount of fertilizer, pesticides and water. It is possible to grow two or sometimes three different crops in succession on the same land within a year is known as **multiple cropping.** This practice can go on for sometime but the land cannot maintain high yield in the long run.

Crop rotation takes into amount the following factors:

(i) Leguminous crop should be grown after non-leguminous crop.

(ii) Crops require less water (irrigation) should be grown after one – that requires more water.

(iii) Crops requiring less manure should be sown after one that requires more manure.

**Important crop patterns of crop rotation**

1. Green gram - Wheat – Moong
2. Ground nut – Wheat – Moong
3. Arhar – Sugarcane – Wheat – Moong
4. Paddy – Wheat – Moong

Optimum diversity may be obtained by integrating both crops and livestock in the same farming operation. Mixed crop alongwith livestock operations have several advantages. First, growing crops only on more level land and pastures or forages on steeper slopes will reduce soil erosion. Second, pasture and leguminous forage crops in rotation enhance soil quality and reduce erosion; livestock manure, in turn, contributes to soil fertility. Third, livestock can buffer the negative impacts of low rainfall periods by consuming crop residue that in "plant only" systems would have been considered crop failures. Finally, feeding and marketing are flexible in animal production systems. This can help cushion farmers against price fluctuations and, make more efficient use of farm labour.

**Soil Management:** A healthy soil is a key component of sustainable agriculture. That is healthy soil along with water and nutrients produces healthy crop plants that are less susceptible to pests and diseases. Accordingly, soil must be protected and nurtured to ensure long term productivity and stability. Methods of protection include using cover crops, compost, reducing tillage, conserving soil moisture by dead mulches, this increases water hold capacity of the soil.

Varietal improvement with limited land at our disposal, we have to increase production of food grains, fodder, sugar, oil, fibers, fruits and vegetables. One of the most important method to do that is to improve the existing varieties of plants by the application of genetics and plant breeding and related sciences. Significant improvement in crop production has been achieved by using the conventional methods of selection and plant breeding.

Some of the objectives of varietal improvement are:

(i) development of high yielding varieties of crop plants.

(ii) food crops developed for better and higher nutritional quality like protein quality in pulses, baking quality in wheat, preserving quality in fruits and vegetables, oil quality in oil seed producing plants.

(iii) development of crop varieties resistance to diseases and pests.

(iv) improving varieties for resistance against heat, cold, frost, draught and water logging.

## 21.5 BIO-FERTILIZERS AND THEIR USE IN AGRICULTURE

For a sustainable agriculture system, it is essential to use renewable inputs (fertilizer, pesticides, water etc.) which can benefit the plant and cause no or minimal damage to the environment. One possible way is to reduce the use of chemical fertilizers and pesticides.

One of the energy efficient and pollution free method is to exploit the ability of certain microorganisms like bacteria, algae and fungi to fix atmospheric nitrogen, solubilize phosphorus, decompose organic material or oxidize sulphur in the soil. When they are applied in the soil, they enhance growth and yield of crops, improve soil fertility and reduces pollution. They are known as "bio fertilizers". Thus bio-fertilizers are living or biologically active products or microbial inoculants of bacteria, algae and fungi (separately or in combination) which are able to enrich the soil with nitrogen, phosphorus, organic matter etc.

### 21.5.1 Important bio fertilizers

Following are some of the important types of bio fertilizers which can be considered for agro based industries.

- **Rhizobium biofertilizer:** *Rhizobium* is a symbiotic bacteria forming root nodules in legume plants. These nodules act as miniature nitrogen production factories in the fields. The nodule bacteria fix more nitrogen ($N_2$) than needed by legume plant and the bacteria. The surplus fixed nitrogen is then secreted and fertilizes the soil. Rhizobium is more efficient than-free living nitrogen-fixing bacteria and can fix upto 200 kg N/ha/yr.
- **Azotobacter biofertilizer:** Azobacter are aerobic free living nitrogen fixers. They grow in the rhizosphere (around the roots) and fix atmospheric nitrogen non-symbiotically and make it available to the particular cereals. These bacteria produce growth promoting hormones which helps in enhancing growth and yield of the plant.
- **Azospirillium biofertilizer:** These are aerobic free living nitrogen fixers which live in associative symbiosis. In this type of association bacteria live on the root surface of the host plant and do not form any nodule with roots of grasses. It increases crop yield and its inoculation benefits crop. They also benefit the host plants by supplying growth hormones and vitamins. These bacteria are commonly used for the preparation of commercial inoculants.
- **Blue green algae:** Blue green algae (BGA or cyanobacteria) like *Nostoc* and *Anabaena* are free living phostosynthetic organisms also capable of fixing atmospheric nitrogen. In the flooded rice fields blue green algae serves as a nitrogen biofertilizer.
- ***Azolla biofertilizers:*** *Azolla* is a water fern inside which grows the nitrogen fixing blue green algae *Anabaena*. It contains 2-3% nitrogen when wet and also produces organic matter in the soil. The *Azolla-Anabaena* combination type biofertilizer is used all over the world. This can be grown in a cooler regions. But there is a need to develop a strain that can tolerant to high temperature, salinity and resistant to pests and diseases. Production technology is very easy and can be adopted by rice farmers. The only constraint in *Azolla* is that it is an aquatic plant and water becomes limiting factor in growing it particularly in summer.
- **Phosphorus solubilising biofertilizer:** Phosphorus is an important element required for plant growth. This element is also needed for nodulation by rhizobium. Some

microorganisms are capable of solubilizing immobilized phosphorus making it available to plants for absorption.

- ***Mycorrhizal*** fungi acts as biofertilizer are known to occur naturally on roots of forest trees and crop plants. In soils low in available nutrients there is an increased absorption of nutrients by plants infected with Mycorrhiza. The fungus has the ability to dissolve and absorb phosphorus that plant roots can not readily absorb.

A wise way will be to develop an integrated nutrient supply system involving the combination of chemical fertilizers and biofertilizers.

## INTEXT QUESTIONS 21.2

1. How does crop rotation practice improve soil quality?

   ______________________________________________

2. What is the difference between polyculture and multiple cropping?

   ______________________________________________

3. Define biofertilizers and give two important advantages of using it.

   ______________________________________________

4. What roles do Rhizobium and blue green algae play in agriculture?

   ______________________________________________

## 21.6 ORGANIC FARMING AND ITS BENEFITS

Organic farming is a type of agriculture or farming which avoids the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. Organic farming systems rely on crop rotation, crop residues, animal manures, legumes, green manure, off-farm organic wastes and biofertilizers, mechanical cultivation, mineral bearing rocks. To maintain soil productivity to supply plant nutrients and biological pest control, controlling weeds, insects and other pests. All kinds of agricultural products can be produced organically, including grains, meat, dairy, eggs, fibres such as cotton, jute, flowers etc. Thus organic farming creates a sustainable lifestyle for generations to come.

Organic farmers build healthy soils by nourishing the living component of the soil, the microbial inhabitants that release, transform, and transfer nutrients. Soil organic matter contributes to good soil structure and water-holding capacity. Organic farmers feed soil biota and build soil organic matter with cover crops, compost, and biologically based soil amendments. These produce healthy plants that are better able to resist disease and insect predation. Organic farmers' primary strategy in controlling pests and diseases is prevention through good plant nutrition and management. Organic farmers use cover crops and sophisticated crop rotations to change the field ecology, effectively disrupting habitat for weeds, insects, and disease organisms. Weeds are controlled through crop rotation, mechanical tillage, and hand-weeding, as well as through cover crops, mulches, flame weeding, and other management methods. Organic farmers rely on a diverse population of soil organisms, beneficial insects, and birds to keep pests in check. When pest populations get out of balance, growers implement a variety of strategies such as the use of insect predators, mating disruption, traps and barriers.

Some important benefits for organic farming and organic foods:

- Organic farming is a science in itself which can be learnt easily by any conventional farmer.
- It has been found that by switching to organic farming, conventional farmer can actually reduce its production cost by over 25% as compared to the cost of conventional farming. This is eliminate the use of expensive synthetic fertilizers and pesticides, minimizing soil erosion by up to 50% and increasing crop yields up to five-folds.
- A well planned transition strategy may allow conventional farmers to adopt new, more effective organic farming practices easily.
- Organic farms can support substantially higher levels of wildlife especially in low lands and where animals can roam in pastures or graze on grassland. Not only does wildlife benefit, but entire ecosystems and ground water are improved by simply following organic farming methods.
- Organic farming practices not only benefit farmers and consumers; but the dairies can benefit. When dairies feed their cows organic feed and graze them on organic fields, the cows experience better health, less sickness, diseases and ultimately produce better tasting milk for consumers.
- Organic farming promotes healthy soils that are teaming with life and rich in micro nutrients and which can be used for decades to grow crops without getting exhausted.
- Consumers purchasing organically grown foods are tastier. Regardless of minimal price differences, consumers can smell, taste and see the difference in the quality of organically grown food products.
- Organically grown products are free from harmful chemicals, artificial flavors and preservatives that ultimately cost consumers more money than non-organically grown products. You can always taste the difference between organically grown and conventionally grown products.

## 21.7 VERMICOMPOST

Vermicomposting is an appropriate technique for efficient recycling of animal wastes, crop residues and agro-industrial wastes. The process of conversion of organic materials into manure is chiefly microbiological. Earthworms are important for producing vermicompost from organic wastes.

Vermicompost can be prepared from all sorts of organic residues. Examples:

- Agricultural residues
  - dry organic wastes (like sorghum straw, rice straw after feeding cattle, dry leaves, pigeon pea residues, groundnut husk and wheat husk)
  - waste vegetables
  - soybean residues
  - weeds (particularly *Parthenium hysterophorus*, also called Vayyaribhama or Pander full or Congress weed, before flowering)
  - sugarcane trash
- Sericultural residues from silk production
- Animal manures
- Dairy and poultry wastes
- Food industry wastes
- Municipal solid wastes
- Biogas sludge
- Bagasse from sugarcane factories

### 21.7.1 Steps in Making Vermicompost

| | |
|---|---|
| **Step 1:** | Cover the bottom of the cement ring with a polythene sheet. (Or use the sheet to cover the ground of the area you're using). |
| **Step 2:** | Spread a layer (15-20 cm) of organic waste on top of the sheet. |
| **Step 3:** | Sprinkle rock phosphate on top of the organic material (2kg). |
| **Step 4:** | Prepare cow dung slurry (15kg) and add the slurry as a layer on top of the mixture. |
| **Step 5:** | Fill the ring completely and evenly with the layered material. |
| **Step 6:** | Paste cow dung or soil over the top of the material. |
| **Step 7:** | Allow the material to decompose for 20 days. After 20 days, put the earthworms on top. They will find the cracks and enter the material. |
| **Step 8:** | Cover the ring with wire mesh or gunny bags to prevent birds from eating the worms. |
| **Step 9:** | Sprinkle water over the whole mixture at 3-day intervals for 2 months, to maintain adequate moisture and body temperature of the worms. ***Note: when the compost is ready, it is black, quite lightweight and has a pleasant, earthy smell.*** |
| **Step 10:** | After 2 months, (or when the compost is ready), remove the ring and heap the material in a cone shape on the floor. Leave the heap undisturbed for 2-3 hours, to let the worms move slowly to the bottom. |
| **Step 11:** | Separate the upper portion of the heap. |
| **Step 12:** | Sieve the lower portion of the heap to separate the worms. They can be used again for preparation of more vermicompost. |
| **Step 13:** | Pack the compost in bags and store them in a cool place. |

## 21.8 INTEGRATED PEST MANAGEMENT (IPM)

The most sustainable way to control pests is a carefully designed integrated pest management (IPM) program. In this approach, each crop and its pests are evaluated as parts of an ecological system. Then farmers develop a control programe that includes cultivation, biological and chemical methods applied in proper sequence and with the proper timing.

The aim of IPM is not to eradicate the pest population completely but to keep the crop damage to economically tolerable level.

Farmers monitor the field and when they find the pest level to be high enough, they first use biological methods and cultivation practices to control and then use small amounts of insecticides mostly insecticides derived from plants as a last resort.

(a) **Biological control includes**

Natural predators, parasites and pathogens of the pests are used. Examples are:

- Pest on cucumber plant called red spider mite is controlled by using a predatory mite that feed on red spider mite.
- Citrus fruits in California heavily damaged by scale insects which were controlled by Australian ladybird which ate away the insects.
- Mealy bug pest of Cassava plant were controlled by a parasitoid wasp which was its natural enemy.
- Hormones are used that disrupt the insects normal life cycle, thereby preventing it from reaching maturity and reproducing and multiplying.

(b) **Cultivation practices**

A variety of cultivation practices like crop rotation, polyculture and inter cropping etc. can be used to get rid of the pests. This has been discussed in details earlier in this lesson.

(c) Some amounts of insecticides, mostly of plant origin (e.g. Pyrethrum and Rotenone neem product) are applied as a last resort.

(d) Pest and disease resistant crop plants can be produced by genetic engineering. Example is $B_t$ cotton, insecticidal for bacterial gene (*Bacilus thuringinesis*) introduced into cotton plant making cotton plant resistant to pest.

Like any other form of pest control method has some disadvantages:

- Farmer should have an expert knowledge about each pest.

- It acts more slowly than conventional pesticides.
- Methods developed for a crop in one area might not apply to areas with even slightest different growing conditions.
- Initial cost may be higher but in the long-term cost become very low.

## 21.9 BIOTECHNOLOGY AND MODERN AGRICULTURE

With conventional breeding practices reached their saturation point, the "gene revolution" seems to hold lot of potential. Agricultural biotechnology or gene technology or genetic engineering may act as the second "green revolution" that can be used to create high-yielding crop varieties that are: (i) herbicide tolerant, (ii) insect resistant, (iii) resistant to pathogens like virus, bacteria and fungi (iv) have better nutritional value and other commercial properties. The crop plants produced by these techniques are called "transgenics" or genetically modified (GM) plants or genetically modified organisms (GMOs).

By using the technique of genetic engineering it has been possible to genetically transform large number of agricultural and ornamental crops. Transgenics have been produced with the following aims:

- Crop resistance to herbicides.
- Crop resistance to insects and diseases.
- Atmospheric nitrogen fixation by cereal crops.
- Tolerance to high salt soils and to flooding in crops.
- Drought resistance in crops.
- Improving nutritional quality of crops.
- Prolonging shelf life of fruits and vegetables.

Some important examples of transgenics or GMOs are:

1. $B_t$ cotton produced by incorporating $B_t$ gene which encodes for BT toxin (insecticidal protein in *Bacillus thuringiensis*) in the cotton plant. The plant becomes insect resistant and this gene has been incorporated in corn, potato, tomato, tobacco etc. making them insect resistant (bio pesticides). Such plants can reduce our dependence on chemical pesticides which will save us money and our environment.
2. "Golden Rice" a transgenic with enhanced vitamin A content producing nutritionally rich rice to save many lives. Salt and flood tolerance genes have been incorporated in rice so that $B_t$ rice in China shows higher yield and a huge reduction in pesticide use. Such rice can be grown on saline soil.
3. By slowing down and controlling ripening in tomato by introducing a bacterial gene that prevents ethylene formation thus delaying ripening. Such tomatoes are easy to handle during transportation and remains on the shelf for a long time.

4. Cold damage to crop plants can be minimized by introducing genes for antifreeze proteins (AFPs) found in the blood of artic fishes. Frost resistant tomatoes have been produced by introducing gene for antifreeze proteins from polar fish living in ice water.

Plant biotechnology can help to make intensive agriculture less damaging to the environment as well as help the country to spend less money on fertilizers, pesticides, herbicides etc.

### 21.9.1 Benefits and controversies on GM products

(a) **Benefits**

(i) **Crops**

- Enhanced taste and quality.
- Reduced maturation time.
- Increased nutrients, yields, and stress tolerance.
- Improved resistance to disease, pests, and herbicides.
- New products and growing techniques.

(ii) **Animals**

- Increased resistance, productivity, hardness, and feed efficiency.
- Better yields of meat, eggs, and milk.
- Improved animal health and diagnostic methods.

(iii) **Environment**

- “Friendly” bioherbicides and bioinsecticides.
- Conservation of soil, water and energy.
- Bioprocessing for forestry products.
- Better natural waste management.
- More efficient processing.

(iv) **Society**

- Increased food security for growing populations.

(b) **Controversies**

(i) **Safety**

- Potential human health impact: allergens, transfer of antibiotic resistance markers, unknown effects.
- Potential environmental impact: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity

(ii) **Access and intellectual property**

- Domination of world food production by a few companies.
- Increasing dependence on industralized nations by developing countries.
- Biopiracy—foreign exploitation of natural resources.

(iii) **Ethics**

- Violation of natural organisms' intrinsic values.
- Tampering with nature by mixing genes among species.
- Objections to transferring animal genes in plants and vice versa.
- Stress for animal.

(iv) **Labeling**

- Not mandatory in some countries (e.g. United States).
- Mixing GM crops with non-GM confounds labeling attempts.

(v) **Society**

- New advances may be skewed to interests of rich countries.

## INTEXT QUESTIONS 21.4

1. Mention two important agricultural inputs which are avoided in organic farming?

______________________________

2. What is IPM and what is its aim?

______________________________

3. What types of improved crop varieties can be produced by gene transfer technology?

______________________________

4. What is "Golden Rice"?

______________________________

## WHAT YOU HAVE LEARNT

- Sustainable agriculture systems are those that are least toxic and least energy consuming, yet maintain productivity and profitability.
- Agricultural practices like crop rotation, inter cropping, polyculture and proper soil management with mulches and cover crops to maintain soil moisture are integral part of sustainable agriculture.
- Biofertilizers are plant nutrients of biological origin like algae, bacteria, fungi which have no harmful effect on soil and environment.

- Organic farming is a type of agriculture which avoids synthetic inorganic fertilizers, pesticides, growth regulators and livestock feed additives.
- Organically grown food products are free from harmful chemicals, or typical flavours and preservatives.
- Vermicompost can be prepared at the backyard of your home, in one corner to your school field or may be public park which will produce manure as well as clean up the environment from garbage accumulation.
- Integrated Pest Management (IPM) is a grand idea to control pest and diseases. This increases production, sakes the environment from pollution and harmful effects of pesticides and saves money which is usually spent on buying pesticides.
- Biotechnology technique is used to produce plants by gene transfer (transgenics) which can be a direct answer to grow plants resistant to diseases, pests, tolerant to cold draught and flooding etc. One can design a plant to suit this condition.

## TERMINAL EXERCISE

1. Define sustainable agriculture and justify its need.
2. What are the two most important effects of increase in population in the cities?
3. Why do you need to improve the existing varieties of plants (give any three reasons)?
4. Mention any four types of crops that one can produce applying gene transfer technology.
5. Explain the aim and objectives of the process of IPM.
6. What are GMOs? Explain briefly giving any two examples.
7. What is biological control of pests?
8. Which are the two most important items which are applied generously in normal agriculture that are avoided in organic farming?
9. How do blue green algae help in agriculture?
10. Define biofertilizer and their uses in agriculture..

## ANSWER TO INTEXT QUESTIONS

**21.1**

1. Sustainable agriculture and farming systems are those that are least toxic and least energy intensive and yet maintain productivity and profitability.
2. Sustainable agriculture is helpful to environment because (i) it protects environment quality, (ii) uses natural resources efficiently, (iii) decreases dependency on non-renewable resources.

**21.2**

1. Crop rotation practice increases soil fertility by growing legume as a rotational crop, decreases soil erosion, controls pests and diseases.

2. Polyculture is the practice of growing plants simultaneously on a piece of land which mature at various times.

   Multiple cropping is growing two or sometimes three different crops in succession on the same land within a year.

3. Biofertilizers are plant nutrients of biological origin like algae, bacteria, fungi which have no harmful effect on soil and environment.

   **Advantages**

   A large amount of money can be saved by reduced the purchase and production of chemical fertilizers, human health can be saved from harmful effects of chemical fertilizers.

4. Rhizobium a symbiotic bacteria live in the root nodules of legume plants and fix atmospheric nitrogen and ultimately make the soil rich in nitrogen which is very essential for plant growth. Blue green algae (BGA) fix atmospheric nitrogen in their special cells called heterocysts and ultimately provide nitrogen to the soil. Both Rhizobium and BGA act as biofertilizers.

**21.3**

1. Two important agricultural inputs which are avoided in organic farming are Chemical fertilizers and pesticides.

2. IPM is Integrated Pest Management, which avoids harmful chemical pesticides and use biological methods and agricultural practices to get rid of the pests.

   Its aim not to eradicate the pests completely but to keep them at economically tolerable level.

3. Gene transfer technology can produce crops:

   - Resistant to herbicides and pesticides.
   - Resistant to insects and diseases.
   - Tolerant to high salt in the soil.
   - With improved nutritional quality.
   - Prolonging shelf life.

4. "Golden Rice" is a transgenic rice with enhanced vitamin A content.

# 22

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# CLEANER TECHNOLOGIES

Industrial revolution resulted in the production of a large number of goods and services for the convenience of people. Life became much easier and comfortable. But large scale industrial production resulted in accumulation of huge amounts of wastes, which in turn created pollution of air, water, land and adversely affected plant and animal life. The environment of earth is loaded with wastes much beyond its carrying capacity. The volume of waste and out of service goods and gagets over loaded and pollution must be controlled in order to provide a healthy environment for man and other animals.

Now there is growing context to apply scientific knowledge and methods to develop "cleaner technologies" so that the natural resources and energy are used efficiently and in such a way waste generation can be minimized that the environment is protected from harmful effects of resulting pollution. Industries are engaged in evolving cleaner technology or eco-friendly technology based on improved manufacturing methods that require less raw materials and energy to produce more and even better quality goods and services. Cleaner technology use raw material efficiently and reduce the quality and quantity of waste itself.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define waste and describe the methods for reducing, recycling and reusing waste;*
- *explain type of waste found in the surroundings;*
- *define waste management;*
- *explain the methods of safe disposal of nuclear wastes;*
- *cite examples of nuclear hazards and identify their causes, prevention and control;*
- *explain the concept of cleaner technologies;*
- *describe the concept of life cycle analysis;*
- *explain the concept of eco-mark.*

## 22.1 TYPES OF WASTES

Waste is an unwanted or discarded material that can not be used in its present form. Waste can be classified into the following categories:

(1) **Industrial solid waste**

The major producers of solid waste are:

- Thermal power plants producing coal ash/ fly ash;
- The integrated iron and steel mills producing blast furnace slag;
- Non-ferrous industries like aluminium, copper and zinc producing red mud and tailings;
- Sugar industries generating press mud;
- Pulp and paper industries producing lime mud;
- Fertilizer and allied industries producing gypsum;
- Hospitals producing bio-medical waste.

(2) **The major producers of liquid effluents**

1. Cement
2. Thermal power plants
3. Iron and steel
4. Fertilizer
5. Zinc smelters
6. Copper smelters
7. Aluminium smelters
8. Oil refineries
9. Distilleries
10. Pulp and Paper
11. Pharmaceuticals

12- Dyes and dye intermediates

13. Pesticides
14. Petrochemicals
15. Tanneries
16. Sugar and
17. Basic drugs

(3) **Municipal solid waste**

Vegetable rejects from domestic units and vegetable markets, plastic material, building debris ,bio-medical waste etc.

(4) **Industrial liquid waste**

There is hardly an industrial process that does not generate liquid effluents. Often these are discharged into the rivers or streams without any treatment. As a result, these effluents pollute river that adversely affects aquatic life and the river ecology. The industrial waste waters often contain valuable materials that can be recovered. This approach improves quality of effluent discharged into the river on one hand fetches additional income to the industry on the other hand. As an example, the recoverable material from industrial waste waters of different industries are given below:

| **Industry** | **Recoverable matter** |
|---|---|
| Pulp and paper | Ligno-sulphate, sodium salts |
| Textile | Caustic soda |
| Distillery | Potassium salts, yeast |
| Fertilizer (phosphatic) | Calcium sulphate, fluoride |
| Coke oven | Ammonia, ammonium sulphate, tar, naphthalene, phenol |

(5) **Municipal liquid waste**

Sewage from hotels and residential colonies.

(6) **Gaseous waste**

Various gases are emitted from industrial installations that have potential use but are not being utilized. For example, Oil and Natural Gas Commission (ONGC) is flaring gas worth Rs 750 crores per annum. This can be converted into methanol and petrol. Carbon dioxide emitted from various sources can be used to produce calcium carbonate. Sulphur dioxide emitted can be converted into either elemental sulphur or gypsum. Waste heat from hot gaseous emissions can be recovered for suitable use.

(7) **Radio-active waste**

Most of such waste is generated from nuclear power plants. The waste is highly hazardous to living animals and hence needs careful planning for its disposal and treatment.

Wastes are divided into the following two categories according to their hazard potential:

(i) **Hazardous waste:** These belong to a special category of wastes containing certain chemicals, metals, and pathogenic organisms that can cause serious health problems and damage to the environment even at low concentration. Indiscriminate disposal of these wastes into environment without proper treatment could lead to complex hazardous pollution of river water, land and ground water resources.

(ii) **Non-hazardous waste:** All other wastes which are not covered under the hazardous category are included in this group.

## 22.2 CONCEPT OF CLEANER TECHNOLOGIES

Generation of enourmous amounts of wastes has caused alarming situation threating human wellbeing. Cleaner technology is using technology in industries in such a way that environment is protected from harmful effects of waste accumutation and the resulting pollution. This led environmentalists, scientists and technologists to think seriously about cleaning the environment by reducing industrial and other types of wastes. The aim is to make industrial manufacturing processes cleaner and more sustainable by redesigning them taking clues from nature, that is, how nature deals with wastes. In nature, waste or the left over of one organism becomes food of another organism, so that nutrients of the earth are endlessly recycled.

- One way to emulate nature is to recycle and reuse the chemicals used in industries instead of dumping them into the environment.
- Industries may interact in such a way that they establish a "resource exchange" programme in which waste of one industry or manufacturer is utilized as raw material by another-industry- similar to food web in nature.
- Use of CNG by automobiles instead of petrol, as an automobile fuel, is an example of cleaner technology which has reduced pollution of the environment.
- Instead of throw away economy which creates huge amount of waste, the manufacturers can make more money if their product is redesigned so that it uses minimum amount of raw materials lasts longer, easy to maintain, repair, remanufacture, reuse or recycle e.g. 'Carrier' a leading manufacturer of air-conditioning equipments are very efficient, easy to repair, remanufacture and recycle.
- Detoxifying hazardous wastes by chemical and biological methods to reduce their toxicity.
- Bioremediation is the process in which a living organism (plant/animal/bacteria) is deployed to make a hazardous wastes harmless. For example bacteria and enzymes help to destroy toxic and hazardous substances or convert them in harmless compounds.

Various plants have been identified which can help to clean up soil and water contaminated with chemicals such as pesticides, organic solvents, radioactive matter and toxic metals such as lead, mercury and arsenic.

The concept of **cleaner technology** is being practiced in different parts of the world under various names such as low and non-waste technologies, environmentally sound technologies, waste recycling, residue utilization and resource recovery technologies.

However ultimate cleaner technologies will be based on renewable resources as raw material and energy and transformation through highly efficient biotechnologies to produce environmentally harmless products.

## INTEXT QUESTIONS 22.1

1. Name the six categories of waste found in the surroundings.

2. State the various ways the gaseous wastes can be used up.

3. Define cleaner technology.

4. What is "throw away" economy? How is it responsible for accumulating waste?

## 22.3 WASTE MANAGEMENT

The following section describes about waste management methods:

**What is waste management**

Waste management deals wth tackling or managing the waste after it is produced. Lot of effort has to be used in managing the waste, the easiest solution being it or burn it.

However, the prime aim should be to reduce production of waste. Waste reduction deals with the problem before the waste is produced rather than managing it after it has been produced.

Thus our priorities to tackle the problem of waste management should be in the order as shown below:

| First Priority | Second priority | Last Priority |
|---|---|---|
| Waste Prevention | Reuse and Recycle | Waste management |
| • Change in manufacturing process to stop production of harmful chemicals.<br>• Useless of harmful resources or materials<br>• Reduce packaging materials in products<br>• Make products that last longer and are easy to repair. | • Reuse products<br>• Repair products<br>• Recycle<br>• Compost (biodegradable)<br>• Reassembled/recyclable products | • Treat waste material to reduce toxicity<br>• Bury waste in land fills.<br>• Incinerate waste<br>• Release waste into the environment for dispersal and dilution. |

The three Rs strategy of waste management involves **reduce, reuse and recycle.**

## 22.4 METHODS FOR REDUCING, RECYCLING AND REUSE OF WASTES

(a) **Reducing**

Reducing consumption and redesigning the product (s) are the best ways to cut waste production.

Some of the ways to reduce resource use are:

- consume less, do not buy unless you absolutely need it.
- redesign manufacturing processes and products to use less material and energy. Example- Fuel efficient cars which will give more milage using fuel.
- redesign manufacturing processes to minimise waste for examples –use of hydrogen peroxide instead of toxic chlorine to bleach paper in the manufacturing process reduces.
- develop products that are easy to repair, reuse,recycle.
- design products which last longer like car tiers which runs for longer distances before they get damaged.
- reduce or get rid of unnecessary packaging or use reusable packaging and recyclable packaging.

(b) **Reuse**

Reuse of products is an important way to reduce resource use, reduce pollution and waste. Reuse means cleaning and using the materials over and over, thereby extending the life span of the products.

- This form of waste reduction reduces the use of material and energy resources, cuts pollution and waste, creates local jobs and saves money, for example recovering automobile parts from old cars in junkyards, recovering and collecting bricks, doors, fine wood works and steel from old houses and reusing them for new constructions.
- In India we had a tradition of using cloths napkins, glass and metal utensils but gradually throw away tissues are substituted for reusable handkerchiefs, disposable paper towels and napkins for reusable cloth ones; throw away paper plates, cups and plastic ones for reusable plates, cups and metal utensils. We are using lot of aluminium foil and plastic bags. We must get back to our good old habit of using more of cotton, jute and metals in our daily life. This will surely reduce the load of garbage.
- While reusing the products, care must be taken to protect the health of people dealing with such objects. For example discarded TV sets, computers and cell phones are dismantled to recover usable parts and in the process one can get exposed to toxic metals like mercury, cadmium and lead. The remaining scrap is dumped in open fields or burned in the open which exposes the workers to toxic fumes of dioxins.

(c) **Recycling**

Recycling is an important way to collect waste material and turn them into useful products that can be sold and used again.

- Recycling involves reprocessing of discarded materials into new useful products. Some common examples are recycled paper products (newspapers, magazines, office and school papers, cardboards), glass, aluminum, steel and some types of plastics.

- Biodegradable organic wastes (kitchen and other biological wastes) can be decomposed by microorganisms and worms and converted into composts which are returned to the soil as manure.
- Primary recycling occurs when waste is recycled into new products of the same type like turning old newspaper into new newspaper material, used aluminum cans into new aluminum cans, waste plastic bags into useful waste collection plastic bags.
- Secondary recycling occurs when waste materials are converted into different products. For example used automobile tyres can be shredded and turned into material to be used as rubberized road surfacing and newspaper can be turned into cellulose insulation, short fibres from paper pulp industry can be converted into paper boards.

## INTEXT QUESTIONS 22.2

1. What should be our priority in tackling waste management?
2. What are the three Rs in waste management?
3. Give examples of primary and secondary recycling.
4. What is fuel efficient car? How does it save resources?

## 22.5 NUCLEAR HAZARDS, THEIR CAUSES, PREVENTION AND CONTROL

Before discussing nuclear hazards, must know about radiation and radioactive materials. Radiation is a form of energy which is produced when the nucleus of an atom is broken apart called fission producing heat and radiation. Nuclear power plants use this heat to turn water into steam. Steam turns the turbine to produce electricity.

Any radiation and any radioactive materials produced during the fission process are considered as waste products. Radiation emitted natural sources is known as **"background radiation",** because it is present everywhere, all the time. Radioactive atoms are known as "radionuclides".

Water acts as a natural barrier to radiation and can be used to isolate radioactive spent nuclear fuel at nuclear power plants.

Nuclear hazards or risk and dangers are associated with each step of the nuclear "fuel cycle" "as shown in the fig. (22.1) below.

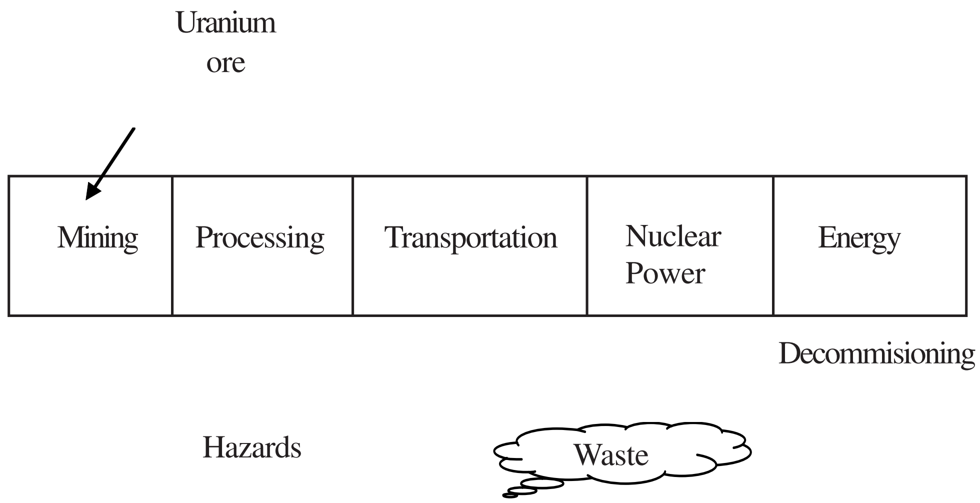


***Fig. 22.1:*** *Fuel cycle*

**Nuclear "fuel cycle" begins with**

- Mining of uranium ore from the underground mines.
- The ore is then crushed (milled) into sand and then concentrated using a solvent to produce "yellow cake".
- It is then sent to a factory where it is turned into fuel "pellets" which are packed into rods.
- The rods are inserted in the core of a reactor, which undergoes nuclear reaction under controlled conditions to avoid explosion.
- The reaction (fission) produces tremendous heat, which boils water to make steam, the steam turns a turbine to produce electricity.

Each step of the 'fuel cycle', (mining, processing, transportation, nuclear power and energy production) poses a potential threat or hazard which is dangerous for life on earth.

Apart from heat, many new radioactive elements (Stronsium-90 and Plutonium-239) are also produced. These are unwanted and dangerous by products or **"radioactive waste".**

Uranium ore and mill waste remain heaped in deserts because there is no place to store them. They blow around with wind and wash with rain giving out radioactive gas for thousands of years in future.

People are concerned about the safety of nuclear power plants that are currently operating. Radiations can be released from them and nuclear contamination can occur at other points in the nuclear fuel cycle. The recent accidents have had a great effect on people's attitudes towards power plants safety.

1. Three Mile Island (USA) 1979
2. Chernobyl (Ukrin) 1986

**1. Three Mile Island (USA) 1979**

Three Mile Island disaster occurred on 14th March, 1979. There was a breakdown of the main pump. The other auxiliary pumps failed to operate and electricity generating turbine stopped. At this point of time emergency coolant should have flooded the reactor to bring down the temperature. The coolant did start to flow but did not cooled the reactor but the faulty meter showed it otherwise. The high temperature resulted in core melt down and radioactive steam was thrown into the atmosphere. This was a nuclear disaster. Pregnant women and children were removed from the accident site. It was over a year before anyone could enter the plant. The damaged reactor was eventually defuelled in 1990 and the situation will be monitored till 2010.

**2. Chernobyl (Ukrain) 1986**

Chernobyl (Ukrain) on 25 April 1986 a test was being conducted to measure the amount of electricity that would be produced even if the steam was shut off but the turbine would still be spinning. To reduce the output of steam, control rods were lowered into the core. To prevent further delay in testing, the cooling system was manually turned off. This was a serious safety violation. As the test or the experiment continued the energy level of the reactor increased two thousand times, the fuel rods broke and the cooling water turned into steam.

There was a huge explosion and the roof of the reactor ripped off the concrete roof of the reactor. Radioactive fumes spread around and this became the world's worst nuclear accident. People suffered radiation sickness and this increased their chances to suffer from leukemia (blood cancer). Chernobyl put 300-400 million people at risk in fifteen countries.

There is an increasing concern about the safety of nuclear reactors and there is an urgent need to develop ways and means to make nuclear generation safe and as a viable source of clean energy.

**Prevention and control**

At both Chernobyl and Three Mile Island, it was operators error by the (human error) that caused the disastrous accident when operators manually stopped normal safety actions from taking place. Mechanical designing of the reactor should be such that the reactors should get shut down immediately under such conditions.

Many new designs do have such shut down mechanism to prevent such disasters.

Huge amount of heat is generated in nuclear power plants, only one third of the heat is used in generating electricity and two third is lost as waste heat. To reduce the harmful effect of the waste heat, costly cooling facilities are constructed and operated. Nuclear power plants are often constructed close to a large water source like lakes, rivers, oceans from where large quantities of water can be drawn directly and returned after cooling process is over.

## 22.6 SAFE DISPOSAL OF NUCLEAR WASTES

When the world entered the atomic age, the problem or the dangers of disposal of nuclear waste were not fully realized. It is now becoming increasingly clear that safe disposal of nuclear waste is not easy and simple.

Radioactive wastes are of two types (1) low level radioactive wastes (LLW) which include civilian applications of radionuclides in medicine, research and industry, materials from decommissioned reactors, protection clothing worn by persons working with radioactive materials or working in nuclear establishments.

(2) High level radioactive wastes (HLW) results from spent nuclear fuel rods and obsolete nuclear weapons.

Some proposed methods of disposing nuclear waste are:

- bury it deep underground in insulated containers. This is a strategy being pursued in United States.
- shoot it into the space or into the sun. The cost would be very high and a launch accident should be disastrous.
- bury it under the ice sheet of Antarctica or Greenland ice cap. The ice could be destabilized by heat from the waste. The method has been prohibited by international law.
- dump it into deep oceans by keeping the waste into glass and steel cases. But the containers might leak and contaminate the ocean. Both HLW and LLW into the Atlantic ocean. The method is prohibited by international law. Until 1983, European countries had been dumping before 1983 when dumping was stopped, by law 90,000 metric tons waste had been disposed in the ocean.
- change it into harmless or less harmful isotopes. Currently no method is known to do that and the method would be too costly.
- presently waste fuel rods are being stored in special storage ponds at reactor sites or sent to reprocessing plants. Even though reprocessing is more expensive but some countries use reprocessing as an alternative to waste storage.

Thus safe disposal of nuclear waste is a matter of debate.

Potentially usable sites or locations where nuclear waste can be disposed off should have some characteristics like-

- low precipitation;
- deep water table;
- slow moving ground water;
- absence or near absence, of exploitable resources in the area;
- absence of surface waters;
- low possibility of tectonic movement;
- adequate buffer zone (in case the waste gets loose).

## INTEXT QUESTIONS 22.3

1. What is 'background radiation'?

______________________________

2. What is a radionuclide?

______________________________

3. What are the different steps of the fuel cycle?

______________________________

4. Name the two recent nuclear disasters and their consequences?

______________________________

5. Name three sites which can be used to dispose nuclear waste.

______________________________

## 22.7 LIFE CYCLE ANALYSIS OR LIFE CYCLE ASSESSMENT

Society has become concerned about issues of natural resources depletion and environment degradation. Many industries have started using "clean technology" processes to provide "greener" products. Thus environmental effects or impacts of products and processes have become a key issue, that is why some companies are trying to find out methods to minimize their efforts on the environment. Many industries are actually using pollution prevention methods to check and improve their environmental performance.

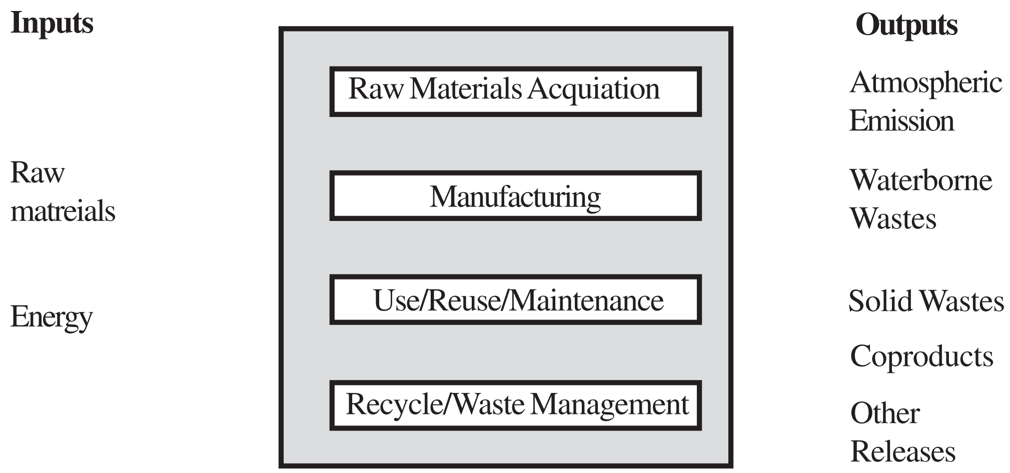


***Fig. 22.2:*** *Life Cycle Stages* (Source EPA 1993)

Life Cycle Assessment (LCA) is actually a concept which considers the entire life cycle of a product. In other words it is a "cradle to grave" approach for assessing industrial production systems. It actually involves all stages of life cycle of the product e.g. raw material extraction, material transportation manufacturing product use and disposal of out of service product etc. The term "life cycle" refers to the major activities in the course of products life span from acquiring the raw material to its manufacture, use, maintenance and final disposal.

Life Cycle Assessment (LCA) is done in a systematic manner:

1. Aim or goal i.e. define or describe the product, process or activity.
2. Inventory analysis i.e. identify and quality energy, water, material used and environmental releases (e.g. air emissions, solid waste disposal and waste water discharge)
3. Impact assessment i.e. assess the human and ecological effects of energy, water and material usage and the environmental releases identified in the inventory analysis.
4. Interpretation i.e. evaluate the results inventory analysis and impact assessment to select the preferred product or service.

**Benefits of conducting LCA**

- It helps the decision makers to select the product or process that results in the least impact to the environment.
- The LCA data identifies the transfer of environmental impacts from one media to another e.g. eliminating air emissions by chemical washing of gaseous emissions and discarding the pollutants as liquid effluents.
- Human and ecological effects of material consumption and environmental releases to air, water and land in relation to each state of the life stage can be assessed.

## 22.8 CONCEPT OF ECOLABELLING

Labeling of environmentally beneficial goods and resources extracted by more sustainable methods can help consumers decide which goods and services to buy product ecolabelling can encourage companies to develop green products and services and help consumers select more environmentally beneficial products and services. Eco-labels are also being used to certify that the fish bearing ecolabels were caught by using sustainable fishing methods and also for timber products to certify and trees were harvested in accordance with by sustainable forest management principles.

### 22.8.1 Objectives of ecolabelling

The main objectives of ecolabelling are as follows**-**

- Protecting the environment and to make consumers aware of environment issues.
- Encouraging efficient management of renewable resources to ensure their availability to future generations.
- Promoting efficient management of non-renewable resources, including fossil fuels.
- Encouraging protection of ecosystems and species diversity.
- Encouraging proper management of chemicals to prevent pollution .

### 22.8.2 Ecolabelling in India

Ecolabelling scheme of Government of India supports cleaner (environmentally friendly) production practices. There is strong emphasis on cleaner manufacturing processes in the criteria used for the granting Eco-labels to products. Presently the scheme is limited to household and some consumer products to meet certain environment criteria alongwith quality requirements of Indian standards. The label is known as **'Eco mark'.**

The products for which notifications have been issued for the criteria are: toilet soaps, detergents, paper, architectural points and laundry soaps.

Eco-label is issued by the Central Pollution Control Board (CPCB) is represented by a pitcher or an **'earthen pot'** indicating that the product is not harmful to the environment like as an earthen pot which is made of soil and after its use returned to it the soil. It is without causing any harmful effect on the environment.

## INTEXT QUESTIONS 22.4

1. What do you understand by life cycle of a product?

______________________________________________

2. What are the objectives of eco-labelling?

______________________________________________

3. What is the Indian ecolabel known as and what is the symbol?

______________________________________________

## WHAT YOU HAVE LEARNT

- 'Cleaner technology' is using technology in industries in such a way that environment is protected from harmful effects of waste accumulation and resulting pollution.
- Waste in our surroundings can be classified in various ways – industrial solid and liquid, municipal solid and liquid, gaseous and radioactive or hazardous and non hazardous
- Industries may interact in such a way that waste of one industry becomes the "raw material" of another.
- Product and process can be redesigned to save accumulation of waste.
- Waste management is reducing or minimize waste, reuse and recycle the waste to make use of the waste.
- The three Rs of waste management are reduce, reuse and recycle.
- Each step of the "fuel cycle" is associated with hazard or risk. The steps are mining, processing, transportation and nuclear power and energy.
- Two important nuclear disaster are Three Mile Island (USA) and Chernobyl (Ukrain).
- It is not possible to control the nuclear radiations once they spread out in the environment accidentally.
- Disposal of nuclear waste must be given serious thought.
- Some special locations or sites must be located for "safer" disposal of nuclear wastes.
- LCA is actually a concept which considers the entire life cycle of a product.
- The ecolabel is issued by Central Pollution Control Board (CPCB) is symbolized a kitchen or "an Earthern Pot" indicating that on life cycle analysis basis.

## TERMINAL EXERCISE

1. Define the term 'Cleaner Technology'. What is the main aim of management of this concept?
2. List the six major types of wastes generally produced?

3. Explain briefly the three 'R's of waste management.
4. Explain the following terms: (a) Throw away economy (b) Bioremediation (c) Ecolabelling (d) Ecomark
5. Give three examples by which waste production can be reduced by redesigning products or processes?
6. Explain the term primary recycling and secondary recycling. Give examples.
7. Briefly state the steps of 'fuel cycle' and the hazards that they cause.
8. Explain briefly the two nuclear disasters that took place in 1979 and 1986 with regard to causes, effects and preventive measures.
9. State five sites and locations where nuclear wastes can be disposed off.
10. Explain the concept of life cycle assessment of a product.

## ANSWER TO INTEXT QUESTIONS

**22.1**

1. Industrial solid and liquid; municipal solid and liquid; gaseous and radioactive waste are generally found in the surroundings.
2. Carbon dioxide emitted from various sources can be used to produce calcium carbonate; sulphur dioxide emitted can be converted into either elemental sulphur or gypsum. Gas from petroleum field can be converted into methanol and petrol.
3. Cleaner technology is using industry to produce products and goods with minimum or no waste and pollution production.
4. Throw away economy is using the products or goods once or partially and disposing it off as waste.

**22.2**

1. Waste prevention should be our priority rather than managing the waste once it has been produced.
2. The three Rs in waste management are waste reduction, reuse and recycle. Reducing consumption and redesigning products we can reduce waste. Reuse of products will reduce waste. Waste can be turned into useful products by recycling.
3. Primary recycling when the waste is recycled into new product of the same type like old newspapers are recycled to produce new newsprint material.

Secondary recycling occurs when the waste material is converted into different products like old automobile tyres are shredded and turned into materials to be used in rubberized road surfacing.

4. A fuel efficient car gives more milage with less petrol and hence valuable resource like petrol.

**22.3**

1. We receive large amount of radiation from natural sources. It is present everywhere, all the time. This radiation is known as background radiation.
2. Radioactive atoms are known as "radionuclide.".
3. Mining of the radioactive are, processing to make it enriched, transporting to factories to turn it to fuel pellets, nuclear reaction to produce nuclear energy.
4. Three Mile Island (USA) in 1979 and Chernobyl (Ukrain) 1986. People at the site of the disaster suffered immediately by getting exposed to high dose of radiation. Their chances of cancer increased. Effect of radiation spread out at far away places exposing people to the risks of cancer and other health hazards.
5. Sites with low precipitation, with deep water table and absence of surface water.

**22.4**

1. "Life cycle" of a product means major activities in the course of life span of a product that is acquiring the raw material to its manufacture, use, maintenance and final disposal.
2. • Protecting environment and make consumers aware of environmental issues.
   • Promoting efficient management of non-renewable resources including fossil fuel.
   • Encouraging protection of eco-systems and species diversity.
   • Encouraging management of resources so that they are protected for future generations.
   • Encouraging proper management of (non toxic chemicals) in products.
3. It is known as "Eco-mark" and the symbol is an "Earthen Pot". The earthen pot symbolizes biodegradable fully harmless material.

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# ENVIRONMENTAL LEGISLATION

The awareness and consideration for environment covers several environmental issues such as pollution of water, air and soil, land degradation, industrialization, urbanization, depletion of natural resources etc.

Environmental Law plays a very crucial and important role in regulating the use of natural resources and in protecting the environment. The success of environmental legislations mainly depends on the way they are enforced. Legislation also serves as a valuable tool for educating masses about their responsibility in maintaining healthy environment.

Numerous legislations have already been put forth at national and international levels. In this lesson, you will learn about some important environmental legislations. Indian legislations are called Acts where as the international legislations are in the form of conventions, protocols and treaties.

## OBJECTIVES

After completing this lesson, you will be able to:

- *describe the constitutional provision for environmental protection and conservation in India;*
- *list and describe the various Indian environmental laws along with their objectives;*
- *describe the various pollution related acts such as water, air and environment act;*
- *explain the various global conventions and their objectives in the field of environment.*

## 23.1 ENVIRONMENTAL LEGISLATION

The genesis of various legislations in the country lies in the environmental problems. There should be effective **legislations to protect the environment** or else the need for resources by the growing population will create havoc on the environment. The other important aspect is enforcement of these laws. To safeguard our environment from further degradation and pollution these must be enforce laws forcefully and effectively.

### 23.1.1 Need for legislation

In the recent past, numerous environmental problems have become threatening for human welfare. An important aspect of environmental problems is that their impact is not confined to the source area but spills over far and wide area.

Effective legislation is needed in order to prevent misuse and degradation of the environment. To curb the destructive practices of unscrupulous people, forest mafia groups, poachers, polluters and over exploitation of environmental resources, effective legislation is necessary. Pollution is an important factor and it does not observe political territories or legislative jurisdictions. Thus environmental problems are **intrinsically global** in nature. Therefore, to prevent such problems environmental legislation is not needed only at the national level but also at the international level.

## INTEXT QUESTIONS 23.1

1. Why is the need for legislation for solving environmental issues?

   ______________________________

2. Why is enforcement of legislation necessary?

   ______________________________

## 23.2 NATIONAL LEGISLATION

At national level serious efforts have been made for the improvement and protection of environment by incorporating changes the constitution of India. Our constitution, originally, did not contain any direct provision regarding the protection of natural environment. However, after the United Nations Conference on Human Environment, held in Stockholm in 1972. Indian constitution was amended to include protection of the environment as a constitutional mandate.

> Although India had an Elephant's Preservation Act of 1879 and a Forest Act of 1927, environment related legislation came very late in 1972 with Wild Life Protection Act 1971.
>
> As we all know, India is one of the twelve mega diversity countries. There are innumerable species, whose potential is not even known till date. Biodiversity has direct consumption value in agriculture, medicine and industry apart from it being a nations' wealth. There is constitutional provision in India for biodiversity conservation.

The forty second amendment Clause (g) to Article 51A of the Indian constitution made it a fundamental duty to protect and improve the natural environment.

"It shall to be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and have compassion for living creatures."

There is a directive, given to the State as one of the Directive Principles of State Policy regarding the protection and improvement of the environment. Article 48A states **"The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country".**

The department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985. This Ministry has overall responsibility for administering and enforcing environmental legislations and policies.

The constitutional provisions are backed by a number of legislations – **Acts and rules**. Most of our environmental legislations are Acts of the Parliament or the State Legislatures. These Acts generally delegate powers to regulating agencies, to make rules for the purpose of their implementation. The Environment Protection Act of 1986 (EPA) came into force soon after the Bhopal Gas Tragedy and is considered umbrella legislation as it fills many lacunae in the existing legislations. Thereafter, a large number of environmental legislations have been passed to deal with specific environmental problems. For example in the recent past the use of CNG for public transport vehicles has been made mandatory in Delhi. This has reduced air pollution in Delhi.

## INTEXT QUESTIONS 23.2

1. On which subject the United Nations conference was held in 1972?

2. Where this conference was held?

3. In which year was EPA passed?

4. Which fuel has been made mandatory for public transport vehicles in Delhi for reducing air pollution?

## 23.3 POLLUTION RELATED ACTS

Among all the components of the environment air and water are necessary to fulfill the basic survival needs of all organisms. So, to protect them from degradation the following acts have been passed.

- Water Acts
- Air Acts
- Environment Act

A few important legislations of each category with brief description are given below:

### 23.3.1 (i) The Water (Prevention and Control of Pollution) Act of 1974 and Amendment, 1988

The main objective of this act is to provide prevention and control of water pollution and maintaining or restoring of wholesomeness and purity of water (in the streams or wells or on land). Some important provisions of this Act are given below:

- The Act vests regulatory authority in State Pollution Control Boards and empowers these Boards to establish and enforce **effluent standards** for factories discharging pollutants into water bodies. A Central Pollution Control Board performs the same functions for Union Territories and formulate policies and coordinates activities of different State Boards.
- The State Pollution Control Boards control sewage and industrial effluent discharges by approving, rejecting or impose conditions while granting consent to discharge.
- The Act grants power to the Board to ensure compliance with the Act by including the power of entry for examination, testing of equipment and other purposes and power to take the sample for the purpose of analysis of water from any stream or well or sample of any sewage or trade effluents.
- Prior to its amendment in 1988, enforcement under the Water Act was achieved through criminal prosecutions initiated by the Boards, and through applications to magistrates for injunctions to restrain polluters. The 1988 amendment strengthened the Act's implementation the pollution provisions. Board may close a defaulting industrial plant or withdraw its supply of power or water by an administrative order; the penalties are more stringent, and a citizen's suit provision supports the enforcement machinery.

### (ii) The Water (Prevention and Control of Pollution) Cess Act of 1977

The Water Cess Act was passed to generate financial resources to meet expenses of the Central and State Pollution Boards. The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a cess (tax) for water effluent discharge. These revenues are used to implement the Water Act. The Central Government, after deducting the expenses of collection, pays the central board and the states such sums, as it seems necessary. To encourage capital investment in pollution control, the Act gives a polluter a 70% rebate of the applicable cess upon installing effluent treatment equipment.

### 23.3.2 The Air (Prevention and Control of Pollution) Act of 1981 and amendment, 1987

To implement the decisions taken at the United Nations Conference on the Human Environment held at Stockholm in June 1972, Parliament enacted the nationwide Air Act. The main objectives of this Act are to improve the quality of air and to prevent, control and abate air pollution in the country. Important provisions of this Act are given below:

- The Air Act's framework is similar to that of the Water Act of 1974. To enable an integrated approach to environmental problems, the Air Act expanded the authority of the central and state boards established under the Water Act, to include air pollution control.
- States not having water pollution boards were required to set up air pollution boards.
- Under the Air Act, all industries operating within designated air pollution control areas must obtain a "consent" (permit) from the State Boards.
- The states are required to prescribe emission standards for industry and automobiles after consulting the central board and noting its ambient air quality standards.
- Act granted power to the Board to ensure compliance with the Act including the power of entry for examination, testing of equipment and other purposes and power to take the sample for the purpose of analysis of air or emission from any chimney, fly ash or dust or any other outlet in such a manner as may be prescribed.
- Prior to its amendment in 1987, the Air Act was enforced through mild court-administered penalties on violations. The 1987 amendment strengthened the enforcement machinery and introduced stiffer penalties. Now, the boards may close down a defaulting industrial plant or may stop its supply of electricity or water. A board may also apply to the court to restrain emissions that exceed prescribed limits. Notably, the 1987 amendment introduced a citizen's suit provision into the Air Act and extended the Act to include noise pollution.

### 23.3.3 Environment Acts

The most important legislation in this category is The Environment (Protection) Act of 1986. Through this Act Central Government gets full power for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating pollution. Details of this Act are given below:

(i) **The Environment (Protection) Act of 1986**

In the wake of the Bhopal tragedy, the government of India enacted the Environment (Protection) Act of 1986. The purpose of the Act is to implement the decisions of the United Nations Conference on the Human Environment of 1972, in so far as they relate to the protection and improvement of the human environment and the prevention of hazards to human beings, other living creatures, plants and property. The Act is an "umbrella" for legislations designed to provide a framework for Central Government, coordination of the activities of various central and state authorities established under previous Acts, such as the Water Act and the Air Act.

In this Act, main emphasis is given to "Environment", defined to include water, air and land and the inter-relationships which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property. "Environmental pollution" is the presence of pollutant, defined as any solid, liquid or gaseous substance present in such a concentration as may be or may tend to be injurious to the environment.

"Hazardous substances" include any substance or preparation, which may cause harm to human beings, other living creatures, plants, microorganisms, property or the environment.

The main provisions of this Act are given below:

Section 3 (1) of the Act empowers the centre to "take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution". Specifically, the Central Government is authorized to set new national standards for the quality of the environment (ambient standards) as well as standards for controlling emissions and effluent discharges; to regulate industrial locations, to prescribe procedures for managing hazardous substances; to establish safeguards preventing accidents, and to collect and dismantle information regarding environmental pollution.

- By virtue of this Act, Central Government has armed itself with considerable powers which include, coordination of action by state, planning and execution of nation wide programmes, laying down environmental quality standards, specially those governing emission or discharge of environmental pollutants, placing restriction on the location of industries and so on.
- The coverage of powers include handling of hazardous substances, prevention of environmental accidents, inspection of polluting units, research, establishment of laboratories, dissemination of information, etc.
- The Environment (Protection) Act was the first environmental legislation to give the Central Government authority to issue direct orders, included orders to close, prohibit or regulate any industry, operation or process or to stop or regulate the supply of

electricity, water or any other service to an industry, operation and process. Another power granted to the Central Government was to ensure compliance with the Act which included the power of entry for examination, testing of equipment and other purposes and power to analyze the sample of air, water, soil or any other substance from any place.

- The Act explicitly prohibits discharges of environmental pollutants in excess of prescribed regulatory standards. There is also a specific prohibition against handling hazardous substances except those in compliance with regulatory procedures and standards. Persons responsible for discharge of pollutants in excess of prescribed standards must prevent or mitigate the pollution and must also to report the governmental authorities.
- The Act provides provision for penalties. Any person who fails to comply with any of the provisions of the Act, or the rules, orders, or directions issued under the Act shall be punished. For each failure or contravention the punishment included a prison term up to five years or fine up to Rs. 1 lakh, or both. The Act imposed an additional fine of up to Rs. 5,000 for every day of continuing violation. If a failure or contravention, occurs for more than one year after the date of conviction, an offender may punished with imprisonment term, which may be extend to seven years.
- The Environment (Protection) Act contains significant innovations for its enforcement, not contained in any other pollution control legislation at the time of the Act's adoption. Section 19 provides that any person, in addition to authorized government officials, may file a complaint with a court alleging an offence under the Act. This "Citizens' Suit" provision requires that the person has to give notice of not less than 60 days of the alleged offence of pollution to the Central Government or the competent authority. Under the Act, the Central Government may, by notification in the office Gazette, make rules for the enforcement of the Act.

## INTEXT QUESTIONS 23.3

1. Match the following:

| Column "A" | Column "B" |
|---|---|
| (i) 70% rebate of applicable cess upon installing effluent treatment equipment | (a) 1974 |
| (ii) The Air Act | (b) 1986 |
| (iii) The Environment Act | (c) the Water Cess Act, 1977 |
| (iv) The Water Act | (d) 1981 |

## 23.4 BIODIVERSITY RELATED ACTS

India is one of the few countries, which had a forest policy since 1984. To protect forest and wild life following legislations have been enacted.

### 23.4.1 The Wild Life (Protection) Act of 1972 and Amendment, 1982

In 1972, Parliament enacted the Wild Life Act (Protection) Act. The Wild Life Act provides for state wildlife advisory boards, regulations for hunting wild animals and birds, establishment of sanctuaries and national parks, regulations for trade in wild animals, animal products and trophies, and judicially imposed penalties for violating the Act. Harming endangered species listed in Schedule 1 of the Act is prohibited throughout India. Hunting species, like those requiring special protection (Schedule II), big game (Schedule III), and small game (Schedule IV), is regulated through licensing. A few species classified as vermin (Schedule V), may be hunted without restrictions. Wildlife wardens and their staff administer the act.

An amendment to the Act in 1982, introduced a provision permitting the capture and transportation of wild animals for the scientific management of animal population.

India is a signatory to the Convention of International Trade in Endangered Species of Fauna and Flora (CITES, 1976). Under this convention, export or import of endangered species and their products are governed by the conditions and stipulations laid down therein. Indian government has also started some conservation projects for individual endangered species like Hungal (1970), Lion (1972), Tiger (1973), Crocodiles (1974), Brown-antlered Deer (1981) and Elephant (1991-92).

(ii) **The Forest (Conservation) Act of 1980**

First Forest Act was enacted in 1927. This is one of the many surviving colonial legislations. It was enacted to consolidate the law related to forest, the transit of forest produce and the duty livable on timber and other forest produce. Subsequently, the Forest (Conservation) Act was promulgated in 1980 to make certain reforms over the preceding Act of 1927.The 1927 Act deals with the four categories of the forests, namely reserved forests, village forests, protected forests and private forests.

A state may declare forestlands or waste lands as reserved forest and may sell the produce from these forests. Any unauthorized felling of trees quarrying, grazing and hunting in reserved forests is punishable with a fine or imprisonment, or both reserved forests assigned to a village community are called **village forests**.

The state governments are empowered to designate protected forests and may prohibit the felling of trees, quarrying and the removal of forest produce from these forests. The preservation of protected forests is enforces through rules, licenses and criminal prosecutions. Forest officers and their staff administer the Forest Act. Alarmed at India's rapid deforestation and resulting environmental degradation, Centre Government enacted the Forest (Conservation) Act in1980. Under the provisions of this Act, prior approval of the Central Government is required for diversion of forestlands for non-forest purposes. An Advisory Committee constituted under the Act advises the Centre on these approvals.

### 23.4.2 Biodiversity Act 2000

India's richness in biological resources and indigenous knowledge relating to them is well recognized. One of the major challenges is in adopting an instrument which helps realize the objectives of equitable benefit sharing enshrined in the Convention. Towards this, legislation on biodiversity was developed following an extensive consultative process. The legislation aims at regulating access to biological resources so as to ensure equitable sharing of benefits arising from their use. The Biological Diversity Bill, which was introduced in the Parliament on 15th May, 2000, was referred to the department related Parliamentary Standing Committee for Science, Technology, Environment and Forests for examination and report.

After examination of witnesses and recording evidences, the Standing Committee approved the Bill with some amendments. The Cabinet approved the proposal for moving the official amendments based upon the recommendations of the Committee. The Biological Diversity Bill 2002 has been passed by the Lok Sabha on 2ndDecember, 2002 and by the Rajya Sabha on 11th December, 2002.

**Salient features of the biodiversity legislation**

The main intent of this legislation is to protect India's rich biodiversity and associated knowledge against their use by foreign individuals and organizations without sharing the benefits arising out of such use, and to check biopiracy. The Act provides for setting up of a **National Biodiversity Authority** (NBA), **State Biodiversity Boards** (SBBs) and **Biodiversity Management Committees** (BMCs) in local bodies. NBA and SBB are required to consult BMCs in decisions relating to use of biological resources or related knowledge within their jurisdiction and BMCs are to promote conservation, sustainable use and documentation of biodiversity.

All foreign nationals or organizations require prior approval of NBA for obtaining biological resources and associated knowledge for any use. Indian individuals /entities require approval of NBA for transferring results of research with respect to any biological resources to foreign nationals/organizations. Collaborative research projects and exchange of knowledge and resources under these projects are exempted provided they are drawn as per the policy guidelines of the Central Government and have its approval the objectives of conservation, sustainable use and benefit sharing. However, Indian citizens/entities/local people including vaids and hakims to have free access to use biological resources within the country for their own use, medicinal purposes and research purposes.

While granting approvals, NBA will impose terms and conditions to secure equitable sharing of benefits. Before applying for any form of IPRs (Intellectual Property Rights) in or outside

India for an invention based on research or information on a biological resource obtained from India, prior approval of NBA will be required. There is an enabling provision for setting up a framework for protecting traditional knowledge. The monetary benefits, fees, royalties as a result of approvals by NBA to be deposited in National Biodiversity Fund, which will be used for conservation and development of areas from where resource has been accessed, in consultation with the local self-government concerned. There is provision for notifying **National Heritage Sites** important from standpoint of biodiversity by State Governments in consultation with local self-government. There also exists provision for notifying items, and areas for exemption provided such exclusion does not violate other provisions. This is to exempt normally traded commodities so as not to adversely affect trade.

This bill seeks to check biopiracy, protect biological diversity and local growers through a three-tier structure of central and state boards and local committees. These will regulate access to plant and animal genetic resources and share the benefits. The proposed National Biodiversity Authority (NBA) will deal with all cases of access by foreigners. Its approval will be required before obtaining any **intellectual property right** on an invention based on a biological resource from India, or on its traditional knowledge. It will oppose such rights given in other countries. The NBA will enjoy the power of a civil court. In addition, centre may issue directives to state if it feels a naturally rich area is threatened by overuse, abuse or neglect.

## INTEXT QUESTIONS 23.4

1. Which country has had a forest policy since 1894?

   ______________________________

2. In which year was the first Forest Act enacted?

   ______________________________

3. Expand the abbreviation NBA, SBB, BMC, and IPR

   ______________________________

4. Name the organization whose prior approval is necessary for foreigners to obtain biological resources and knowledge associated with it.

   ______________________________

## 23.5 INTERNATIONAL LEGISLATIONS

There is no international legislation body with authority to pass legislation similar to national legislations, nor are there international agencies with power to regulate resources at a global scale. As a result, international legislation must depend on the agreement of the parties concerned. Certain issues of multinational concern are addressed by collection of policies, agreements, and treaties that are loosely called International Environmental Legislations. Most of the international legislations are international agreements to which nations adhere voluntarily. These agreements are generally finalized through international conventions or treaties. Nations that have agreed to be bound by the convention are known as Parties. Convention provides a framework to be respected by each party, which has to adopt its own national legislations to make sure that convention is implemented at national level. To support the conventions, some time protocols are also to be framed. **A protocol is an international agreement that stands on its own but is linked to an existing convention.** This means that the climate protocol shares the concerns and principles set out in the climate convention. It then builds on these by adding new commitments-which are stronger and far more complex and detailed than those in the convention.

### 23.5.1 Wetland Convention (Ramsar Convention)

It is an international convention came in force in 1975. The convention provides the framework for international cooperation for the conservation and wise use of wetland habitats. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) serves as the Depositary for the Convention, and its secretariat, the Ramsar Bureau, is in Gland, Switzerland. India became signatory to this convention on in 1981.

The Convention aims to halt the loss of wetlands and to ensure the conservation of fauna and flora and their ecological processes. Obligations of parties include:

- designating one or more wetlands for inclusion in the list of Wetlands of International Importance (e.g. six Ramsar wetlands in India).
- promoting wise judicious use of wetlands, including mangroves.
- promoting conservation of wetlands through establishment of nature reserves.
- irrespective of their listing under the Convention and managing wetlands for the benefit of water fowl.
- promoting training in the field of wetland research, managing and warding.
- consulting with other parties about implementation of the convention, especially with regard to trans frontier wetlands, shared water systems, shared species, and development of wetland projects.

### 23.5.2 Montreal Protocol

The United Nations Environment Programme (UNEP) has been addressing this issue since 1977. Under the auspices of UNEP, the nations of the world arrived at ***The Convention for the Protection of the Ozone Layer*** in Vienna in 1985. Through this convention, nations committed themselves to protecting the ozone layer and to co-operate with each other in scientific research to improve understanding of the atmospheric processes and serious consequences of ozone depletion. The convention provides for future protocols and specified procedures for amendment and dispute settlement.

To pursue the objectives of convention for the protection of ozone layer *the **Montreal Protocol on Substances*** that deplete the Ozone layer was agreed to by nations in 1987 and has since been amended five times so far. Its control provisions were strengthened through five amendments to the Protocol adopted in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999). The Protocol aims to reduce and eventually eliminate the emission of man-made ozone depleting substances.

The Vienna Convention and Montreal Protocol are considered as highly effective regime for reducing and possibly, in the future, eliminating –emissions of ozone depleting chemicals into the atmosphere.

The Montreal Protocol uses three kinds of provisions as economic incentives to encourage participation and compliance with the Protocol's control regime; (1) entry into force requirements, (2) controls on trade with non-parties, and (3) research and technology transfer benefits. The Protocol promotes technology transfer to developing countries, thereby offering economic incentives for developing countries to join and comply through a network of 507 monitoring stations located all over the country. Under the National Ambient Air Quality Monitoring Programme, 290 station covering over 90 cities/towns are being monitored by the CPCB (Central Pollution Control Board).

### 23.5.3 Climate Conventions

Global warming (greenhouse effect) is probably the greatest threat to the future of the planet. It is mainly caused by gases (gases like carbon dioxide, methane, nitrous oxide, CFCs, water vapors) emitted by industrialized countries on the burning of fossil fuels (coal, oil and gas) for electricity, heating and transport. Because of gases that have been emitted in the past, and are still pouring into the atmosphere it is already too late to prevent some climate change. However, if we start reducing emissions now, we may be able to avoid some of the worst effects.

Today, action occurs at every level to produce, to avoid, and to understand the risks associated with climate change. Many nations have prepared national plans and are actively pursuing programmes and policies that will result in green gas emission reduction. At the global level, countries, around the world have expressed a firm commitment stop climate change and strengthen international action and broader participation under the auspices of the UN Framework Convention on Climate Change (UNFCCC).

UN Framework Convention on Climate Change (UNFCCC) is the landmark international treaty unveiled at the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992. The UNFCCC commits signatory countries to limit anthropogenic (i.e., human induced) greenhouse gas emissions to levels that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure the food production is not threatened and to enable economic development to proceed in a sustainable manner.

In pursuance with the objectives of the Convention on Climate Change the **Kyoto Protocol** was agreed upon in December 1997 in Kyoto, Japan.

The Protocol calls on all parties – developed nations and developing nations – to take a number of steps to formulate national and regional programmes to improve "local emission factors", activity data, models, and national inventories of greenhouse gas emissions and sinks that remove these gases from the atmosphere. All parties are also committed to formulate, publish and update climate change mitigation and adoption measures, and to cooperate in promotion and transfer of environmentally sound techniques and in scientific and technical research on the climate system.

**Carbon tax**

Many countries now impose tax on green house gas emission from fossil fuel emissions. Taxes motivate industries to improve efficiency and develop $CO_2$ capturing technologies.

**Carbon sequestration**

Automobiles, power plants and industries add a lot of $CO_2$ from burning of fossil fuels. To mitigate the emission, large scale tree plantations may be created improving agricultural practices also to sequester $CO_2$ from the atmosphere.

### 23.4.4 Biological Diversity Convention

The Convention on Biological Diversity (CBD) was adopted during the United Nations Conference on Environment and Development (UNCED - or the "Earth Summit") in Rio de Janeiro on 5 June 1992. CBD has been instrumental in highlighting conservation of biodiversity on the international agenda and its implementation on national level. More than 150 states have signed the Convention, and it entered into force on 29 December 1993. By May 1998 a total of 174 states had ratified the Convention, making it one of the most widely adopted environmental treaties of all times. India ratified the Convention in 1994.

The CBD places emphasis on decision making at the national level. The CBD has 42 articles.

## INTEXT QUESTIONS 23.5

1. Define intimation environmental legislations.

2. What is protocol.

3. Explain abbreviations CFCs, CBD.

4. Which gases are responsible for global warming.

## ACTIVITIES

**Activity 1**

Only Central Government legislation is discussed in this unit, prepare a list of environmental legislations of your state and municipality area.

**Activity 2**

Write a case study on Environmental Movement of your area or nearby area. Highlight its important achievements.

## WHAT YOU HAVE LEARNT

- The various national and international legislations, which have been framed to stop environmental degradation.
- India is one of the few countries of the world that have made specific reference in the constitution to the need for environmental protection and improvement. The Central Government and State Governments have utilized this provision to pass various Acts in order to protect the environment from destruction.
- There is a great contribution of UN in addressing global environmental challenges. To implement the agenda of UN, there is movement towards environment protection on a worldwide scale through special conventions, protocols and multilateral agreements.
- Despite of the presence of satisfactory legislative measures and administrative set-up, it is difficult to enforce the legislation due to lack of expertise, shortage of funds, and no seriousness on the part of implementing authority.

- The main objective of water act of 1974 is to provide prevention and control of water pollution and maintaining or restoring of wholesomeness and purity of water.
- The main objective of Air Act 1981 is to improve the quality of air and to prevent, control and abate air pollution in the country.
- Through environment acts Central Government gets full power for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating pollution.
- Most of the international legislation is international agreements to which nations adhere voluntarily.
- A protocol is an international agreement that stands on its own but is linked to an existing convention.
- The aim of Wetland convention is to halt the loss of wetlands and to ensure the conservation of flora and fauna and their ecological process.
- The objective of Montreal protocol is aims to reduce and eventually eliminate the emission of man-made ozone depleting substances.

## TERMINAL EXERCISE

1. What are Environmental legislations and how are they important for environmental improvement and conservation?
2. What are National Legislations and International Legislations? How are they are different from each other?
3. Describe in brief some pollution related acts.
4. What are Ramsar Convention and Montreal Protocol? Describe in brief.
5. Describe the Environmental Protection Act,1986
6. What is main aim of biodiversity act and its salient features?
7. What are the main objectives of climate convention?
8. Write short note on (a) Water Act (b) Air Act, (c) Wildlife Act, (d) Forest Act.

## ANSWER TO INTEXT QUESTIONS

**23.1**

1. Legislation is needed in order to prevent misuse and degradation of the environment.
2. An important aspect of environmental problem is that their impact is not confined to the source area but spills over far and wide.

**23.2**

1. Human Environment
2. Stockholm.
3. 1986
4. CNG

**23.3**

(1) c (2) d (3) b (4) a

**23.4**

1. India
2. 1927
3. National Biodiversity Authority, State Biodiversity Boards, Biodiversity Management Committee, Intellectual Property Right.
4. National Biodiversity Authority

**23.5**

1. Certain issues of multinational concern addressed by collection of policies, agreements and treaties that are loosely called international environmental legislation.
2. A protocol is an international agreement that stands on its own but is linked to an existing convention.
3. Chloro- flouro carbon (CFC), Convention on Biological Diversity
4. $CO_{2,}$ methane, $NO_{2,}$ CFCs and water vapour

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# ENVIRONMENTAL IMPACT ASSESSMENT

Every country strives to progress ahead one aspect of progress is economic development through manufacturing and trading. Every country builds industries which provide employment, serve the consumers needs and help to generate revenue.

Development projects in the past were undertaken without any consideration to their environmental consequences. As a result rivers and lakes got polluted, air pollution reached at threatening level and pilling of industrial wastes resulted in land degradation. Industrialization and economic growth provided material comforts and luxuries of life but at the same time deteriorated the quality of life.

In view of the colossal damage to environment by developmental activities people are now concerned about the environmental impact of developmental projects. EIA enables the decision makers to analyse the effect of developmental activities on the environment, if any well before the developmental project is implement.

In this lesson, you shall learn about Environmental Impact Assessment (EIA) which is a tool for preventing adverse environmental impact of developmental activities, significance , methodology and practice.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the importance of protecting the environmental side by side with industrial development (need for EIA);*
- *define the concept and legal aspect of EIA;*
- *enumerate how undesirable impacts of developmental projects can be anticipated and also overcome;*

- *describe the methods of EIA;*
- *outline the procedures of EIA followed in India;*
- *list the methods for environmental clearance and forestry clearance process;*
- state about alternate scenario of evaluation of EIA;

## 24.1 IMPORTANCE OF EIA IN RESPECT OF ENVIORNMENTAL PROTECTION

Unfortunately industrial development has had adverse impact on the environment. Most of the developmental activities such as building of dams, roads, airports, industries, railway tracks, cities etc. use enormous amounts of natural resources as raw material and they may generate waste, which is disposed off into the environment. Waste disposal causes damage to air, soil and water, and brings about depletion of natural resources.

The protection of the global environment is in the interest of all of us living on this planet. Various measures have been taken at national and international levels to correct a number of environmental problems as you have already learnt in the previous lesson.

In light of the above it is important to anticipate the likely environmental problems and threats that may arise out of the proposed developmental activities and human actions. Such an anticipation is termed “Environmental Impact Assessment” (EIA).

EIA is tool that improves decision making and ensures that the project under consideration is an acceptable option.

## 24.2 CONCEPT AND LEGAL BASIS OF ENVIRONMENTAL IMPACT ASSESSMENT

### 24.2.1 Concept of Environmental Impact Assessment (EIA)

After reading the previous lessons, you must be convinced that sustainable development and environmental conservation are necessary for survival and well being of future generations.

This is Environmental Impact Assessment (EIA). EIA is a tool which helps to evaluate environmental impact of proposed developmental projects or programs are visualized clearance accorded after mitigation strategies are included in the plan. EIA thus proves to be a tool which improves decision making and ensures that the project under construction is environmentally sound and within limits of the capacity of assimilation and regeneration capacities of the ecosystem. Environmental clearance of developmental projects is mandatory for the new project. (Fig. 24.1a and 24.1b)

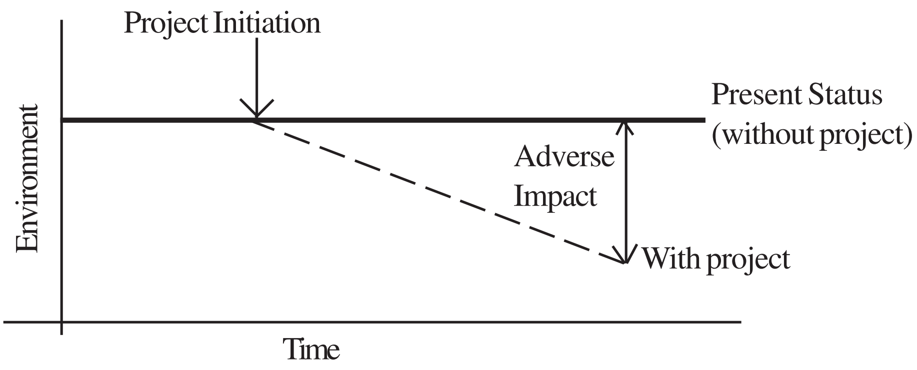



***Fig. 24.1:*** *(a) Anticipated environmental impact of developmental project.*

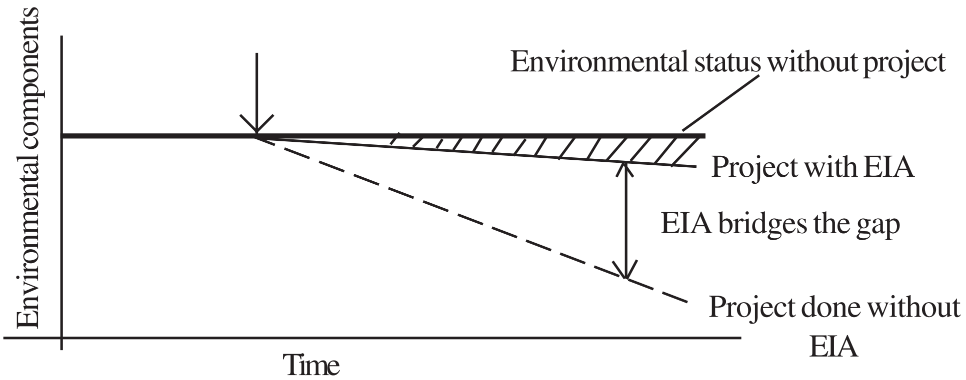



***Fig. 24.1:*** *(b) Environmental impact rectification after EIA*

The important aspects of EIA are:

- risk assessment,
- environmental management and
- post product monitoring.

EIA provides a cost effective method to eliminate or minimize the adverse impact of development projects.

**24.2.2 Legal bases of environmental impact assessment**

The EIA process will be designed such that its guidelines follow basic legal and policy equipments. For example: EIA is to-

(1) serve as a primary environmental tool with clear provisions.

(2) apply consistently to all proposals with potential environmental impacts.

(3) use scientific practice and suggests strategies for mitigation.

(4) address all possible factors such as short term, long term, small scale and large scale effects.

(5) consider sustainable aspects such as capacity for assimilation, carrying capacity, biodiversity protection.

(6) lay down a flexible approach with and provides for public involvement.

(7) have in built mechanism of follow up and feedback for comply into mandatory requirements.

(8) include mechanisms for monitoring, auditing and evaluation.

EIA was introduced in India in 1978, with respect to river valley projects. Later the EIA legislation was enhanced to include other developmental sections since 1941. EIA is now mandatory for 30 categories of projects, and these projects get Environmental Clearance (EC) only after the EIA requirement are fulfilled.

EIA appraises the environmental health and social implications of planned developmental projects. It thus links environment with development. The goal of EIA is to ensure environmentally safe and sustainable development.

## INTEXT QUESTIONS 24.1

1. Expand EIA and define the term.

2. Why is EIA necessary? Answer in one or two sentences.

3. What are the important aspects of EIA.

## 24.3 ENVIRONMENTAL CLEARANCE

Environmental clearance or the 'go ahead' signal is granted by the Impact Assessment Agency in the Ministry of Environment and Forests, Government of India.

All projects that require clearance from central government can be broadly categorized into the following:-

(1) Industries

(2) Mining

(3) Thermal power plants

(4) River valley projects

(5) Infrastructure and CRZ (Coastal Regulation Zone)

(6) Nuclear power projects.

## 24.4 WHAT ALL IS ASSESSED IN ENVIRONMENTAL IMPACT ASSESSMENT

In order to carry out an environmental impact assessment, the following are essential:

(i) assessment of existing environmental status.

(ii) assessment of various factors of ecosystem (air, water, land, biological).

(iii) analysis of adverse environmental impacts of the proposed project to be started.

(iv) impact on people in the neighborhood.

## 24.5 ENVIRONMENTAL COMPONENTS OF EIA

The EIA process looks into the following components of the environment.

**Air environment**

- Quality of ambient air.
- Wind speed, direction, humidity etc.
- Quantity of emission likely from project.
- Impact of the emission on the area.
- Pollution control desires / air quality standards.

**Noise**

- Levels of noise present and predicted
- Strategies for reducing noise pollution.

**Water environment**

- Existing ground and surface water resources, their quality and quantity within the zone.
- Impact of proposed project on water resources.

**Biological environment**

- Flora and fauna in impact zone.
- Potential damage (likely) due to project, due to effluents, emissions and landscaping.

- Biological stress (prediction).

**Land environment**

- Study of soil characteristics, land use, and drainage pattern, and the likely adverse impact of the project.
- Impact on historical monuments and heritage site.

Assessment of expected economic benefits arising out of the project have to be compared to the all the above mentioned factors.

Thus we can say that environmental concerns have to be made a part of the decision to set up a project.

## INTEXT QUESTIONS 24.2

1. What is meant by environmental clearance?

   ______________________________

2. Name any three projects requiring such clearance.

   ______________________________

3. Name any two environmental components of EIA.

   ______________________________

## 24.6 EIA PROCESS AND PROCEDURES

EIA process and procedure have several components. Each one is separately mentioned below:

### 24.6.1 Method of carrying out EIA

Preparation of EIA report comprises the following steps:

(1) Collection of baseline data from primary and secondary sources;

(2) Prediction of impacts based on past experience and mathematical modelling;

(3) Evolution of impacts versus evaluation of net cost benefit; preparation of environmental management plans to reduce the impacts to the minimum;

(4) Quantitative estimation of financial cost of monitoring plan and the mitigation measures;

(5) Preparation of environmental management plans to reduce the impacts to the minimum;

(6) Quantitative estimation of financial cost of monitoring plan and the mitigation measures.

### 24.6.2 Steps in EIA process

EIA involves the steps mentioned below. However, EIA process is cyclical with interaction between the various steps.

- **Screening:** The project plan is screened for scale of investment, location and type of development and if the project needs statutory clearance.
- **Scoping:** The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring. The EIA agency has to follow the published guidelines by the Ministry of Environment and Forest (MoEF) of government of India.
- **Collection of baseline data:** Baseline data is the environmental status of study area.
- **Impact prediction:** Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted which presupposes a good understanding of the project by the assessment agency.
- **Mitigation measures and EIA report:** The EIA report should include the actions and steps for preventing, minimizing or by passing the impacts or else the level of compensation for probable environmental damage or loss.
- **Public hearing:** On completion of the EIA report, public and environmental groups living close to project site may be informed and consulted.
- **Decision making:** Impact Assessment (IA) Authority along with the experts consult the project-in-charge along with consultant to take the final decision, keeping mind EIA and EMP (Environment Management Plan).
- **Monitoring and implementation of environmental management plan:** The various phases of implementation of the project are monitored.
- **Risk assessment:** Inventory analysis and hazard probability and index also form part of EIA procedures.

### 24.6.3 Composition of the expert committees for EIA

1. The Committees will consist of experts in the following disciplines:

   (1) Eco-system management

   (2) Air/ water pollution control

   (3) Water resource management

   (4) Flora/ fauna conservation and management

   (5) Land use planning

(6) Social Sciences/ Rehabilitation

(7) Project appraisal

(8) Ecology

(9) Environmental Health

(10) Subject Area Specialists

(11) Representatives of NGOs/persons concerned with environmental issues.

2. The Chairman will be an outstanding and experienced ecologist or environmentalist or technical professional with wide managerial experience in the relevant development.

3. The representative of Impact Assessment Agency will act as a Member- Secretary.

4. Chairman and members will serve in their individual capacities except those specifically nominated as representatives.

5. The membership of a committee shall not exceed 15 members.

## 24.7 ENVIRONMENTAL APPRAISAL PROCEDURE IN INDIA

An Appraisal Committee constituted by the Ministry of Environment and Forests to first scrutinized a project. This committee evaluates the impact of the project based on the data presented by the project authorities. If necessary, the Ministry of Environment and Forests may also with the investors and hold consultations with experts on specific issues as and when necessary.

After considering all the facets of a projects, environmental clearance is accorded subject to implementation of the stipulated environmental safeguards. In case of projects where the project proponents have submitted complete information, a decision is taken within 90 days. The six regional offices of the Ministry functioning at Shillong, Bhubaneshwar, Chandigarh, Bangaloru, Lucknow and Bhopal undertake monitoring of cleared projects. The primary objectives of this procedure is to ensure adequacy of the suggested safeguards and also to undertake mid-course corrections required. If any. Any changes in the scope of project are identified to check whether review of earlier decision is called for or not.

Coastal Zone Management Plans (CZMPs)are prepared by coastal states or Union Territories as per rules set by CRZ notification 1991. This is prepared based on identification and categorization of coastal areas for different activities and then submitted to the MoEF for approval. The ministry then forms a task force for examining their plans. Some times one or more natural resources becomes limiting resource in a given region and that restrict the scopes of development portfolios. MoEF has been sponsoring carrying capacity studies for different regions. The studies involves:-

1. a list of natural resources available.
2. preparation of existing environmental settings;
3. perspective plans and their impact on natural resources through creation of 'Business As Usual Scenario;
4. identification of 'Hot Spots' requiring immediate remedial action to overcome air, water or land pollution;
5. formulated of a developed plan which should be for the betterment and a comparison between 'Business as Usual' and the improved plan for betterment would indicate the future course of action to be adopted for development of the region after it has discussing with the local people and the planners.

## 24.8 ISSUES OF ENVIRONMENTAL CLEARANCE/ REJECTION LETTER

**Single window clearance**

When a project requires both environmental clearance as well as approval under the Forest (Conservation) Act, 1980, proposals for both are required to be given simultaneously to the concerned divisions of the Ministry. The processing is done simultaneously for clearance or rejection, although separate letters may issue. If the project does not involve diversion of forestland, the case is processed only for environmental clearance. (For more details on forest clearance, See Fig. 24.2).

**Time frame**

Once all the requisite documents and data from the project authorities are received and public hearings (where required) have been held, assessment and evaluation of the project from the environment angle is completed within 90 days and the decision of the ministry shall be conveyed within 30 days thereafter.

**Post project monitoring**

It is to be noted that whenever a project is given environment clearance, a set of recommendations and conditions are stipulated by the Appraisal Committee on a case to case basis, which have to be complied with by the project proponent once the project is commissioned. The project authorities are required to submit a half- yearly compliance report to the Ministry about the compliance of conditions stipulated in the environmental clearance order by the Ministry. To monitor the implementation of the recommendations and conditions stipulated by the Appraisal Committee subject to which the environmental clearance has been given. The six regional offices of the Ministry located at Shillong, Bhubneshwar, Chandigarh, Bangloru, Lucknow and Bhopal, help the Ministry in post-project monitoring of the cleared projects.

Cases of non-compliance of the recommendations and conditions by cleared projects/units are brought to the notice of the Ministry, which may then initiate action against the project authorities as described under section 24.10 as well as in Flow Chart No. 3 (Obtaining environmental clearance flow chart)

## INTEXT QUESTIONS 24.3

1. State the various steps in EIA.

______________________________

2. Name six regional offices of India those undertake monitoring of cleared projects.

______________________________

3. What are the steps included for issuing environmental clearance or rejection letter?

______________________________

## 24.9 THE MAIN PARTICIPANTS OF EIA

EIA applies to public and private sections. The six main players (Fig. 24.2) are:

(i) Those who propose the project

(ii) The environmental consultant who prepare EIA on behalf of project proponent.

(iii) Pollution Control Board (State or National).

(iv) Public has the right to express their opinion.

(v) The Impact Assessment Agency.

(vi) Regional centre of the Ministry of Environment and Forest.

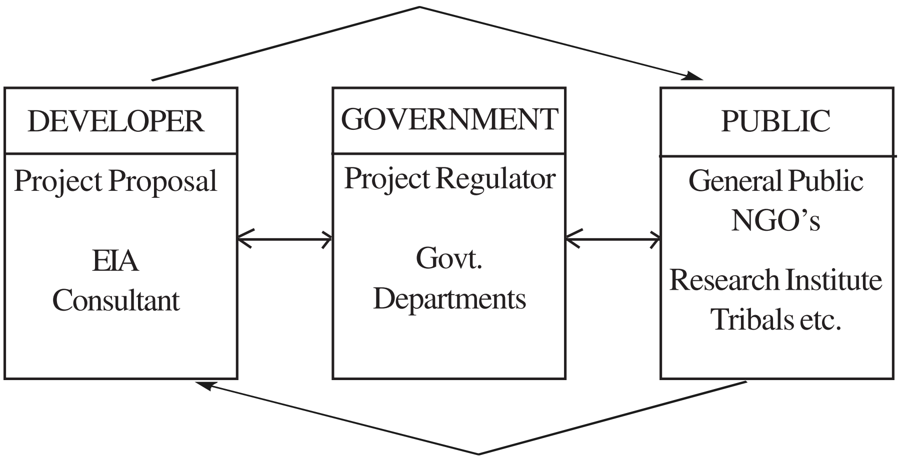
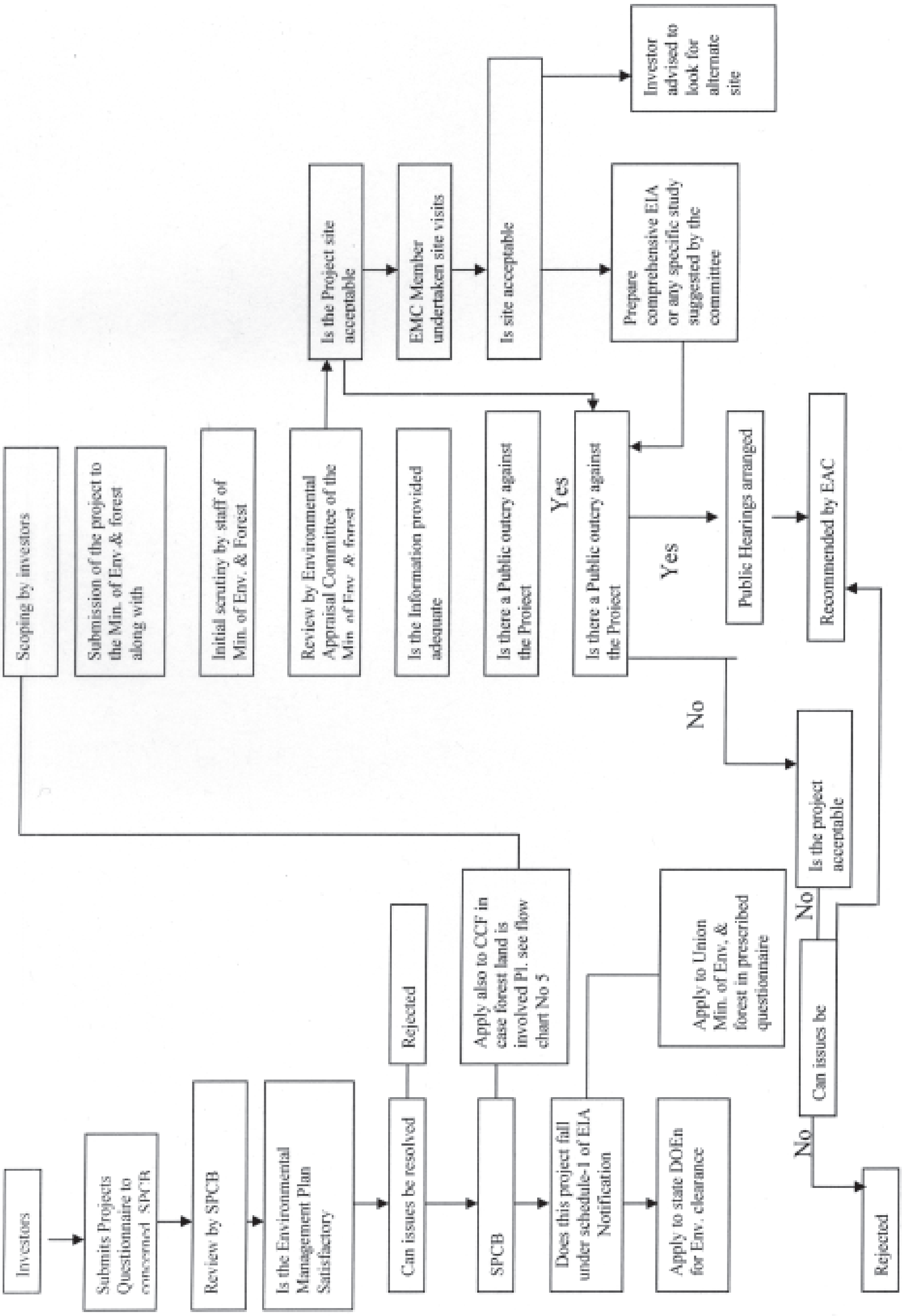



***Fig. 24.2:** Participants for EIA*

## 24.10 ENVIRONMENTAL CLEARANCE

The entire EIA process upto obtaining environmental clearance are summerised in the following flow chart:

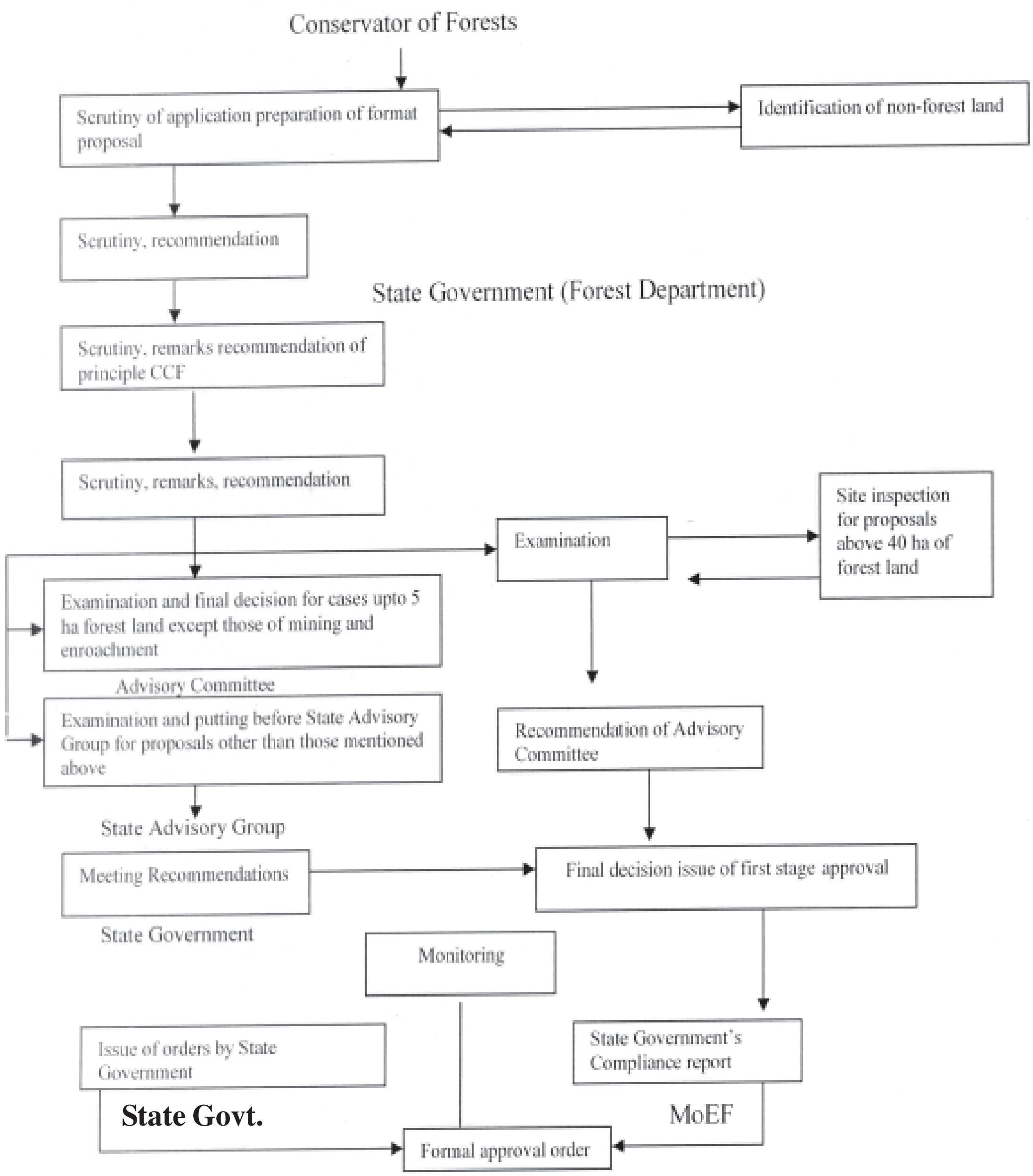


# 24.11 FORESTRY CLEARANCE

The methods for clearance process given in the following flow chart are self explanatory.

**Obtaining forest clearance**

Flow chart showing various steps involving in examination of cases received under FC Act



## 24.12 ALTERNATE SCENARIO OF EVALUATION OF EIA

An effective EIA exercise is focussed, time bound, cost effective and makes assessment understandable.

The sole objective is to erase any situations of environmental damage during construction and implementation of the developmental project. It should also be keep in mind the general public and people in the local and neighborhood of the project.

The evaluation of EIA is possible only when (a) there is public awareness of those responsible for protecting environmental quality and enforcement; (b) The EIA report and information contained therein is reliable.

## INTEXT QUESTIONS 24.4

1. Who gives the clearance for foresting projects?

   ______________________________

2. Apart from the government, two other's are participants for EIA, name them.

   ______________________________

3. What does the statement, "evaluation of EIA is possible only if EIA report is reliable", mean?

   ______________________________

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***List of projects requiring environmental clearance from the central government***

1. Nuclear power and related projects such as heavy water plants, nuclear fuel complex, rare earths.
2. River valley projects including hydel power, major irrigation and their combination including flood control.
3. Ports, harbours, airports (except minor ports and harbours).
4. Petroleum refineries including crude and products pipelines.
5. Chemical fertilisers (nitrogenous and phosphatic other than single superphosphate).
6. Pesticides (technical).
7. Petrochemical complexes (both olefinic and aromatic) and petrochemical intermediates such as DMT, Caprolactam, LAB etc, and production of basic plastics such as LDPE, HDPE, PP, PVC.

8. Bulk drugs and pharmaceuticals
9. Exploration for oil and gas and their production, transportation and storage
10. Synthetic rubber
11. Asbestos and asbestos products
12. Hydrocyanic acid and its derivatives
13. Primary metallurgical industries (such as production of iron and steel, aluminium, copper, zinc, lead, and ferro-alloys)
14. Chlor alkali industry
15. Integated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints
16. Viscose staple fibre and filament yarn
17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy
18. All tourism projects between 200m-500 metres of High Water Line and at locations with an elevation of more than 1000 metres with investment of more than Rs. 5 crore
19. Thermal power plants
20. Mining projects (with lease more than 5 hectares)
21. Highway projects except projects relating to improvement work including widening and strengthening of roads with marginal land acquisition along the existing alignments provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger Reserves, Reserve Forests
22. Tarred roads in the Himalayas and forest areas
23. Distilleries
24. Raw skins and hide
25. Pulp, paper and newsprint
26. Dyes
27. Cement
28. Foundries (Individual)
29. Electroplating
30. Meta aminophenol

## WHAT YOU HAVE LEARNT

- Developmental projects are an essential component of economic development and progress of a country.
- To prevent adverse impacts of developmental projects and programmes an environment, Environmental Impact Assessment or EIA is carried out before the implementation.
- While development is important, more important is environmental protection so that there is sustainable development and the environmental resources remain available to future generations.
- EIA is tool for anticipating any harmful effects or developmental activities on the environment. As it clears the project plans only after mitigating all probable damaging effects on the environment.
- As a tool EIA improves decision making and ensures environmental safety.
- With EIA, a project is implemented with minimal damage to the environment.
- Important aspects of EIA are (i) risk assessment, (ii) environmental management and (iii) post product monitoring.
- Integrity, utility and sustainability are the core values of EIA.
- There are several legal bases of EIA as it not only appraises environmental health but also the social implications of planned developmental projects.
- In India the projects that require clearance for the government are related to industries, mining power plants, river valley projects, nuclear power projects and coastal regulation zone (CRZ).
- The environmental components of EIA are associated with air, water, organisms, noise, and land.
- The EIA report is prepared after the following are carried out:
    - collection of baseline data
    - prediction of impact
    - evaluation of net cost benefit versus evolution of impacts
    - monitoring strategies and mitigation strategies and their quantities estimation.
    - environmental monitoring plans
- EIA processes are screening, scoping, collection of baseline data, impact prediction, mitigation measures, public hearing, decision making, monitoring and implementing EMP and risk assessment

- Experts from ecosystem management, pollution control, resource management, land use planning, rehabilitation project appraisal, ecology, and NGOs concerned with environmental issues
- Procedure for Environmental appraisal in India stepwise are

  (1) submission of documents by investor.

  (2) scrutiny by multidisciplinary staff or Ministry of Environment and Forests.

  (3) placement before experts and evaluation by them.

  (4) recommendations from Appraisal Committees are their passed by Ministry of Environment and Forests.

  (5) ministry accepts or rejects proposal.
- Clearance or rejection issues are (a) single window clearance (b) time frame and (c) post project monitoring.
- The participants in EIA are (i) developer who proposes the project, (ii) government departments which regulate the projects and (iii) the general public
- There are various steps in forestry clearance or for obtaining environmental clearance for various projects.
- An effective EIA is focused, time bound, cost effective and reliable.
- There are 30 projects which require environmental clearance.

## TERMINAL EXERCISE

1. What is EIA?
2. Why is EIA important?
3. Give an account of the importance of development as against environmental protection.
4. Explain the three core values of EIA
5. Numerate the legal bases of EIA.
6. What is meant by environmental clearance?
7. For which projects is environmental clearance mandatory?
8. What all is assessed under EIA?
9. What is the composition of the expert committee for EIA.
10. Describe the various components of process of EIA

11. Where are experts drawn from for EIA.

12. Describe stepwise the procedure for environmental appraisal.

## ANSWER TO INTEXT QUESTIONS

**24.1**

1. Environmental Impact Assessment. It is a tool to anticipate the likely environmental problems and threats due to a particular developmental activity.
2. To prevent environmental damage due to developmental activities
3. Risk Management, environmental management, post product monitoring

**24.2**

1. Go-ahead signal from the government of India for carrying out developmental activity
2. Industires / Mining /Thermal power plants/River Valley Project/Nuclear Power Projects (any three)
3. Air/Land/Water/Biological/Noise (any two)

**24.3**

1. Screening, scoping, collectionof baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, risk management.
2. Shillong, Bhubaneshwar, Chandigarh, Bangaloru, Lucknow and Bhopal.
3. Single window clearance, time frame, post project monitoring.

**24.4**

1. Government of India, Ministry of Forest
2. Developer and Public
3. The EIA report has to be exactly in keeping with the process and procedure laid down for EIA.

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# 25

# ENVIRONMENT RELATED INSTITUTIONS AND ORGANISATIONS

The role of national government is critical for control of environmental pollution control, conservation and improvement of environment for promoting sustainable development. To address the diverse environmental issues a number of environment related institutions and organization have been setup at international, national level by United Nations, national governments and civil society. An environmental organization is an organization seeks to protect, analyze or monitor the environment against misuse or degradation or lobby for these goals. Environmental organization may be a government organization, a non-government organization, a charity or trust. Environmental organizations can be global, national, or local. This lesson provides information on leading environmental organizations, both within and outside the government, working for the conservation and improvement of environment at global and national level.

## OBJECTIVES

After completing this lesson, you will be able to:

- *list different ministries and institutions concerned with environmental administration in India;*
- *explain the role and responsibilities of global institutions in the field of environmental management;*
- *explain the role and activities of important national and international NGOs in environmental conservation and sustainable development;*
- *explain the role of United Nations bodies for environment.*

## 25.1 HISTORICAL BACKGROUBD TO ENVIRONMENTAL INSTITUTIONS IN INDIA

India's consciousness to protect the environment and to restore it, exists since the early days of civilisation. The vedic and post-vedic history bears testimony to this. However, in the modern days, especially in the post independent era because of high priority to economic growth, environment receded to a less important place. It is only in 1972 steps were initiated with the formation of the National Committee on Environmental Planning and Coordination(NCEPC) that gradually evolved as a separate department of environment and reached the full-fledged stage of Ministry of Environment and Forests in 1985. Initially the Constitution of India did not contain any provision towards the promotion/protection of environment. However, the 42nd amendment of the constitution in 1977 added some important clauses that entrusted the government the responsibility of providing a clean and well-protected environment.

## 25.2 NATIONAL ENVIRONMENTAL AGENCIES

The Ministry of Environment and Forest, Central Pollution Control Board, Indian Board for Wildlife are the main national environmental agencies.

### 25.2.1 The Ministry of Environment and Forests (MoEF)

The Ministry of Environment and Forests (MoEF) is the nodal agency in the administrative structure of the Central Government, for planning, promoting, coordinating and overseeing the implementation of environmental and forestry programmes in the country. The main activities undertaken by the ministry include conservation and survey of the flora and fauna of India, forests and other wilderness areas; prevention and control of pollution; afforestation and reducing land degradation. It is responsible for the administration of the national parks of India. The main tools utilized for this include surveys, environmental impact assessment, control of pollution, regeneration programmes, support to organizations, research to find solutions and training to augment the requisite manpower, collection and dissemination of environmental information and creation of environmental awareness among all sectors of the country's population.The Ministry is also the nodal agency in the country for the United Nations Environment Programme (UNEP).

### 25.2.2 Central Pollution Control Board

The Central Pollution Control Board (CPCB), is statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. It serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986.

Principal functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) to improve the quality of air and to prevent, control or abate air pollution in the country.

Air Quality Monitoring is an important part of the air quality management. The National Ambient Air Quality Monitoring (NAAQM) Programme has been established with the objectives to determine the present status of air quality, for controlling and regulating emission of air pollutants from industries and other sources to meet the air quality standards. It also provides background air quality data needed for setting of industries and town planning.

Fresh water is a finite resource essential for use in agriculture, industry, propagation of wildlife and fisheries and for human existence. India is a riverine country but there are numerous lakes, ponds and wells which are used as primary source of drinking water even without treatment. Most of the rivers being fed by monsoon rains, which are limited to only three months of the year, run dry throughout the rest of the year often carrying wastewater discharges from industries or cities or towns endangering the quality of our scarce water resources. The parliament of India in its wisdom enacted the Water (Prevention and Control of Pollution) Act, 1974 with a view to maintaining and restoring wholesomeness of our water bodies. One of the mandates of CPCB is to collect, collate and disseminate technical and statistical data relating to water pollution. Hence, Water Quality Monitoring (WQM) and Surveillance are of utmost importance.

The scheme of labeling of Environment Friendly Products is on anvil for household and other consumer products to meet certain environment criteria along with the quality requirements of Indian Standards. The scheme is known as Ecomark Scheme of India.

**Functions of the Central Board at the national level**

- Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.
- Plan and execute nation-wide programme for the prevention, control or abatement of water and air pollution:
- Co-ordinate the activities of the State Board and resolve disputes among them;
- Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
- Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
- Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;

**Environmental Governance and State Pollution Control Board**

The umbrella Act, EPA (Environmental Protection Agency) 1986 added strength to all preceding provisions. Special stipulations were made for industrial, vehicular and noise pollution control in the country.

In India, states do not pursue independent environmental policy of their own but adopt the policies formulated at the national level subject to such variations as may be necessary to suit to the local conditions. The central government has also been issuing guidelines to the states on various environmental matters.

### 25.2.3 Indian Board for Wildlife (IBWL)

The IBWL is the apex advisory body in the field of Wildlife Conservation in the country and is headed by the Honorable Prime Minister of India. The IBWL has been reconstituted w.e.f. 7.12.2001. The XXI meeting of the IBWL was held on 21.1.2002 under the Chairmanship of the Honorable Prime Minister of India at New Delhi.

## INTEXT QUESTIONS 25.1

1. Name the national environmental agencies.

   ______________________________

2. What are the main functions of MoEF?

   ______________________________

3. When was CPCB established?

   ______________________________

4. Expand the following:CPCB, NAAQM, IBWL.

   ______________________________

5. When was IBWL reconstituted and who is the head of this organization?

   ______________________________

## 25.3 INTERNATIONAL ENVIRONMENTAL AGENCIES

United Nations Environment Programme (UNEP), World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) are some of the main international agencies.

### 25.3.1 United Nations Environment Programme (UNEP)

UNEP was created by United Nations General Assembly, as an outgrowth of the United Nations Conference on the Human Environment, held in Stockholm, Sweden that same year. The United Nations Conference on the Environment and Development took place in Rio de Janeiro in 1992 and the World Summit on Sustainable Development, held in Johannesburg in 2002 (also known as RIO+10) did not substantially change its configuration. It is headquartered in **Nairobi** (Kenya).

UNEP's main mandate is to coordinate the development of environmental policy for keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action. Its activities cover a wide range of issues encompassing the atmosphere, marine and terrestrial ecosystems.

UNEP has played a significant role in developing international environmental conventions, promoting environmental science and information and illustrating the way those can work with national governments and regional institution and Non-Governmental Organizations (NGOs). UNEP has also been active in funding and implementing environment related development projects for promoting **sustainable development** through sound environmental practices.

The implementation of UNEP's work is done by the following seven divisions:

- Early Warning and Assessment
- Environmental Policy Implementation
- Technology, Industry and Economics
- Regional Cooperation
- Environmental Law and Conventions
- Global Environment Facility Coordination
- Communications and Public Information

Among UNEP's many initiatives is the **"Clean Up the World"** campaign, which attempts to build awareness throughout the world regarding the huge impacts of our modern life style.

UNEP has aided in the development of guidelines and treaties on issues such as the international trade in potentially harmful chemicals, transboundary air pollution, and contamination of international waterways.

The World Meteorological Organization and the UNEP established the Intergovernmental Panel on Climate Change (IPCC) in 1988. UNEP is also one of several Implementing Agencies for the Global Environment Facility (GEF).

**Funding**

UNEP receives the necessary **funding** for its programs from the Environmental Fund, which is maintained by voluntary contributions of member governments, supplemented by contributions to more than seventy trust funds and by small contributions from the regular budget of the United Nations. The UNEP budget for the 2004-2005 biennial is 130 million dollars.

### 25.3.2 World Health Organisation (WHO)

**Constitution and history**

The WHO's constitution states that its objective "is the attainment by all peoples of the highest possible level of health.". Its major task is to combat disease, especially key infectious diseases, and to promote the general health of the people of the world.

**The World Health Organization (WHO)**

It is one of the original agencies of the United Nations, its constitution formally coming into force on the first **World Health Day**, (7 April 1948), when it was ratified by the 26th member state. The WHO has 193 Member States.

The WHO is financed by contributions from member states and from donors.

The Regional Offices are:

Regional Office for Africa (**AFRO**);

Regional Office for Europe (**EURO**);

Regional Office for South East Asia (**SEARO**);

Regional Office for the Eastern Mediterranean

Regional Office for Western Pacific (**WPRO**);

Regional Office for the Americas (**AMRO**),

**Activities**

Activities of WHO includes coordinating international efforts to monitor outbreaks of infectious diseases, such as SARS(Severe Acute Respiratory Syndrome), malaria, swine flu, and AIDS as well as to sponsor programs to prevent and treat such diseases. The WHO supports the development and distribution of safe and effective vaccines, pharmaceutical diagnostics and drugs. After over two decades of fighting smallpox, the WHO declared in 1980 that the disease had been eradicated - the first disease in history to be eliminated by human effort.

WHO aims to eradicate polio within the next few years. In addition to its work in eradicating disease. WHO is devoting increasing attention to various health-environment related issues— for example, campaigns to boost the consumption of fruits and vegetables worldwide and to discourage tobacco use.

Environment and health are closely related. The Principle of the Rio Declaration on Environment and Development, 1992 states "human beings are at the centre of concern for sustainable development. They are entitled to a healthy and productive life in harmony with nature." Environmental hazards are responsible for an estimated 25% of the total burden of disease worldwide.

### HELI

To tackle environment related health hazards WHO has developed **Health Environment Link Initiative (HELI).** HELI is a global effort by WHO and UNEP to support action by developing country policymakers on environmental threats to health.

HELI encourages countries to address health and environment issues as integral to economic development. HELI supports valuation of ecosystem 'services' to human health and well-being – services ranging from climate regulation to provision or replenishment of air, water, food and energy sources and generally healthy living and working environments. HELI activities include country-level pilot projects

### 25.3.3 Food and Agriculture Organization of the United Nations (FAO)

It is a specialised agency of the United Nations with a member states that leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information, and helps developing countries and countries in transition modernise and improve agriculture, forestry and fisheries practices, ensuring good nutrition and food security for all. Its Latin motto, *fiat panis*, translates into English as "let there be bread".

The FAO headquarters are located in Rome and has five regional offices.

Regional Office for Africa in Accra, Ghana

Regional Office for Latin America and the Caribbean in Santiago, Chile

Regional Office for Asia and the Pacific in Bangkok, Thailand

Regional Office for the Near East in Cairo, Egypt

Regional Office for Europe in Budapest, Hungary

WHO member states appoint delegations to the World Health Assembly, WHO's supreme decision-making body. All UN member states are eligible for WHO membership and according to the WHO web site, "Other countries may be admitted as members when their application has been approved by a simple majority vote of the World Health Assembly."

## INTEXT QUESTIONS 25.2

1. What does UNEP stand for? Who created it and where is its headquarter located?

   ______________________________

2. What kind of programme does UNEP fund and implement?

3. What is the full form of WHO and what is its main objective?

4. Which is the first disease in history to be eliminated by human efforts?

5. What does HELI stands for?

6. Who created FAO? Mention its one important function.

## 25.4 COMMISSION ON SUSTAINABLE DEVELOPMENT (CSD)

It was established in December 1992 by General Assembly Resolution A/RES/47/191 as a functional commission of the UN Economic and Social Council (ECOSOC), implementing a recommendation in Chapter 38 of Agenda 21, the landmark global agreement reached at the June 1992 United Nations Conference on Environment and Development or **Earth Summit** held in Rio de Janeiro.

### Mission

The Division for Sustainable Development (DSD) provides leadership and is an authoritative source of expertise within the United Nations system on sustainable development. It promotes sustainable development as the UN Commission on Sustainable Development (CSD) and through technical cooperation and capacity building at international, regional and national levels.

### Goal

- Integration of the social, economic and environmental dimensions of sustainable development in policy-making at international, regional and national levels;
- Wide-spread adoption of an integrated, cross-sectoral and broadly participatory approach to sustainable development;
- Measurable progress in the implementation of the goals and targets of the Johannesburg Plan of Implementation.

**it says:**

"In order to ensure the effective follow-up of the conference, as well as to enhance international cooperation and rationalization the intergovernmental decision making capacity for the integration of environment and development issues and to examine the progress of the implementation of Agenda 21 at the national, regional and international levels, a high level Commission on Sustainable Development should be established in accordance with Article 68 of the Charter of the UN." Agenda 21 (1) The General Assembly met in the autumn of 1992 to debate the setting up of the CSD; it resolved that:

- the Economic and Social Council (ECOSOC)has been requested to establish a high level commission as a functional council body.
- representatives of 53 states have been elected by the council for up to three year terms.
- the commission will meet once a year for two or three weeks. It is a functional ECOSOC commission with a full time secretariat based in New York.

The CSD's mandate (Resolution 1993/207) is:

- to monitor progress on the implementation of Agenda 21 (deals with environment and development issues) and activities related to the integration of environmental and developmental goals by governments, NGOs, and other UN bodies.
- to monitor progress towards the target of 0.7% GNP from developed countries for Overseas Development Aid.
- to review the adequacy of financing and the transfer of technologies as outlined in Agenda 21.
- to receive and analyse relevant information from competent NGOs in the context of Agenda 21 implementation.
- to enhance dialogue with NGOs, the independent sector, and other entities outside the UN system, within the UN framework.

Sustainable development to satisfy the needs of present generations without endangering the needs of future generations will not be brought about by policies only: it must be taken up by society at large and the choices each citizen makes every day, as well as the big political and economic decisions of the countries. This requires profound changes in thinking, in economic and social structures and in consumption and production patterns.

## 25.5 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

**The convention and the protocol**

Over a decade ago, most countries joined an international treaty — the United Nations Framework Convention on Climate Change (UNFCCC) — to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. More recently, a number of nations approved an addition to the treaty: the Kyoto Protocol, which has more powerful (and legally binding) measures.

This section contains numerous resources — for beginners or experts — such as introductory and in-depth publications, the official UNFCCC and Kyoto Protocol texts and a search engine to the UNFCCC library.

**Facing and surveying the problem**

A major accomplishment of the Convention, which is general and flexible in character, is that it recognizes that there is a problem. That was no small thing in 1994, when the treaty took effect and less scientific evidence was available. (And there are still those who dispute that global warming is real and that climate change is a problem.) It is hard to get the nations of the world to agree on anything, let alone a common approach to a difficulty which is complicated, whose consequences aren't entirely clear, and which will have its most severe effects decades and even centuries in the future.

The Convention sets an ultimate objective of stabilizing greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system." It states that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."

The Convention requires precise and regularly updated inventories of greenhouse gas emissions from industrialized countries. The first step in solving a problem is knowing its dimensions. With a few exceptions, the "base year" for tabulating greenhouse gas emissions has been set as 1990. Developing countries also are encouraged to carry out inventories.

> Countries ratifying (approve and sanction) the treaty — called "Parties to the Convention" in diplomatic jargon — agree to take climate change into account in such matters as agriculture, industry, energy, natural resources, and activities involving sea coasts. They agree to develop national programmes to slow climate change.

The Convention recognizes that it is a "framework" document — something to be amended or augmented over time so that efforts to deal with global warming and climate change can be focused and made more effective. The first addition to the treaty, the Kyoto Protocol, was adopted in 1997.

### 25.5.1 Kyoto Protocol- what it means

The Kyoto Protocol, an international and legally binding agreement to reduce greenhouse gas emissions worldwide, entered into force on 16 February 2005.

**Responsibility and vulnerability**

- The Convention places the heaviest burden for fighting climate change on industrialized nations, since they are the source of most past and current greenhouse gas emissions. These countries are asked to do the most to cut what comes out of smokestacks and tailpipes, and to provide most of the money for efforts elsewhere. For the most part, these developed nations, called "Annex I" countries because they are listed in the first annex to the treaty, belong to the Organization for Economic Cooperation and Development (OECD).
- These advanced nations, as well as 12 "economies in transition" (countries in Central and Eastern Europe, including some states formerly belonging to the Soviet Union) were expected by the year 2000 to reduce emissions to 1990 levels. As a group, they succeeded.
- Industrialized nations agree under the Convention to support climate-change activities in developing countries by providing financial support to these countries. A system of grants and loans has been set up through the Convention and is managed by the Global Environment Facility. Industrialized countries also agree to share technology with less-advanced nations.

Because economic development is vital for the world's poorer countries and because such progress is difficult to achieve even without the complications added by climate change the Convention accepts that the share of greenhouse gas emissions produced by developing nations will grow in the coming years. It nonetheless seeks to help such countries limit emissions in ways that will not hinder their economic progress.

The Convention acknowledges the vulnerability of developing countries to climate change and calls for special efforts to ease the consequences.

## INTEXT QUESTIONS 25.3

1. What is the full form of CSD and when was it established?

   ____________________

2. What is the aim of UNFCCC?

   ____________________

3. What is Kyoto Protocol and when it was adopted?

   ____________________

## 25.6 NON GOVERNMENTAL ORGANISATION

A non-governmental organization (NGO) is an organization that is not part of a government. It is largely funded by private contributions that operate outside of institutionalized government or political structures. NGOs are therefore typically independent of governments. In general, NGOs have their agendas. There are many NGOs that are committed to the cause of wildlife conservation, environmental protection, resource conservation and sustainable development. Activities and areas of important international and national NGOs working in environmental field are given below.

## 25.7 INTERNATIONAL UNION FOR CONSEERVATION OF NATURE (IUCN)

International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental network - a democratic membership union with more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries. IUCN's work is supported by over 1,000 professional staff in 60 offices and hundreds of partners in public, NGO and private sectors around the world. The Union's headquarters are located in Gland, near Geneva, in Switzerland.

IUCN works to develop pragmatic solutions to the most pressing environment and development challenges. It supports scientific research, manages field projects all over the world and brings governments, non-government organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice.

**IUCN's vision and mission**

- To influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.
- The nature provides all the basic requirements of life including water, food, clean air, energy and shelter so it must be protected and used wisely. But social and economic development must also continue to reduce poverty and improve people's lives.
- The backbone of all life on earth, including our own, is biodiversity – the intricate network of animals, plants and the places where they live. Conserving biodiversity – stopping the extinction of animal and plant species, and stopping the destruction of natural places – is the core of IUCN's work.
- Profoundly linked to biodiversity are four of humankind's greatest challenges: climate change, energy, livelihoods and economics. IUCN therefore works on each of these four areas through its core work on biodiversity.

**Functions**

1. **Knowledge**: IUCN develops and supports cutting edge conservation science, particularly in species, ecosystems, biodiversity, and the impact these have on human livelihoods.
2. **Action**: IUCN runs thousands of field projects around the world to better manage natural environments.
3. **Influence**: IUCN supports governments, NGOs, international conventions, UN organizations, companies and communities to develop laws, policy and best-practice.
4. **Empowerment**: IUCN helps implement laws, policy and best-practice by mobilizing organizations, providing resources, training people and monitoring results.

## 25.8 WORLDWIDE FUND FOR NATURE (WWF)

The World Wide Fund for Nature (WWF) is an international non-governmental organization working on issues regarding the conservation, research and restoration of the environment, formerly named the World Wildlife Fund, which remains its official name in the United States and Canada. It is the world's largest independent conservation organization with over 5 million supporters worldwide, working in more than 90 countries, supporting around 1300 conservation and environmental projects around the world. It is a charity, with approximately 60% of its funding coming from voluntary donations by private individuals. 45% of the fund's income comes from the United States, the United Kingdom, and the Netherlands.

The mission of WWF is "to halt and reverse the destruction of our environment" Currently, much of its work focuses on the conservation of three biomes that contain most of the world's biodiversity forests, freshwater ecosystems and oceans and coasts. Among other issues, it is also concerned with endangered species, pollution and climate change.

The organization was formed as a charitable trust on September 11, 1961, in Morges, Switzerland, under the name *World Wildlife Fund*. It was an initiative of Julian Huxley and Max Nicholson, who had thirty years experience of linking progressive intellectuals with big business interests through the Political and Economic Planning think tank. There is also a head office in Toronto, Canada for the Canadian Fund.

In its deed of foundation, the organization stated its original mission to be the "conservation of world fauna, flora, forests, landscape, water, soils and other natural resources by the management of land, research and investigation, and publicity, coordination of efforts, cooperation with other interested parties and all other appropriate means."

In the last few years, the organization set up offices and operations around the world. The initial focus of its activities was the protection of endangered species. As more resources became available, its operations expanded into other areas such as the preservation of biological diversity, sustainable use of natural resources, and the reduction of pollution and wasteful consumption.

In 1986, the organization changed its name to *World Wide Fund for Nature*, retaining the WWF initials, to better reflect the scope of its activities. However, it continues to operate under the original name in the United States and Canada

### Green peace

In 1971, motivated by their vision of a green and peaceful world, a small team of activists set sail from Vancouver, Canada, in an old fishing boat. These activists, the founders of Greenpeace, believed a few individuals could make a difference.

Their mission was to "bear witness" to US underground nuclear testing at Amchitka, a tiny island off the West Coast of Alaska, which is one of the world's most earthquake-prone regions. Amchitka was the last refuge for 3000 endangered sea otters, and home to bald eagles, peregrine falcons and other wildlife. Even though their old boat, the Phyllis Cormack, was intercepted before it got to Amchitka, the journey sparked a flurry of public interest. The US still detonated the bomb, but the voice of reason had been heard. Nuclear testing on Amchitka ended that same year, and the island was later declared a bird sanctuary.

**Greenpeace** is the world's largest grassroots environmental network, uniting 77 national member groups and some 5,000 local activist groups on every continent. With over 2 million members and supporters around the world, they campaign on today's most urgent environmental and social issues. Based in Amsterdam, the Netherlands, Greenpeace has 2.8 million supporters worldwide, and national as well as regional offices in 41 countries. Today, Greenpeace is an international organisation that prioritises global environmental campaigns.

Greenpeace's cornerstone principles and core values are:

- to prevent environmental destruction in a peaceful, non-violent manner;
- financial independence from political or commercial interests;
- seek solutions for and promote open, informed debate about society's environmental choices.

### Vision and Mission

A peaceful and sustainable world based on societies living in harmony with nature. A society of interdependent people living in dignity, wholeness and fulfilment in which equity and human and peoples' rights are realized.

- To collectively ensure environmental and social justice, human dignity, and respect for human rights and peoples' rights so as to secure sustainable societies.

- To halt and reverse environmental degradation and depletion of natural resources, nurture the earth's ecological and cultural diversity and secure sustainable livelihoods.
- To secure the empowerment of indigenous peoples, local communities, women, groups and individuals, and to ensure public participation in decision making.
- To engage in vibrant campaigns, raise awareness, mobilize people and build alliances with diverse movements, linking grassroots, national and global struggles.

## INTEXT QUESTIONS 25.4

1. What is the full form of IUCN and where is its headquarter located?

   ______________________________

2. When and where was WWF formed?

   ______________________________

3. What is the present full form of WWF and what was its earlier full form?

   ______________________________

4. Which ecosystem contains the most biodiversities of the world?

   ______________________________

## 25.9 TATA ENERGY RESAERCH INSTITUTE (TERI)

TERI is a public interest research and advocacy organisation that promotes environmentally sound and equitable development strategies. It was formally established in 1974 with the purpose of tackling and dealing with the rapid depletion of the earth's finite energy resources which are largely non-renewable, and on account of the existing methods of their use which are polluting.

TERI has been actively working for developing solutions to global problems in the fields of energy, environment and current patterns of development, which are largely unsustainable. The Institute has grown substantially over the years, particularly, since it launched its own research activities and established a base in New Delhi, its registered headquarters. TERI has its branches in North America, Europe, Japan, Malaysia and the Gulf.

TERI not only has offices in different parts of the world, but its activities has wide geographical relevance. It organizes annual Delhi Sustainable Development Summit (DSDS), a major event focusing on sustainable development, the pursuit of the Millennium Development Goals (MDGs) and assessment of worldwide progress in these critical areas. TERI has also established a World Sustainable Development Forum (WSDF), which is guided by the patronage of a group of select world leaders. WSDF would extend the experience of each DSDS to other parts of the world and carry out careful evaluation and monitoring of developments worldwide, particularly in meeting the MDGs.

## 25.10 NATIONAL NON-GOVERNMNETAL ORGANISATIONS (NGOS)

### 25.10.1 Centre for Science and Environment (CSE)

The Centre for Science and Environment (CSE) is a public interest research and advocacy organisation based in New Delhi. CSE researches into lobbies for and communicates the urgency of development that is both sustainable and equitable. The challenge of environmental degradation due to extreme exploitation of natural resources on one hand and problems created by rapid industrialization on the other hand, is one of the important task taken up by CSE to bring about a balance of the two. CSE makes efforts to create awareness about problems and propose sustainable solutions.

There is a growing interest amongst all sections of people including students in environmental issues. With this in mind, CSE has been developing non-formal environmental education. Their tools for creating awareness are periodicals publications, films, exhibitions and other products.

Two of their interesting publications are 'Down to Earth' and 'Gobar Times' magazine for children.

### 25.10.2 Kalpavriksh

An NGO estabished in 1979 and works on environmental awareness, campaigns, litigation, research, and other areas. It has taken a position on a number of environment-development issues, more often than not confronting the state through measures ranging from protest letters to street demonstrations. Many of its members have been through an intense and diverse learning process: initiating local protests against the destruction of Delhi's largest green area (the Ridge), treks through the Himalayan region with the Chipko Andolan, the first detailed study of the impacts of the Narmada projects, investigations into police firing in Bharatpur bird reserve, and all this while continuing nature walks and lobbying for wildlife conservation and animal rights. With such a background, it is not surprising that the NGO has continued to participate in mass movements challenging the state and its policies, while episodically supporting elements of the state that have moved progressively on environmental and development fronts.

Kalpavriksh believes that a country can develop meaningfully only when ecological sustainability and social equity are guaranteed, and a sense of respect for, and oneness with nature, and fellow humans is achieved. It is a non-hierarchical organisation and the group takes all decisions after appropriate debate and discussion.

### 25.10.3 Development Alternatives

It is a non-profit organization engaged in research and action for sustainable development. It was established in 1983 and is registered under the Societies Registration Act with the Government of India. Development Alternatives believes that 'development', being a dynamic process, is all about evolving inter-relationships between social and environmental factors, particularly interactions between nature, machines, institutions and people. The activities of Development Alternatives Group broadly cover the three primary areas that underlie any form of sustainable development process: the design and large-scale dissemination of appropriate technologies, environmental management systems and effective people-oriented institutions and policies. Development Alternatives and its associate organisations operate on the philosophy that sustainable development benefits not only the economy, but also the environment and above all - the people. The Development Alternatives Group is, therefore, dedicated to bring about a better balance among the basic prerequisites of sustainable development: social equity, environmental quality and economic efficiency.

The mission of the Development Alternatives Group is to promote sustainable national development.

The corporate objectives are to innovate and disseminate the means for creating sustainable livelihoods on a large scale, and thus to mobilise widespread action to eradicate poverty and regenerate the environment.

The activities of Development Alternatives cover a broad array of development issues. And these issues are complex, requiring sophisticated, trans-disciplinary responses.

The Group has built up a strong capacity to identify the priority issues confronting the nation and devise effective ways to solve them. It has therefore brought together a cadre of professional staff members with a wide range of skills and backgrounds but a common, solid commitment to excellence and team work.

### 25.10.4 Sulabh International

Sulabh International is a social service organization which works to promote human rights, environmental sanitation, non-conventional sources of energy, waste management and social reforms through education. It was founded by Dr Bindeshwar Pathak in 1970.

It has played a defining role in changing the mindset of the people of India towards sanitation. It has played an important role in preventing the practice of defecation in the open and have motivated people for using of toilets and following sanitation practices. Prior to intervention of Sulabh in 1970 toilet was a subject of cultural taboo.

A healthy and hygienic India, free of the practice of defecation in the open and faecal pollution of environment. A society free of untouchability, social discrimination and prevalence of the sub-human practice of manual cleaning of human excreta (scavenging).

**Mission**

To educate and motivate the people, sensitize policy makers and functionaries and promote activities and programmes of the Govt. and as well as the people, to achieve Sulabh's vision in the foreseeable future.

Sulabh has been also working for changing the attitude of people towards those who clean human excreta manually (known as scavengers). Respectability has been lent to discussion and writing about toilet practices. Untouchables (before independence) engaged in the profession of cleaning excreta have acquired social acceptance and people do not hesitate associating with them in their day-today routine and social gatherings.

Sulabh's approach to restore human dignity to the scavengers has five distinct stages:

- Liberation;
- Rehabilitation;
- Vocational training;
- Social elevation; and,
- Proper education to next generation.

Sulabh innovations include a scavenging-free two-pit pourflush toilet (*Sulabh Shauchalaya*); safe and hygienic on-site human waste disposal technology; a new concept of maintenance and construction of pay-and-use public toilets, popularly known as Sulabh Complexes with bath, laundry and urinal facilities being used by about ten million people every day and generates biogas and biofertiliser produced from excreta-based plants, low maintenance waste water treatment plants of medium capacity for institutions and industries.

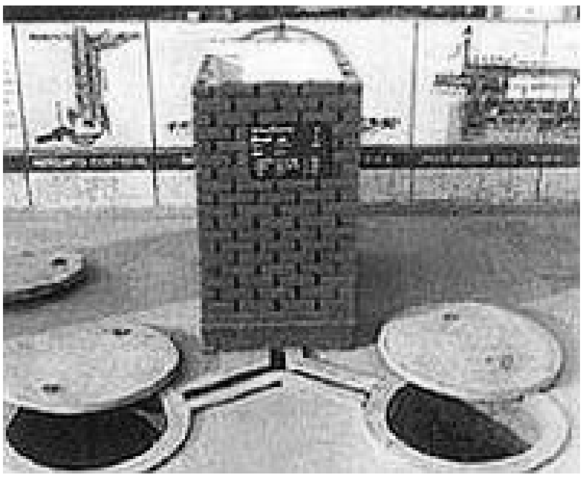

***Fig. 25.1:*** *Two pit pourflush toiled (Sulabh Shauchalaya)*

Other work includes setting up English-medium public school in New Delhi and also a network of centres all over the country to train boys and girls from poor families, specially scavengers, so that they can compete in open job market.

In October 2007, Sulabh announced the design of a cheap toilet system that recycles human waste into biogas and fertiliser.

## INTEXT QUESTIONS 25.5

1. What is the full form of TERI and what was its basic purpose?
2. What is Down to Earth?
3. When was Kalpavriksh established and what is the main function it performs?
4. What is the mission of Development Alternatives?
5. Who founded the Sulubh International. What sort of work this organisation undertake?

## WHAT YOU HAVE LEARNT

- The role of national government is critical for control of environment pollution control, conservation and improvement of environment for promoting sustainable development.
- In 1972, National Committee in Environmental Planning and Coordination (NCEPC) was formed, that gradually evolved and become a full fledged Ministry of Environment and Forests in 1985.
- CPCB (Central Pollution Control Board) is a statuary organization constituted in 1974. Its main function is to monitor, control and regulate air and water quality.
- CPCB advises Central Government on any matter concerning prevention and control of air and water pollution.
- Indian Board for Wildlife (IBWL) is an apex advisory body in the field of wildlife conservation in the country.
- The international environment agencies are: United Nations Environment Programme (UNEP), FAO, WHO, their main job is to coordinate the environment polices for

keeping the global environment under review and bring the issues to the attention of international community for action.

- WHO (World Health Organisation) has the objective as "Attainment by all people the highest possible level of health." Formally came into force on 7th April,1948, thus 7th April is celebrated as World Health Day.
- FAO (Food and Agriculture Organisation ) of the United Nations. Its aim is to modernize and improve agriculture, forestry and fisheries. It ensures food security for all.
- Commission on Sustainable Development (CSD) in June,1992, the landmark global agreement reached for its formation in the Earth Summit held in Rio De Janeiro. It was established in Decemebr,1992.
- Main function of CSD is to monitor the progress and activities related to the integration of environmental and developmental goals by governments, NGOs and other UN bodies.
- United Nations Framework Convention on Climate Change (UNFCCC). The main aim of the convention is to consider what can be done to reduce 'global warming' and to cope with whatever temperature increases are inevitable.
- Kyoto Protocol is an international and legally binding agreement to reduce green house gas emissions worldwide. It came into force in 16th February, 2005.
- Non- government organisations (NGOs) are independent of governments. There are many NGOs that are committed to the cause of wild life conservation, environmental protection, resource conservation and sustainable development.
- International Union for Conservation of Nature (IUCN) is the oldest and largest global environmental network. Its headquarter in Switzerland.
- World Wide Fund for Nature (WWF) is an international NGO which works on issues regarding conservation research and restoration of the environment.
- The national NGOs are Centre for Science and environment (CSE), Kalpavriksh, Sulubh International and Development Alternatives,

## TERMINAL EXERCISE

1. What is the full form of CPCB and what are its main functions?
2. What are Rio+10 and where was it held?
3. Which is the wildlife conservation body in India and what is it called?
4. Which agency of the United Nations develops policy guidelines for environmental programme at international levels?

5. Which disease was totally eridicated by WHO in 1980 ?
6. Write the full form and brief description of the following:
   i. SARS
   ii. AIDS
   iii. WHO
   iv. FAO
   v. NGO
   vi. CSE
   vii. UNFCCC
   viii. TERI
   ix. IUCN
   x. WWF
7. Who is the founder of Sulubh Interantional? State three functions of this organization.
8. Match the following

| A | B |
|---|---|
| Kalpavriksh | Environment magazine |
| Gobar Times | Indian NGO Concern with environment |
| Down to Earth | An Island |
| Greenpeace | Children's magazine |
| Amchitka | International NGO concerned with environment |

9. What does HELI stands for and why was it created?
10. Write main functions of Food and Agriculture Organization.
11. What are the main objectives of Kyoto Protocol?
12. What are the major objectives and functions of IUCN?

## ANSWER TO INTEXT QUESTIONS

**25.1**

1. (i) Ministry of Environment and Forests
   (ii) Central Pollution Control board

(iii) State Pollution Control Board

(iv) Indian Board for Wild Life

2. For planning, promoting, coordinating and overseeing the implementation of environmental and forestry programme in the country.
3. September, 1974
4. (i) Central pollution Control Board, National Ambient Air Quality Monitoring, Indian Board for Wildlife.

**25.2**

1. United Nations Environment Programme. It was created by United Nations General Assembly, Nairobi (Kenya)
2. UNEP is active in funding and implementing environment related development project for promoting sustainable development.
3. World Health Organisation. Its objective is the attainment by all peoples of the highest possible level of health.
4. Small pox is the first disease eradicated/eliminated in 1980 by human efforts.
5. Health and Environment Link Initiative
6. FAO is created by United Nations and its objective is to defeat hunger.

**25.3**

1. Commission for Sustainable Development, established in december,1992.
2. It is an international body to consider what can be done to reduce global warming and to cope with whatever temperature increases is inevitable.
3. Kyoto Protocol is an international and legally binding agreement to reduce green house gas emissions world wide. It started to work on 16$^{th}$ February, 2005.

**25.4**

1. International Union for Conservation of Nature, its headquarter located in Gland, in Switzerland.
2. WWF was formed as a charitable trust, 11 September, 1961 a Morges, Switzerland under the name World Wildlife Fund.
3. Present full form is World Wide Fund for Nature and the earlier full form World Wildlife Fund.
4. Forest, freshwater ecosystems and ocean and coasts contains most of the world's biodiversity.

**25.5**

1. Teri is Tata Energy Research Institute it was established in 1974, basic purpose of setting up of this institute/organisation was to tackle the acute problems of earth's depleting finite energy research.
2. Fortnightly environment magazine publish by CSE (Centre for Science and Environment).
3. 1979 and main function are environmental awareness, campaigns, litigation, research and other areas relating environmental issues.
4. Is to promote sustainable national development.
5. Dr Bindeshwar pathak founded Sulubh International in 1970. It's a social service organisation which provides human rights, environmental sanitation, and non-conventional source of energy, waste management and social reforms through education.

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# 26

# ENVIRONMENTAL ETHICS AND GANDHIAN APPROACH

You have learnt about the basic concepts of environment and the environmental issues. You have also learnt about the need for conservation and management of natural resources. The earth is one, but the world is not. We all depend on one biosphere for sustaining our lives. Yet each community, each country, strives for survival and prosperity with little regard for its impact on others. It is our fundamental duty to make this planet earth a decent habitable place. The challenge of living in harmony with the earth is as old as human society itself. Environmental ethics relates to our obligations and responsibilities towards nature. For an equitable share we must have equal responsibilities. In this lesson you shall learn about environmental ethics, our responsibilities towards environment and the Gandhian approach to environmental protection.

## OBJECTIVES

After studying this lesson, you will be able to:

- *define ethics and explain the importance of environmental ethics;*
- *list the approaches to environmental ethics;*
- *develop a sense of respect for all life on earth;*
- *focus on the need for creating awareness of the environment in children as through nature study;*
- *recall the traditions of harmonious living with nature and correlate religious beliefs and traditional practices of conservation of nature as a whole;*
- *highlight and create awareness about traditional festivals, arts, crafts and ecofriendly techniques, explain how social customs, traditions, beliefs and values influences environment and are in turn influenced by it;*

- *describe various movements of conservation and public participation and emphasize the need for public participation in decision making and natural resource conservation;*
- *convince regarding the need for corporate environmental ethics;*
- *outline Gandhian thoughts and their relevance to the current concern for environment conservation.*

## 26.1 WHAT IS MEANT BY "ETHICS"

Ethics is a branch of philosophy. It deals with morals and values. An ethics is a principle that we use to decide whether an action is good or bad, right or wrong. Being ethical leads to right conduct and good life that is a life worth living.

But one must remember that each one owes some responsibility towards the environment which provides not only food and other materials but also satisfies aesthetic needs of humans comforts.

## 26.2 ENVIRONMENTAL ETHICS AND THEIR IMPORTANCE

Environmental ethics is that part of philosophy which considers the **ethical relationship between human beings and natural environment.**

As already pointed out that it is necessary that humans must learn to live in harmony with nature. You have learnt in earlier lessons that an equilibrium is maintained in natural ecosystems between different components through various processes including assimilation and recycling. But over exploitation of resources by growing human population has upset the natural balance. The use of technology and economic growth have led to ecological problems. The economic progress has been achieved at an enormous cost to the environment as manifested by growing pollution, loss of biodiversity and critical shortage of basic resources. The role of ethics becomes important, therefore, as it helps to assess strengths and weaknesses of a developmental activities such as deforestation, building a dam, mining, draining a wetland etc. There are many ethical decisions that humans need to make with respect to the environment. For example, should one continue to cut forests? How long increasing use of fossil fuel can continue? Do humans have the right to cause extinction of other species? What environmental obligations do we have for maintaining a healthy environment for future generations?

**Box -1**

In the present day context, there are many issues that need serious thinking:-

As urbanization is increasing, so also the need for water, this in turn leads to drawing of ground water. Over exploitation of sub-soil water has led to rapid decline in the level of water table, and if this continues for long, soon many areas would become a desert. The question is that are human needs more important or is it necessary to protect the environment. Recently the Supreme Court has banned construction and boring of new tubewells in the Aravalli region of Faridabad (Haryana) in adjoining Delhi. Hopefully, these measures may prevent rapidly depletion of vegetation and ground water in the area.

**Box - 2**

Industrial waste, both solid and liquid are usually dumped indiscriminately into the surrounding land and water bodies. Is it ethical to throw the waste outside ones' boundary? Can any industry afford not to be insensitive to the environment? Are the birds, animals, plants, soil and water quality not important to an entrepreneur or should he/she only be concerned about his/her profits?

Environmental ethics is the guiding force that should make every human care for their surroundings.

Environmental ethics exerts influence on a large range of disciplines including law, sociology, theology, economics, ecology and geography. It makes us think on several issues such as are humans more important than wildlife? Do animal have rights? What responsibility do we have towards non-human world? Such questions are the pressing issues of environmental ethics.

## 26.3 APPROACHES TO ENVIRONMENTAL ETHICS

All ethics so far evolved rest on a single premise, that the individual is a member of community of interdependent components. Human instincts prompt to compete for the place in that community but ethics prompt humans to also cooperate.

There are basically **three** approaches to environmental ethics. One view is that humans are the dominant and important species on the planet earth. That gives them the power to manipulate and use nature for their own benefit. This view is "human centred" and thus it is called **anthropocentric.**

A second human centred view is that humans have the ethical responsibility towards future generations of human beings so humans are the 'stewards or caring managers' who must leave earth in a good condition for future generations. The critics of anthropocentric view point talk of human ignorance. They feel, humans yet do not know how many species live on the earth, how they interact with the environment and with each other. Environmental wisdom talks of total dependence of humans on nature and the nature is for all species. This is **life centric** or **biocentric** approach.

An extension of the above view seeks respect for all life and demands reverence towards the entire environment. Such a non-anthropocentric approach that talks of ethical responsibility towards other species and even ecosystems is also called **ecocentric.** According to this view point, it becomes compulsory to save the planet. The basic fact is that humans cannot erode the planet completely, but it can destroy us in entirely. It is our basic necessity to protect the environment so that we can ensure our survival, and prevent ourselves from perishing.

Therefore it can said that everything in nature and all natural systems have intrinsic value. If mankind has to survive, the environment needs to be protected.

## 26.4 RESPECT FOR ALL LIFE ON EARTH

In order to survive on this planet in a sustainable manner, one must remember the following:

- All we need for our survival and consume comes from nature.
- We know very little about planet earth.
- Humans are dependent on other organisms for survival , hence they have a responsibility towards them.

The earth is our home and home for all other living beings too. We need to remember the age old adage "live and let live". We are duty bound to defend our planet from any harm and if it is wounded we have to assist in its recovery.

## INTEXT QUESTIONS 26.1

1. Define (i) ethics (ii) environmental ethics

2. Name the approaches to environmental ethics.

3. State one justification for environmental ethics.

## 26.5 TRADITIONS OF HARMONIOUS LIVING WITH NATURE

Indian philosophy aims not only at the well being of all humans but also of all beings. The Sanskirt verse: "**Sarve Bhavantu Sukhinah Sarve Santu Nirmayah**"

Refers to "**May all be sinless and may all experience happiness**."

The Vedas, Mahabharata and Ramayana all chant praises about cosmic harmony and environmental protection. These Indian systems respect not only humans but also care about welfare of other beings.

Nature and environment were given importance from Rigvedic period onwards. Verse states- "the sky is like a father, the earth like a mother and space like their son". The universe is a family of three if any damage occurs to one-the universe goes off balance.

In many of our states, new year begins and is celebrated with the harvesting of the rabi crops in the month of April. Baisakhi in Punjab, Nabo Barsho in Bengal, Tamil and Telugu new year of Tamilnadu and Andhra Pradesh are few examples. In Kerala Vishu Kini is celebrated at this time when folks arrange and decorate small mounds of grains, vegetables and fruits and consider it auspicious to see them on the morning of first day of the festival.

Indian festivals, traditional art and crafts also can be looked into from the viewpoint of environmental ethics. Worship of plants and animals has long been known in India.

**Box - 1**

Colours from tesu (flame of the forest) flowers, pomegranate peel, turmeric are used a sources of different colours, earthen lamps, vegetable oil and cotton wicks are used for decorating homes during special occasions. Special food items are prepared at some festivities to highlight the importance of different plants and plant products that laddoo made from Amaranthus (ramdana or chaulai) are eaten .

**Box -2**

In various parts of the country, people worship various animals and plants. A large number of Hindu Gods have a "Vahana" i.e. vehicle that they ride. The goddess of wealth Lakshi rides an owl, Durga is astride a tiger and Saraswati sits on a swan expresses colaboration between human and gods. Plants like tulsi, banyan and banana, coconut fruit are worshipped; turmeric is used in rituals considered auspicious associated with Hindu, Islamic and Buddhist cultures. Clumps of trees (ranging from bamboo in eastern Himalayas to forest in Himachal Pradesh) or a portion of the forest is considered as the place where gods or spirits of ancestors reside. Thus they are left undisturbed and the area is considered 'sacred groove'. The sanctity of the area ensures that the flora and fauna flourish and biodiversity is maintained. In India, the Bishnois of Rajasthan have sacrified their lives to protect sacred 'khejdi' trees.

It is recorded that some sacred groves have water bodies within their boundaries. Hunting, logging etc. is prohibited and these areas are preserved for generations. They represent native vegetation in natural or near natural state. In the Himalayas Sherpas considered certain mountains as sacred and do not climb into them (for conquering peaks during expeditions)

**Box – 3**

Approximately 13,720 sacred groves are known to exist in India. Cutting of plants and killing of animals is prohibited through social traditions and taboos. Dead wood collection, honey gathering is allowed. Many such groves are found around shrines, monasteries and burial grounds in the various parts of the country.

## 26.6 INCULCATING ENVIRONMENTAL ETHICS

It is common knowledge that we acquire habits and attitudes in our childhood. The values inculcated during childhood stay life long. Therefore, it is extremely important to inculcate respect for the environment in every child. If children are exposed to live issues, they understand and try to resolve them when they grow up to be administrators, policy makers, teachers, home-makers or politicians.

In the school curriculum activities such as (i) growing plants and taking care of them (ii) visits to national parks and sanctuaries (iii) creating stories/ poems/ plays on nature conservation, should be included. Tree plantations for 'greening schools' and its neighbourhood, weeding lawns, making attractive posters and messages related to environment should become competitive events every year for various classes.

Nature study should inculcate in the children love for living beings and urge for maintaining the surroundings.

The 'land ethic' is an idea that should be created in every citizen's mind. According to this, each person is a citizen of the land and thus responsible for its "health". Health is the capacity of land for self-renewal. Conservation is our effort to understand and preserve this capacity.

## INTEXT QUESTIONS 26.2

1. Why must children be made aware of environmental ethics?

2. State two traditions which express life in harmony with environment.

3. What is a 'sacred grove'?

## 26.7 CONSERVATION MOVEMENT AND PUBLIC PARTICIPATION

- Government alone cannot take up the burden of creating awareness and ensuring a clean environment. There is a need for public participation at every step. If the common man is aware of what is going on at the local and national level, thus surely decision-making by the authorities can be influenced.
- The Silent Valley project in the Western Ghats was abandoned due to protests environmental activists and by public representation. It helped to save the rain forests of that area which is one of the hot spot of biodiversity in the world.
- You have already learnt that the Bishnois of Rajasthan had once upon a time laid down their lives to protect the local Khejdi trees (*Prosopis spicigera*)
- A noted environmental activist and lawyer M.C. Mehta filed a public interest litigation (PIL) against the Union, Government of India. His interest was to protect India's Taj Mahal from the effluents of the Mathura refinery. This landmark case created awareness about the right of every citizen to clear air, water and land. It also opened the doors for many other PILs and the judgement given by the court.
- Some such cases are those that caused the shifting of polluting industries from Delhi and NCR (National Capital Region); the compulsory use of CNG (Compressed Natural Gas) for buses in Delhi and NCR the use of the campaign, 'Green Fuel Clean Fuel' led to the use of unleaded petrol for cars in Delhi (first time in India). Also these show that awareness or activism by individuals public organizations, NGOs etc. can definitely lead to a cleaner environment.
- The agitation against dams is a controversial issue, and the Narmada Bachao Andolan has been very actively pursing the case of the Narmada Dam oustees (people displaced due to construction of the dam). Similar instance have arisen over the Tehri Dam.

Awareness in public domain also leads to positive and fruitful cooperation between the government and people of the area. Joint forest management practices have participation of the official machinery and local inhabitants in forest conservation, aforestation, wild life management and also other natural resources.

## 26.8 CORPORATE ENVIRONMENTAL ETHICS

Ethics is also necessary in business management. One of the important lesson learnt during the past century is that the economy and environment are dependent on each other. A clean environment is now taken as one of the basic social responsibilities of the corporate world. The industry produces a large amount of waste products and disposal of waste or lowering of pollution levels has a cost. The cost of controlling waste determines a company's profit margins. This is why it is cheaper to dump wastes into river than to install a waste water treatment facility; it is cheaper to release waste in the air than to trap them in filters. Such pollution is unethical and immoral, but the corporate world may adopt such practices to cut costs and make profits. However such decisions are based on short term profitability rather than long term benefit to society.

Recent environmental movements have moved the business community towards environmental ethics. Industrial houses have now become interested in efficient, green and clean technology. The use of solar cars and technology with low carbon foot prints.

In some of the metropolitan cities, corporate houses have taken charge of developing and maintaining green patches and "gardens" to act as the "lungs" of the city. Corporate houses also sponsor prizes for competitions of school going children and college going youth on themes and topics of the environment.

Above all EIA (Environment Impact Assessment) has enforced the environmentally ethical operations of all new business projects.

> Many public participation functions or movements now follow and endorse eco-friendly practices e.g. an NGO in Pune (Nirmalaya) makes compost out of flowers offered at Ganesh Chaturthi and offers it to the earth.
>
> Many Durga Puja committees have re-discovered traditional organic paints and other techniques to avoid using toxic plastic paints and non-biodegradable material for making idols and for decorations at the puja venue
>
> (Also read box 19.1 of lesson 19 on Concept of Sustainable Development.

## INTEXT QUESTIONS 26.3

1. Give on example of PIL which led to taking steps against environmental pollution.

   ______________________________

2. What is meant by corporate environmental ethics?

   ______________________________

3. State one ethical step take by business houses in honour of the environment.

   ______________________________

## 26.9 GANDHIAN THOUGHT AND THEIR RELEVANCE TO CURRENT CONCERNS FOR ENVIRONMENT CONSERVATION OR GANDHIAN LEGACY

The life and work of Mohandas Karamchand Gandhi (1869-1948) have had a considerable influence on the environmental movement in India. Mahatma Gandhi has been acknowledged as the 'patron saint' of the Indian environmental movement. Environmental activists have relied heavily on Gandhian thought of non-violent protest or satyagrah and have drawn heavily on Gandhain philosophy against heavy industry which may displace or crush the poor and downtrodden.

The chipko movement (Chandi Prasad Bhatt and Sunder Lal Bahuguna), Baba Amte and Medha Patkar (Narmada Bachao Andolan) all derived inspiration from Gandhi. Other groups like Sulabh International that work for uplifting of Harijans and sweepers, who once lifted night soil were also inspired by Gandhian thought. Gandhi was indeed an "early environmentalist" who anticipated the environmental crisis of the modern industrial society. His writings in 'Hind Swaraj' published in 1909 explained how the current mode of development is "exploitative of man by man and of nature by man".

The Gandhian emphasis on frugality and simple life does not mean that environmental ethics is contradictory to pleasure. However, it is to be understood that there is no pleasure in wasteful consumption. Pleasures come from living in harmony with each other and with nature. Pleasures should not be based on exploitation of creatures. It should not harm the earth, but it should come from creative work and activity and cooperation. Environmental ethics also teaches us to appreciate the harmony in nature and its bounties.

Environmental considerations must form an integral part of all planning for India's growth and development, last but not the least, let us not forget what Gandhiji said:

"**Mother Nature has enough for our needs but not enough for our greed**."

## INTEXT QUESTIONS 26.4

1. Who are the founder of Chipko movement?

   ______________________________

2. What type of work does Shulubh International?

   ______________________________

3. Why Gandhiji was known as early environmentalist?

   ______________________________

4. What was the main slogan of Gandhiji?

   ______________________________

## WHAT YOU HAVE LEARNT

- The planet earth is the only habitable space for humans.

- An ethics is a principle that we use to decide whether an action is good or bad, right or wrong. It is branch of philophy which deals with morals and values.
- Environmental ethics is the part of philosophy which considers the ethical relationship between human beings and natural environment.
- We must learn to respect nature, all living creatures and remember that our resources are finite.
- Nature and environment were given importance from Rigvedic period onwards.
- Traditional practices have been environment friendly.
- Activities such as growing plants, visits of national parks and sanctuaries, creating stories or poems or plays on nature should be included in school curriculum.
- Modern day indiscriminate use of resources and increasing pollution loads have led to dangerous results thus the need to inculcate environmental ethics.
- Gandhian philosophy promotes the concept to co-existence with nature.

## TERMINAL EXERCISE

1. What is meant by environmental ethics?
2. What are the approaches to environmental ethics?
3. Why is it necessary to have environmental ethics?
4. With the help of a suitable example, explain how the concept of environmental ethics as promoted in Indian Scriptures.
5. What is meant by "sacred groves"?
6. It is necessary to make children aware of environmental issues. Why?
7. In what ways can business houses practice environmental ethics.
8. What is meant by Gandhijis statement, "Mother nature has enough for our needs but not enough for our greed".
9. Relate three traditional practices as examples of environmental ethics.
10. Collect material to write notes on -

    (i) Chipko movement.

    (ii) Narmada Bachao andolan highlighting the environmentaly unethical moves and the protests against them.

## ANSWER TO INTEXT QUESTIONS

**26.1**

1. (i) It is a branch of philosophy. It deals with morals and values.

   (ii) Environmental ethics is at the part of philosophy which considers the ethical relationship between human beings and natural environment.

2. Anthropocentric, eccentric, biocentric or life centric.

3. If mankind has to survive, the environment needs to be protected.

**26.2**

1. Because they should acquire habits and attitudes in their childhood. It is necessary to inculcate the respect for the environment in the beginning.

2. Respects to nature; respect to plants and animals.

3. An area ensures that the flora and fauna flourish and biodiversity is maintained. These areas are preserved for generations.

**26.3**

1. M.C. Mehta file a PIL for protection of Taj Mahal from the effluents of the Mathura refinery.

2. To provide a clean environment to the nation is the basic responsibility of corporate world.

3. Use of green and clean technology, development of green patches and gardens (any one)

**26.4**

1. Chandi Prasad Bhatt and Sunder Lal Bahauguna

2. For uplifting of Harijins and sweepers who once lifted night soil where also inspired by Gandhian thought.

3. He anticipated the environmental crisis of the modern industrial society.

4. Mother Nature has enough for our needs but not enough for our greeds.

# 27

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# GLOBAL CIRCULATION OF WATER

More than three-fourths of the earth's surface is covered by water. Water is an odorless, tasteless, substance than can naturally exist as gas, liquid and solid within a relatively narrow range of air, temperature and pressure found on the earth's surface. It is absolutely essential for survival of all living beings. Though water is apparently available in abundant quantity, there is scarcity of usable quantity of water in a large part of the world.

In this lesson we shall examine the ways by which water flows through the environment. You will learn about the global distribution of water, its different sources and how it circulates through the global hydrological (water) cycle. Though earth is not the only planet which has water, it is the only planet that has the conditions suitable for the constant global circulation of water. We shall also look into the significance of fresh water in the life processes.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define what is meant by fresh water;*
- *explain the importance of fresh water in nature;*
- *recall that water is a renewable resource;*
- *identify different sources of water and its importance for life;*
- *explain the term precipitation and evaporation;*
- *illustrate diagrammatically various steps involved in hydrological cycle.*

## 27.1 GLOBAL DISTRIBUTION OF WATER

A little over 97% of the water on earth is salt water which is present in the oceans. We cannot drink salt water or use it for irrigation of crops. It is technologically possible to remove salt from ocean water, but then it is a very expensive process. Only 2.7% of the water present on earth is fresh water and it contains less than 1000 ppm of dissolved solid of any type. About 2% of the earth's fresh water (i.e. about 66% of all fresh water) is in solid form, locked in ice caps of Antarctica and glaciers that occupy high alpine locations. Because it is frozen and far away, fresh water in ice caps is not available for use. That leaves about 1% of all the earth's water in a form useable to humans, plants and land animals. The fresh water is found in lakes, rivers, streams, ponds and in the ground. A small amount (0.001%) of water is found as vapor in the atmosphere (Fig. 27.1). The distribution of fresh water, however, is geographically uneven, varying greatly from country to country and even within a country from one region to another region.

For instance some areas of the world have a rich supply of fresh water, while others are arid or semi arid areas with limited supplies. In certain areas, much of the rain water is not used due to lack of adequate arrangements for storing water. Thus, much of this water is wasted, or cause serious flooding, with resultant loss of life and property.

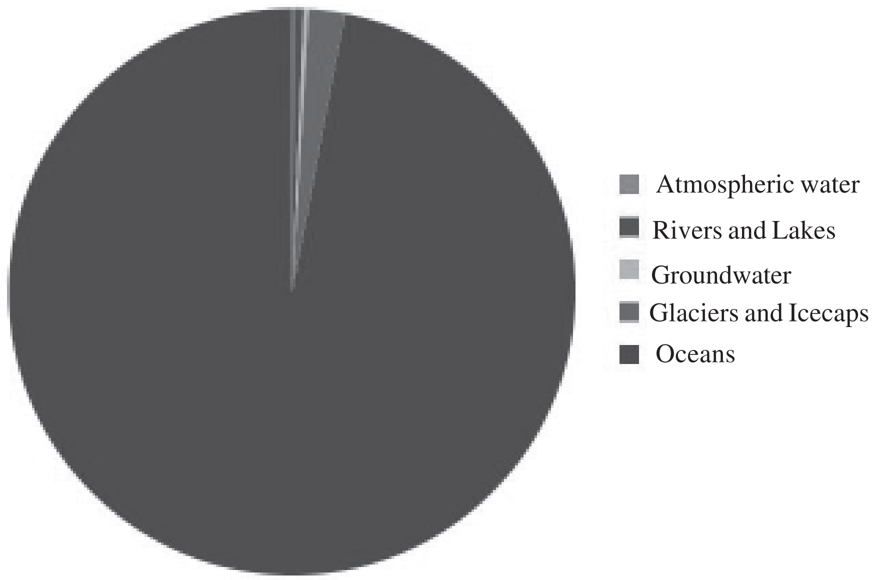


***Fig. 27.1:*** *Distribution of water on earth.*

Though water is a renewable resource, but fresh water is finite. Fresh water is a scarce resource in many parts of the world including India. It is under increasing pressure as a result of pollution of water sources and increasing demand of the growing population. Worldwide consumption of water has increased six fold. This is more than twice the rate of population growth.

## INTEXT QUESTIONS 27.1

1. Which part of earth is covered with water?

______________________________

2. To be considered as fresh water, how much solids can be there?

______________________________

3. In arid and semi arid areas what is true regarding the amount of water present.

______________________________

## 27.2 IMPORTANCE OF WATER FOR LIFE AND HABITAT

- Water is an inescapable necessity for all life on earth. It is the most important component of protoplasm in the cells of living organisms. On an average, 70% of our body is made up of water. Water is also the only source of hydrogen and one of the many sources of oxygen available to the body through metabolic processes.
- Water is also an important ecological factor that determines the structure and functioning of ecosystem. The different biomes of the earth are the result of the differences in temperature and precipitation patterns in those regions. In fact, the cycling of all other elements depends on water as it serves as a medium for their transportation during the various steps and is the solvent medium for the nutrient uptake by the plants and other organisms.
- The world's oceans have an even greater effect on global warming than forests do. Water has a greater capacity for heat absorption, and since the greater part of the earth's surface is covered by water, the temperature of the atmosphere remains fairly constant. In addition to the climate moderating influence of oceans, they also support an enormously large population of photosynthetic plankton that account for most of the photosynthesis on the earth. As you would recall, without photosynthesis there would not be enough oxygen to support life.
- Fresh water ecosystems are the main sources for drinking water, agriculture, industry, sanitation, as well as for fresh water fisheries. Fresh water also provide recreational opportunities (swimming, rafting, snorkeling) and a means of transportation (ships, boats, canoe etc). In addition, fresh water ecosystems are home to numerous organisms (fish, amphibians, aquatic plants and invertebrates). It has been estimated that 40% of all known fish species on earth are found in fresh water ecosystems.
- Human survival since the ages has depended on the relationship between human settlements and availability of fresh water resources. Many early civilizations have

grown and flourished on riverbanks. Availability of fresh water at appropriate times and in suitable quantity and quality is vital to ecological health of a country as well as vital to the towns and cities. It is required for irrigation, domestic use and industrial needs. Worldwide approximately 70% of water is used for agriculture and only 1.1% is used for domestic and municipal supplies and the rest is used by various industries.

No matter whom we are or where we are, we all depend on water in so many ways. We need it to stay healthy, for its sheer life giving properties. However, despite the importance of fresh water resources in our lives, we are beginning to take this resource for granted. Much water is being wasted, used inefficiently and polluted through human activities. Per capita availability of fresh water is declining all over the world. In the past two decades, as a result of developments and mismanagement of fresh water resources have resulted in huge water shortages. Water crisis has not only affected crop production but it has also impacted the environment quality, wildlife and other living creatures.

Fresh water resources form an intrinsic part of the earth's hydrological cycle. You will learn more about the global hydrological cycle in the next section.

## INTEXT QUESTION 27.2

1. State any two important uses of water for maintaining life on earth.

2. Why did early civilizations settle near river banks?

3. Why there is an increasing shortage of fresh water? Give two reason?

## 27.3 GLOBAL HYDROLOGICAL CYCLE

Fresh water for human needs and the maintenance of the natural environment and ecosystems is supplied through a continuous movement of water in all its forms (ice, liquid and vapour), by a system known as **hydrological cycle**. This cycle is driven by solar energy. It involves a continuous recycling of water between the atmosphere, land and oceans by several processes (Fig. 27.2). Within the atmosphere vertical and horizontal air movements including winds, transfer moisture from place to place. The streams, rivers, glaciers transfer water from land to the oceans where large scale currents transfer water within the oceans.

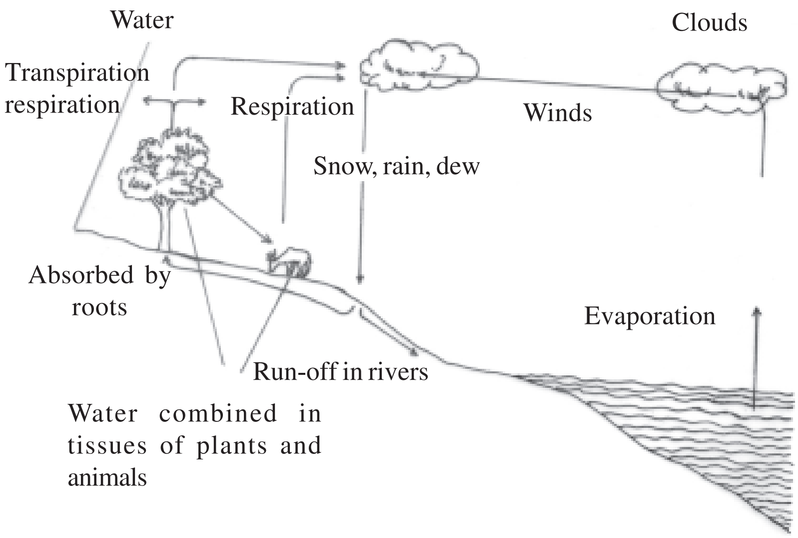


***Fig. 27.2:** Global hydrological cycle*

The three main processes involved in the hydrological cycles are –

- evaporation and evapotranspiration;
- precipitation and
- surface runoff.

Atmospheric water, surface water and ground water are all part of this hydrological cycle. Let us now consider how water recycles within and between these regions through the above mentioned processes.

### 27.3.1 Evaporation and evapotranspiration

The largest reservoirs of water on the earth's surface are the oceans. Studies have shown that the oceans, seas and other water bodies like lakes, rivers and streams provide about 90% moisture to the atmosphere through evaporation each day. You are familiar with the term **evaporation**. It is the phase change of liquid water into vapour or gas on heating. This heat as you know is provided by the sun. In addition, some portion of water vapour enters the atmosphere through sublimation, a process by which water changes from solid state that is ice, directly into vapour without changing into liquid form. Also, plants loose large quantities of water through **transpiration** release about 10% of the water in the atmosphere. During transpiration water is transferred through the soil by capillary action and from the soil through the roots of the plants by osmosis and then taken up to the leaves. Since it is difficult to separate the processes of transpiration and evaporation, **evapotranspiration** is generally used for describing the combined process of evaporation and transpiration. These three processes together provide all the water to the atmosphere.

### 27.3.2 Precipitation

After water enters the lower atmosphere, it is carried upwards by the rising air currents. High up in the atmosphere the air cools and loses its capacity to hold water vapour. As a result the excess water condenses i.e., changes from vapour to liquid and forms cloud droplets. The droplets ultimately grow in size and cause **precipitation**. These are four major types of precipitation namely drizzle, rain, snow and hail. Thus most of the water is returned to the oceans and on land in the form of rain, snow, hail etc.

### 27.3.3 Surface runoff

When precipitation falls over land, it travels through various routes. Some of it evaporates back into the atmosphere; some of it enters the ground and is stored as ground water. Ground water is found in two layers of the soil:-

- Zone of aeration where the gaps are completely filled with water.
- Zone of saturation where the gaps are filled with water air as well as water. Boundary between these two zones is known as the **water table**, which rises or falls as the level of ground water increases or decreases.

This water is discharged either directly or indirectly into the rivers and seas by way of springs. The rest of the water moves as surface runoff into streams and rivers and ultimately flows into the ocean or other water bodies from where it enters the cycle again.

At different stages of the water cycle human beings and other organisms intercept it and withdraw water for their use. As water continually evaporates, condenses and precipitates, the rate of evaporation and rate of precipitation at a global level is equal and the total amount of water vapour in the atmosphere is approximately the same over time. But evaporation over the continents is less than precipitation while the converse is true over the oceans.

### 27.3.4 Balance and stores of water

The total volume of water in the hydrological cycle is estimated approximately to be 1,384 million $km^2$. The global water cycle involves many complex pathways and stores. At any time, maximum water is stored in the oceans and seas (Table 27.1). Most of the freshwater as mentioned earlier is stored as ice and in polar caps and in glaciers. If all of this ice were to melt then it would release enough water to keep the rivers of the world flowing for up to 1000 years!

*Table 27.1: Natural stores of water in the global hydrological cycle*

| Stores | Percentage (%) |
|---|---|
| Oceans | 97.71 |
| Ice caps | 1.9 |
| Ground water | 0.5 |
| Soil moisture | 0.01 |
| Lakes and rivers | 0.009 |
| Atmosphere | 0.0001 |

Though rivers play a vital role in the water cycle, they are not the major stores of water in the way that oceans are. They are conduits rather than stores. Lakes stores more water than rivers and for a longer time. About two thirds of all fresh water on the surface is stored in the 250 large lakes of the world.

Water moves through these stores and this movement keeps the hydrological cycle running, though different stores keep the water for different times. Oceans, ice caps and glaciers are long term stores, whereas rivers and atmosphere are short term stores. It becomes clear from table 27.2 and fig.27.1 that relatively small amounts of water are recycled very fast and most of the water is trapped in long term stores.

*Table 27.2: The global water cycle storage times*

| Store | Typical residence time |
|---|---|
| Plants and animals | 1 week |
| Atmosphere | 8-10 days |
| Rivers | 2 weeks |
| Soil | 2 weeks to a year |
| Lakes, reservoirs, wetlands | Years |
| Ground water | Days to thousands of years |
| Ice | Thousands of years |
| Oceans | Thousands of years |

## INTEXT QUESTIONS 27.3

1. What is surface run-off?

2. Name three long-term stores of water.

3. How long can water be stored in the body of a living organism?

## 27.4 INDUCED CHANGES IN THE HYDROLOGICAL CYCLE

Human activities can alter the global water cycle in many ways, either deliberately or by accidentally.

- The movement of water vapour across oceans and continents can be altered by air pollution which can cause global warming. Significantly changes in precipitation patterns inevitable as precipitation is dependent on ambient temperature.
- Evaporation rate and pattern change due to altered ground surface conditions. For examples, urbanization or development of reservoirs affect evaporation rate.
- Increasing or decreasing the length or density of the river channels, can directly change river runoff.
- Ground water can be affected by pumping out excessive water that lowers the water table or through increased percolation of due to water logging to development of reservoirs and dams.
- Altering the vegetation pattern from deforestation, cropping or afforestation etc. can significantly greater influence of runoff water.

## INTEXT QUESTIONS 27.4

1. How does global warming change movement of water vapour across oceans and continents?

______________________________________________

2. How can river run-off be altered?

______________________________________________

3. State one way of reducing water table.

______________________________________________

## WHAT YOU HAVE LEARNT

- Water is probably the most important renewable natural resource on planet earth.
- 97.41% of the water on earth is salt water found in the oceans. About 2% of the earth's fresh water is in solid form, locked in ice caps and glaciers. This fresh water is found in lakes, rivers, streams, ponds, and in the ground.
- Water is essential for life, and since the earliest time humans have relied on fresh water ecosystems for drinking water, for agriculture, industry, sanitation, as well as for food.

- Much water is being used inefficiently and polluted through human activities and per capita availability of fresh water is declining all over the world.
- Fresh water resources form an intrinsic part of the earth's hydrological cycle.
- The hydrological cycle involves the continuous recycling of water between the atmosphere, land and oceans.
- The basic structure of the cycle is simple. Water is evaporated from oceans, rivers, lakes and vegetation, becomes part of the atmospheric moisture. Global winds distribute this across the earth's surface. Condensation creates clouds and precipitation brings it back to the surface from where it evaporates to re-enter the global water cycle.
- Human activities can alter the global hydrological cycle in several ways.

## TERMINAL EXERCISES

1. How does hydrological cycle is driven?
2. In which form water locks in ice caps?
3. Where did primitive human settlement find?
4. 'Living beings cannot survive without water'. Explain this statement in your words.
5. Draw a neat diagram to depict the movement of water in the hydrological cycle.
6. What is the role of oceans in the water cycle?
7. What is precipitation? When does it occur?
8. State three ways by which usable water is becoming scarce.
9. What is meant by global circulation of water?
10. Explain in brief about the various steps involves in hydrological cycle.

## ANSWERS TO INTEXT QUESTIONS

**27.1**

1. More than ¾
2. Less than 1000 ppm
3. limited

**27.2**

1. Metabolic source of hydrogen (H)/ component of protoplasm/ resource for agriculture/ keeps atmospheric temperature within limits or constant
2. Water was available easily for consumption/irrigation.
3. Water is wasted/used inefficiently/ polluted (any two)

**27.3**

1. Precipitation reaching land and traveling through various routes
2. Oceans, Ice caps, glaciers
3. 7 days

**27.4**

1. Changing precipitation patterns
2. Increasing or decreasing length/ density of river channels
3. Dumping out excessive water.

# 27

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# IMPORTANCE OF ENERGY IN SOCIETY

Energy is the capacity to do work and power is the rate of energy delivery. Energy is essential for most activities of modern society. Its use or consumption is generally taken as an index of standard of living. We use energy in the form of fire wood, fossil fuels and electricity to make life comfortable and convenient.

At home we use electricity for our lights and fans, air-conditioner, water heater and room heaters, oven, microwave, washing machine and drier etc. We use petrol, diesel, CNG for our cars, buses, autos etc. Large amount of energy is consumed in agriculture and industry. In offices we use energy to run air conditioners, fans, lights, computers, copying machines etc.

We use fossil fuel to run buses, trucks, trains, aeroplanes, ships etc and thus transportation uses a large percentage of all the energy used. In this lesson, we learn about the role of energy in society.

## OBJECTIVES

After completing this lesson, you will be able to:

- *explain the concept of energy;*
- *explain the importance of energy for human society;*
- *explain the 1st and 2nd law of thermodynamics;*
- *list various sources of energy.*

## 27.1 WHAT IS ENERGY?

**"The ability to do work"**

Energy from the sun gives us light during the day. It dries our clothes when they are hanging outside on a clothesline. It helps plants and crops to grow. Energy stored in plants is eaten by animals (herbivores), giving them energy. Predator animals eat their prey, which gives the predator animal energy. When we eat food, our bodies transform the energy stored in food into energy to do work. When we talk, run or walk, think or read we "burn" food energy in our bodies. But where does energy come from?

## 27.2 LAWS GOVERNING ENERGY

The **First law of thermodynamics** deals with conservation of energy. It states that energy cannot be created or destroyed but can only change from one form to another. For example, the energy of the sunlight is absorbed by the green plants it in the process of photosynthesis and store the solar energy as chemical energy in form of food or biomass.

The **Second law of thermodynamics** states that in every energy transformation, some energy is always lost in the form of heat which is unavailable to do further useful work. In other words no energy transformation is hundred percent efficient i.e., at each energy transformation some energy is lost as waste heat and dissipated into the environment.

Heat is familiar to everyone because we all know how it feels in hot summer and cold winter days. The degree of hotness of a body can be measured with a thermometer, which contains a fluid that expands as the temperature rises. Heat is one of the many forms that energy can take and heat is one form of energy into which all the other forms of energy can be fully converted. It is for this reason that a measure of heat, the *Calorie (Cal) or Joule* is used to express the amounts of energy.

*A gram Calorie (c): It is the amount of heat required to raise the temperature of one gram of water through one degree centigrade* (from 14.5°C to 15.5°C) *and is the unit in which energy value of food or any other organic matter is expressed, although it is now being replaced by joules.*

*Joule (J): A practical unit of work. It is the derived SI unit of energy/work, being the work* done when a force of one *Newton* displaces the point by one metre.

Energy in the form of heat is hard to harness because the molecular motions are chaotic. Heat is a degraded energy and cannot do any work if every thing is at the same temperature. If there are differences in temperature, the chaotic motions can tend to spread from points of concentration (high temperature) to points of lesser concentration (low temperature).

## INTEXT QUESTIONS 27.1

1. How would you define energy?

2. What is a gram calorie?

_______________________________________________

3. What is the SI unit of energy?

_______________________________________________

4. State the First and the Second law of thermodynamics.

_______________________________________________

## 27.3 SOURCES OF ENERGY

Energy being so essential for our lives, it is important for us to know about the various sources of energy. Energy sources are broadly divided into two categories, namely, renewable (an energy source that we can use over and over again) and non renewable sources (when the energy source cannot be reused).

### 27.3.1 Renewable sources

Renewable energy is the term used to describe energy that comes from sources whose supplies are regenerative and virtually inexhaustible. Renewable energy sources can be replenished in a short period of time. Some of the important renewable sources of energy are described below:

(i) **Solar energy**

The most common energy received on our planet (Earth) is the direct sun light. Solar energy is inexhaustible and it comes to earth in the form of visible light and infrared radiation. We have always used the energy of the sun as far back as humans have existed on this planet. People worship sun as "Sun God" because it is sun energy which runs the earth. Every day we use the energy of the sun in many different ways. Without sunlight life would not exist on our planet. Plants use sunlight to make food. Animals eat plants as food. Decaying plants, hundreds of millions of years ago produced fossil fuels - coal, oil and natural gas, thus what we use today is actually sunlight stored millions and millions of years ago. As consumption is increasing it is getting depleted fast. Although the amount of solar energy reaching the earth's surface is immense, but it is not easy to store and transport.

Solar energy can be harnessed in a variety of ways to heat homes, heat water, grow plants and produce electricity. Solar power includes active, passive, and photovoltaic technologies and practices. Active and passive solar technologies use the sun's energy for cooking, space heating, and water heating. Photovoltaic (solar cells), convert solar energy directly into electricity. The simplest solar cells are used to energise watches and calculators and the like, while more complex systems of large panels of solar cells can light houses, provide power to space crafts and satellites. Currently, there is a renewed interest in developing innovative ways to use solar energy for reducing our dependence on fossil fuels.

(ii) **Biomass**

Biomass energy or bioenergy is the energy from organic matter such as fire wood, twigs, dead plant parts, cattle dung, livestock manure and dead animal matter. Plant leaves convert sunlight into chemical energy, which is stored in the plants.

Animals that eat the plants store chemical energy in their bodies; some of it also remains in manure and other wastes. Biomass fuels are renewable because the raw materials can be produced simply by growing more crops or collecting more organic waste. The use of renewable energy is not new, traditionally wood has been as the main source of energy for thousands of years, ever since people started burning wood to cook food or to keep warm. Even today fire wood and crop residues form the largest biomass energy source and is used by rural communities and forest dwellers.

But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biogas can be produced from cattle dung, human faeces and other organic waste by a process called "anaerobic digestion" in a biogas plant. It contains about 55 to 75% methane, which is inflammable and can be used for cooking, lighting, heating or for producing electricity. Even the methane gas which is given off during composting of organic waste or from landfills can be used as a biomass energy source

Biogas is a clean, non-polluting and low - cost fuel. The digested left over material which comes out of the biogas plant in the form of slurry is a valuable by-product, which can be used as organic manure in agricultural fields. Biomass fuels are obtained from agricultural wastes (crops), alcohol fuels, animal waste and municipal solid waste. Now, the biomass which would normally present a disposal problem is converted into electricity (e.g., manufacturing wastes, rice hulls, and black liquor from paper production).But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes.

Today, new ways of using biomass are still being discovered. One way is to produce ethanol, a liquid alcohol fuel from biomass. Unlike other renewable energy sources, biomass can be converted directly into liquid fuels (biofuels) for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are ethanol and biodiesel.

Ethanol is made by fermenting any biomass rich in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Ethanol can be used in special types of cars that are made for using alcohol fuel instead of gasoline. The alcohol can also be combined with gasoline. Plants grown for making alcohol or diesel are known as energy crops, such as fast-growing trees and grasses.

(iii) **Bio-diesel**

Bio-diesel is obtained by trans-etherification of vegetable oils. Oil rich seeds of the wild plants rich in non-edible oils are the potential source of bio-diesel. Seeds of Pongamia, Jatropha, Neem are favorites for producing bio-diesel.

The use of biomass energy has the potential to greatly reduce greenhouse gas emissions. Biomass generates about the same amount of carbon dioxide as fossil fuels, but the green plants remove carbon dioxide from the atmosphere as they grow and develop. The net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. Consumer demand for clean renewable energy have stimulated growth in green power—solar, wind, geothermal steam, biomass, and hydroelectric sources of power.

(iv) **Hydropower**

Flowing water creates energy that can be captured and turned into electricity. This is called **hydroelectric power or hydropower.** Hydro-energy from water is also a renewable energy source. Hydroelectric energy or hydropower is energy which is produced by the action of falling water turning a waterwheel, propeller or turbine. Almost all hydroelectric energy is used to produce electricity, although early pioneers built waterwheels to grind grain and operate other machinery.

The most common type of hydroelectric power plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity. The water stored at a higher elevation is a source of potential- energy. It is converted to kinetic-energy in the turbines and then to electrical-energy. Generally more than 90% of the potential energy of the water can be converted into electrical energy.

Another type of hydroelectric power plant is called a pumped storage plant that can even store power. The power is sent from a power grid into the electric generators. The generators then spin the turbines backward, which causes the turbines to pump water from a river or lower reservoir to an upper reservoir where the power is stored. To use the power, the water is released from the upper reservoir back down into the river or lower reservoir. This spins the turbines forward, activating the generators to produce electricity.

Small hydroelectric plants or micro-hydroelectric power system doesn't necessarily require a large dam but just use a small canal to channel the river water through a turbine which can produce enough electricity for a home, farm, or a small village.

(v) **Wind energy**

The kinetic energy of the wind can be changed into other forms of energy, either mechanical energy or electrical energy. When a boat lifts a sail, it is using wind energy to push it through the water. This is one form of energy. Farmers have been using wind energy for many years to pump water from wells using windmills. In Holland, windmills have been used for centuries to pump water from low-lying areas and grind grains. Today, the wind is also used to make electricity.

Wind energy is a clean renewable energy source produced by the daily cooling and heating patterns on the surface of the earth. Wind energy can be harnessed to produce electricity, pump water, grind grain and move sailing vessels. Wind generators consist of a steel tower, propeller blades to capture the wind and a generator. Individual wind generators are commonly built near homes or farms but may be arranged in clusters or wind farms. Wind can be used to do work. Blowing wind spins the blades on a wind turbine just like a large toy pinwheel. This device is called a wind turbine and not a windmill. A windmill grinds or mills grain, or is used to pump water.

The blades of the turbine are attached to a hub that is mounted on a turning shaft. The shaft goes through a gear transmission box where the turning speed is increased. The transmission box is attached to a high speed shaft which turns a generator that makes electricity. Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a *rotor*. We have many windy areas in the country, especially the coastal regions of India.

(vi) **Wave energy**

Oceans and sea waves are caused indirectly by solar energy. Wave energy is derived from wind energy, which is driven in turn from solar energy. Wave energy may be converted to mechanical energy and then to electricity.

(vii) **Ocean thermal energy conversion**

Conversion of solar energy stored as heat in the ocean into electrical energy by making use of the temperature difference between the warm surface water and the colder deep water.

(viii) **Geothermal energy**

Geothermal energy refers to energy contained in underground rock and fluids. Thermal or heat energy deep within the earth may heat water or form steam. Geothermal energy is used to power steam turbines and generate electricity, although it can be used to heat homes and other buildings. This heat is a result of the increase in temperature of the earth with increasing depth below the surface. It is the energy which comes from inside the earth i.e. the energy contained in underground rock and fluids. Geothermal energy is responsible for heating of water of hot water springs.

(ix) **Fuel cell technology**

Notes

Fuel cells are devices that directly convert hydrogen into electricity. Hydrogen is a colourless, odourless gas found on earth only in combination with other elements such as oxygen, carbon and nitrogen. To use hydrogen, it must be separated from these other elements.

Hydrogen as a fuel is high in energy and a very promising clean fuel. A fuel cell converts hydrogen (produced and stored) and oxygen from the air into electricity. A machine that burns pure hydrogen produces energy and pure water without causing any pollution. Fuel cells are a promising technology for use as a source of heat and electricity in buildings, and as an electrical power source for vehicles.

Large amounts of hydrogen are available in combined form in water. But free hydrogen is not available in nature. Hydrogen can be made from hydrocarbons by applying heat, a process known as "reforming" hydrogen. This process makes hydrogen from natural gas. An electrical current can also be used to separate water into its components i.e. oxygen and hydrogen in a process called electrolysis. Some algae and bacteria, using sunlight as their energy source, give off hydrogen under certain conditions. Large amount of energy is needed to produce hydrogen from water, so it will not come into its own as a clean alternative until renewable energy is widely available for the process.

In the future, hydrogen could substitute electricity as an important energy carrier. An energy carrier stores, moves and delivers energy in a usable form to consumers. Renewable energy sources, like the sun, can not produce energy all the time. The sun does not always shine. But hydrogen can store this energy until it is needed and can be transported to wherever it is required.

Hydrogen has been used in NASA's space program as fuel since the 1970s to propel rockets and now the space shuttle into orbit and in fuel cells that provide heat, electricity and drinking water for astronauts. In the future, hydrogen may be used as a fuel for motor vehicles and aircrafts, and provide power for our homes and offices.

### 27.3.2 Non-renewable energy

Non-renewable energy resources have limited amount of stocks available. The regeneration rate of non renewable energy resources is negligible when compared with the rate of consumption. That is, non-renewable energy that we are using up cannot be recreated in a short period of time or at least, in our lifetime. Fossil fuels are important energy resource. Fossil fuels (coal, lignite, peat) are found under the ground and below the sea floor (petroleum etc.) in liquid and gaseous form. Fossil fuels are the remains of ancient plant and animal life found on earth. Fossil fuel energy is released in the form of heat.

Notes

(i) **Oil (Petroleum)**

Oil is a liquid fossil fuel that is found under the ground and below the sea floor. Fossil fuels were formed before and during the time of the dinosaurs when plants and animals died. Their decomposed remains gradually changed over the years to form coal, oil and natural gas.

Oil and natural gas is formed by complex decay processes from microscopic life forms called phytoplankton (tiny plants called algae) which floated in the world's oceans million years ago. Just like today's phytoplankton, they harnessed and stored the solar energy through the process of photosynthesis. Zooplanktons are tiny animals which eat phytoplankton but themselves are the main food for the fish and some whales.

When these myriads of tiny floating plants died, they sank to the sea floor and got buried and slowly hardened into rocks. Heat from the earth's interior and the weight of the overlying rocks gradually changed the energy containing substances in the buried phytoplankton into liquid hydrocarbon and gases. Hydrocarbons are simple molecules made up of carbon and hydrogen atoms joined together in chains or in rings. These molecules, being light and mobile, migrated upwards through the rock but eventually became trapped beneath impermeable rock structures in the earth's crust.

Petroleum is one of our most vital resources. During the past thirty years consumption of petroleum has grown more steeply than other energy sources. Petroleum provides about 40% of the commercial energy used in the world. Think of the various ways, petroleum is used like cars, planes, tractors, shipping, electricity, cooking, agriculture, industries etc. These are only a few of the seemingly endless list of uses we have for petroleum. Fossil fuels took millions of years to form. We are using up the fuels formed more than 65 million years ago. They can not be renewed; they can not be made again. We can save fossil fuels by conserving them and finding ways to harness energy from seemingly "endless sources," like the sun and the wind. Oil is obtained by drilling deep wells into the ground and then pumping it out. Oil can be converted into gasoline. Both oil and gasoline are burned in automobiles and in aeroplanes. We depend on oil for 90% of our transport, and for food, pharmaceuticals, chemicals etc. Our modern way of life is totally dependent on oil and gas. But oil industry experts estimate that current reserves will only last for about 40 years.

(ii) **Natural gas**

Natural gas is also fossil fuel that is a mixture of gases found under the ground. Natural Gas is collected and transported almost the same way as oil. Natural gas burns in home furnaces and cooking ranges. It is now being used in cars and buses for transportation.

(iii) **Coal**

Coal is the most common solid fossil fuel which was used as a primary source of energy in homes and industry. It is found under the ground in solid form and have to be mined and transported for use. Our country has large coal reserves.

Notes

Coal is mostly carbon but contains small amounts of sulphur. It is formed from plants, mostly trees which grew millions of years ago in low lying swampy areas. When these trees died, they sank to the bottom of the swamps. In the swamps they did not rot fully as there was no air. Partially decayed plant matter in swamps and bogs is called peat which has low heat content. These peats get covered by sand and mud as water subsides. More material is deposited on them for years and the plant matter gets converted into coal under pressure and heat. That is plant material get metamorphosed into coal in millions of years. This is the most plentiful fossil fuel but it is very polluting.

### 27.3.3 Nuclear energy

Nuclear energy is liberated from a nuclear reaction, fission or fusion, or by radioactive decay. In a conventional nuclear reactor, isotopes of uranium and plutonium undergo controlled nuclear fission. The resulting heat produces steam, that in turn, spins turbines to generate electricity. Large fuel supply, low immediate environmental impact, low emission of $CO_2$, low chances of accidents because of multiple safety systems make this energy a much wanted resource. Unlike other energy resources, nuclear energy produces highly radioactive materials that must be kept safely for thousands of years until their radioactivity falls to safe levels.

Also, when the useful life (40-60 years) of a nuclear reactor comes to an end, it cannot be shut down and abandoned like a coal burning plant. It contains large qualities of radioactive materials that must be kept out of the environment for many thousand of years. The safety features make nuclear power plants very expensive to build and maintain.

However, management of the nuclear waste disposal, its vulnerability to terrorist attacks and misuse of the technology for making nuclear weapons make it a difficult choice and it remains world's slowest growing energy source.

## INTEXT QUESTIONS 27.2

1. Define the terms renewable energy sources and non-renewable energy sources.

2. What are the various ways can solar energy be used?

3. List the various sources of renewable and non-renewable energy sources.

4. Why is hydrogen known as a clean energy source?

Notes

5. How is coal formed in nature?

______________________________________________

## 27.4 WORRYING SIGNS

A couple of centuries ago virtually everyone would have depended on the fuel they could find within a short distance from home. Now, the fuels required for heat and light travel vast distances to reach us, sometimes crossing not only continents but political and cultural watersheds on the way. These distances create a whole host of challenges from oil-related political instability to the environmental risks of long-distance pipelines. Also we can not use fossil fuels forever as they are a non-renewable and finite resource.

The International Energy Agency says the world will need almost 60% more energy in 2030 than in 2002, and fossil fuels will still meet most of its needs.

Not everyone depends on the fossil fuels. Nearly a third of today's world population (6.1bn people) has no electricity or other modern energy supplies, and another third have only limited access.

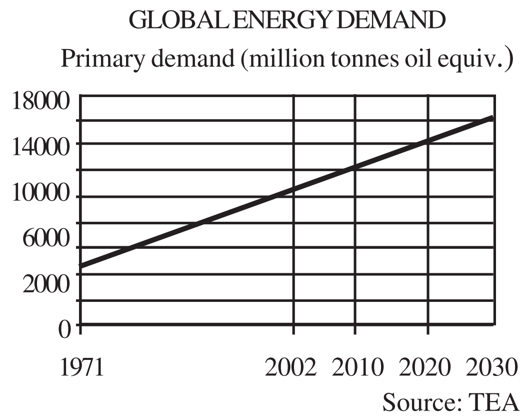


***Fig. 27.1:** Facts and figures on soaring global energy demand*

However, we can also get energy to do several jobs at once, as combined heat and power plants do. And we can use less of it by becoming energy-efficient.

Cheap, available energy is essential for ending poverty: ending poverty is key to easing the pressures on the planet from the abjectly poor who have no choice but to eat the seed corn Our energy use is unsustainable, but we already know what a benign alternative would look like.

But large amounts of energy are needed to produce hydrogen from water, so it will not come into its own as a clean alternative until renewable energy is widely available for the process.

## WHAT YOU HAVE LEARNT

- Energy is defined as "**ability to do work**" and power is the rate of energy delivery.
- It is required by all living organisms including humans. Nothing can move or work without the use of energy.
- The behavior and transformation of energy is strictly governed by the laws of thermodynamics.
- The **First law** of thermodynamics state that the energy can neither be created nor destroyed. This is also known as law of conservation of energy. Energy flows downhill i.e. from higher potential to lower potential.
- **The Second law** of thermodynamic states that energy transformations are never 100% efficient. i.e. at each step of energy transformation some amount of energy is lost as waste heat. The conventional unit of measuring energy is gram calorie.
- The various energy sources are broadly divided into two broad categories namely renewable and non renewable.
- Renewable energy is the term used to describe energy that comes from sources whose supplies are regenerative and virtually inexhaustible.
- The most important and inexhaustible source of energy is the sun. Solar energy is harnessed by green plants by the process of photosynthesis for making food and the biomass which is subsequently used as energy source by animals including man.
- The other renewable sources of energy include solar energy, biomass, wind energy, hydroelectric energy, geothermal energy, and wave or tidal energy.
- Non renewable energy sources have limited amount of stocks available. The regeneration rate of non renewable energy resources is negligible when compared with the rate of consumption.
- Fossil fuels are important non renewable energy source. Fossil fuels (coal, lignite, peat, gas, oil) are found under the ground and below the sea floor in liquid and gaseous form. Fossil fuels are the remains of ancient plant and animal life found on earth. Fossil fuel energy is released in the form of heat. Fossil fuel is hydrocarbons and they include coal, lignite, peat, petroleum and natural gas.
- There is growing emphasis to promote the use of renewable energy sources to reduce our dependence on fossil fuels because the latter will exhausted soon.
- Growing use of fossil fuels has increased the amount of carbon dioxide in the atmosphere leading to global warming and climate change.

- Fossil fuels are a non-renewable and finite resource and we can't use them for ever.
- Nuclear energy is liberated by a nuclear reaction (fission or fusion) or by radioactive decay. Nuclear power is generated in a specially designed nuclear power plant that converts nuclear energy into useful power such as mechanical or electrical power.
- In a nuclear electric power plant, heat produced by a reactor is generally used to make steam to drive a turbine that in turn drives as electric generator.

## TERMINAL EXERCISE

1. What do you understand by bio-energy? Describe the various types and ways of using biomass energy.
2. Define first and second law of thermodynamics.
3. Prepare a list of renewable and non renewable energy resources.
4. What is a fuel cell? Which fuel is used to propel rockets?
5. What type of conditions necessary for biogas generation?
6. What is the average composition of biogas?
7. Why hydrogen is considered as a clean energy source?
8. What is the ultimate source of energy in coal and petroleum?
9. Describe the process of coal and petroleum formation.
10. State the reasons for increasing emphasis on developing renewable sources of energy.
11. Which type of power or energy causes no pollution?

## ANSWER TO INTEXT QUESTIONS

**27.1**

1. Energy is the capacity to do work.
2. It is the amount of heat required to raise the temperature of one gram of water through one degree centrigrade from $14.5^0$ to $15.5^0$C.
3. SI unit of energy is Joule (J). It is the work done when a force of one Newton displaces the point by one metre.
4. First law: energy can neither be created nor destroyed but can only change from one form to another.

Second law states that in every transformation, some energy is always lost in the form of heat.

**27.2**

1. Energy that come from sources whose supplies are inexhaustible and also the energy sources are generative or can be renewed. Energy resources that have limited amount of stocks available and the energy resources cannot be recreated in a short period of time.

2. Solar energy can be used in a variety of ways like to heat up homes, heat water (as solar cooker to prepare food). And produce electricity.

3. Renewable energy sources – Solar, wind, hydropower, geothermal, ocean, thermal energy, biomass, hydrogen.

   Non-renewable energy sources – Coal, gas, oil or petroleum.

5. Hydrogen produces clean energy and pure water without causing any pollution.

6. Coal is formed from trees which grew millions of years ago in swampy areas. The trees sank to the bottom of the swamps when they died. They did not rot fully as there was no air. Many layers of sand and mud got deposited on these plant remains for without of years and the plant matter turned into coal under pressure and heat.

28

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# GROUND WATER RESOURCES

Ground water resources as the name suggests is the water found underneath the soil. This water falls as the rain fall or snow melt either lost as surface runoff. Some amount also percolates through soil under the influence of gravity and get collects in the soil pore spaces due to the presence of underlying above the impervious layer. In this lesson, you shall learn about the ground water resources which are vitally important for agriculture, industries and day to day living.

## OBJECTIVES

After completing this lesson, you will be able to:

- *recall the difference between surface water and groundwater;*
- *list various ways in which groundwater can be obtained;*
- *suggest methods of economical use of water in our homes;*
- *describe how the groundwater is re-charged naturally and through human agencies;*
- *highlight the risk of depletion of groundwater if not properly managed.*

## 28.1 SURFACE WATER AND GROUNDWATER

Water and water vapour are in constant circulation, powered by the energy from sunlight and gravity as a natural process called hydrologic cycle about which you have learnt in the previous lesson. Water evaporates from the ocean and land surfaces, is held temporarily as water vapour in the atmosphere, and falls back to the earth's surface as precipitation. Source of all freshwater on earth is rainfall. When rainfall occurs, part of it flows on the surface of the land as run-off. The run-off water ultimately gets into a water body like stream, river, pond or lake. This water is called **surface water**.

Part of the precipitation infiltrates below the ground surface into the soil zone. When the soil zone becomes saturated, water percolates downward. A zone of saturation occurs where all the soil pores are filled with water. Part of the rain water slowly infiltrates into the soil under the pull of gravity. Thus, an underground water body is created called **aquifer** and the accumulated water is called **groundwater**. Under the pull of gravity, groundwater flows slowly and steadily through the soil. In low areas it emerges in springs and streams (Fig. 28.1).

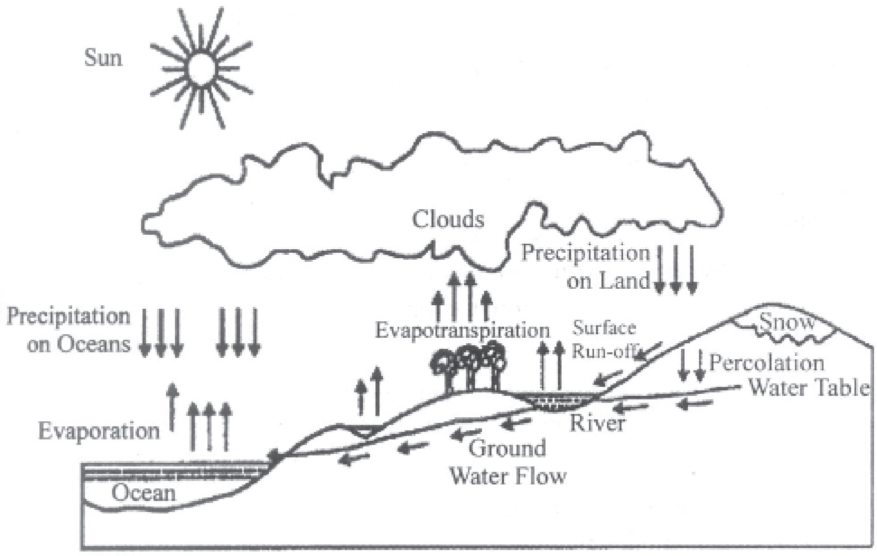


***Fig. 28.1:** Hydrological cycle depicting surface water, groundwater and water table*

Both surface water and groundwater eventually return to the ocean, where evaporation replenishes the supply of atmospheric water vapour. Winds carry the moist air over land, precipitation occurs, and the hydrologic cycle continues. The process of precipitation replenishing the groundwater supply is known as **recharge**. In general, recharge occurs only during the rainy season in tropical climates or during spring in temperate climates. Typically, 10 to 20% percent of the precipitation that falls to the earth percolates through soil and contributes to the water-bearing strata, i.e. aquifer.

Groundwater is constantly in motion. Compared to surface water, it moves very slowly, the actual rate depends on the transmissibility and storage capacity of the aquifer. Sometimes outflows of groundwater take place through springs and riverbeds. The renewal time of groundwater near the water table may be a year or less, while in deep aquifers it may be as long as thousands of years.

**Water table** also called **groundwater table**, is the upper level of an underground surface in which the soil or rocks are permanently saturated with water (Fig. 28.2). The depth at which the pore space in the soil is completely filled with water and the level at which this occurs is called the water table (Fig. 28.1). The water table separates the groundwater zone that lies below it from the capillary fringe, or zone of aeration, that lies above it. The water table fluctuates both with the seasons and from year to year because it is affected by rainfall and climatic variation. It is also affected by the quantum withdrawal from wells or by artificial recharging.

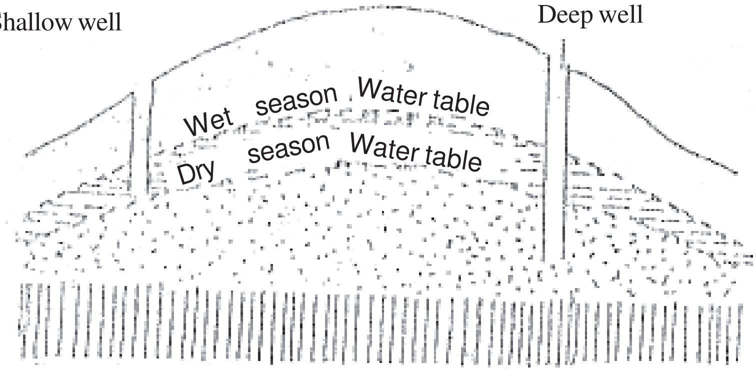


***Fig. 28.2:** Water Table*

Ground water is exploited for domestic use, livestock and irrigation since time immemorial. In India a very large percentage of population depends on groundwater for domestic needs.

The major difference between surface water and groundwater are as follows:

| Surface water | Ground water |
|---|---|
| Surface water is the water which remains on the surface of land in form of streams, rivers, ponds or lakes. | Groundwater is the water which is normally found underground and is obtained by digging wells, tube wells and hand pumps. |
| Surface water is exposed and can be easily contaminated. | Groundwater is underground (hidden) and thus can not be easily contaminated. |
| Surface water often needs to be transported to the place of use and is thus expensive. | Groundwater is often available at the place of their use and need not be transported. It is thus cheaper. |
| Surface water can not be directly consumed as it is contaminated. | Groundwater is mostly un-contaminated and can be directly consumed. |
| Surface water is exposed and subject to evaporation losses and thus less dependable in times of drought. | Groundwater is underground and does not get lost due to evaporation. It is thus more dependable in times of drought. |

## INTEXT QUESTIONS 28.1

1. What is groundwater?

______________________________

2. Where does it come from?

______________________________

3. What is an aquifer?

_______________________________________________

4. What do you mean by water table?

_______________________________________________



## 28.2 GROUNDWATER SOURCES

The value of an aquifer as a source of groundwater depends on the porosity of the geologic layer, of which it is formed. Water is withdrawn from an aquifer by pumping it out of a **well** or **infiltration gallery**. An infiltration gallery typically includes several horizontal perforated pipes radiating outward from the bottom of a large-diameter vertical shaft. Wells are constructed in several ways, depending on the depth and nature of the aquifer. Wells used for public water supplies, usually more than 100 feet (30 metres) deep and from 4 to 12 inches (10 to 30 cm) in diameter, must penetrate large aquifers that can provide dependable yields of good-quality water. A submersible pump driven by an electric motor can be used to raise the water to the surface.

### 28.2.1 Methods of groundwater abstraction

There are large number of methods to obtain groundwater. The most common methods are as follows:

1. **Springs:** The water table generally follows the topography of the ground surface. The slope in the water table profile results in sub-soil flow. Groundwater movement is comparatively very slow as compared to surface water. The flow depends on slope and permeability. When the water table is above the surface water level in some hilly areas, groundwater flows out as a spring. This spring water can be easily used as source of drinking. The oldest water supplies to towns as in Rome, Lyon were from such sources. A majority of our hilly population depends on such sources in Himalayan regions.
2. **Dug-well:** It covers ordinary open wells of varying dimension dug or sunk from the ground surface into water bearing stratum to extract water for irrigation purposes. These are broadly masonary wells, kuchcha wells and dug-cum-bore wells. All such schemes are of private nature belonging to individual cultivator.
3. **Shallow tube-well:** It consists of a bore hole built into ground with the purpose of tapping ground water from porous zones. The depth of a shallow tube well does not exceed 60-70 m. The tube wells are generally operated for 6 to 8 hours during irrigation season and give yield of 100-300 m/day, which is roughly 2 to 3 times that of a dug well.
4. **Deep tube well:** It usually extends to the depth of 100 m and more and is designed to give a discharge of 100 to 200 cubic m/h. These tube wells operate round the clock

during the irrigation season, depending upon the availability of power. Their annual output is roughly 15 times that of an average shallow tube well.

5. **Handpump:** Handpumps are commonly used to draw groundwater in villages and slum areas in urban centres. These are manually operated. Thus no electricity or other power is required to operate them.

## 28.3 ECONOMIC USE OF WATER

### a. At home

Economic water use can have major environmental, public health, and economic benefits by helping to improve water quality, maintain aquatic ecosystems, and protect drinking water resources. By using water more efficiently and by purchasing more water efficient products, we can also help mitigate the effects of drought. Efficiency measures can also save money on water and energy bills.

| Bathroom | Kitchen and Laundry | Garden and landscaping | Equipment |
|---|---|---|---|
| • Do not let the water run while shaving or brushing teeth use mug while shaving or brushing teeth.<br>• Take short showers instead of tub baths. Turn off the water while soaping or shampooing.<br>• If you must use a tub, close the drain before turning on the water and fill the tub only half full. Bathe small children together.<br>• Never use your toilet as a waste basket. | • Simple practices save a lot of water.<br>• Store drinking water in the refrigerator.<br>• Wash fruits and vegetables in a basin. Use a vegetable brush.<br>• Do not use water to defrost frozen foods; then ahead of use.<br>• Scrape, rather than rinse, dishes before loading into the dishwasher.<br>• Add food wastes to your compost pile instead of using the garbage disposal.<br>• Wash only full loads of laundry or use the appropriate water level or load size selection on the washing machine.<br><br>**Note:** Homes with high-efficiency plumbing fixtures and appliances save about 30% of indoor water use and yield substantial savings on water, sewer, and energy bills. | • Depending on climate, up to 75% of a home's total water use during the growing season is for outdoor purposes.<br>• Detect and repair all leaks in irrigation system.<br>• Use properly treated wastewater for irrigation wherever available.<br>• Water the lawn or garden during the coolest part of the day (early morning is best). Do not water on windy days.<br>• Water trees and shrubs, which have deep root systems, for a longer time and less frequently than shallow-rooted plants that frequently require smaller amounts of water. Check with the local extension service for advice on watering needs in your area.<br>• Set sprinklers to water the lawn or garden only – not the street or sidewalk.<br>• Use soaker hoses or trickle irrigation systems for trees and shrubs.<br>• Install moisture sensors on sprinkler systems.<br>• Use mulch around shrubs and garden plants to reduce evaporation from the soil surface and to cut down on weed growth.<br>• Minimize or eliminate fertilizing, which promotes new growth needing additional watering.<br>• Do not use water that contains bleach, automatic-dishwashing detergent or fabric softener for irrigation. | • Install low-flow faucet aerators and showerheads.<br>• Consider purchasing a high efficiency washing machine which can save over 50% in laundry water and energy use.<br>• Repair all leaks. A leaky toilet can waste about 1000 litres per day. To detect leaks in the toilet, add food coloring to the tank water. If the colored water appears in the bowl, the toilet is leaking. |

**b. Outdoor uses**

- Sweep driveways, sidewalks and steps rather than using hose pipes to wash them.
- Wash the car with water from a bucket, or consider using a commercial car wash that recycles water.
- When using a hose, control the flow with an automatic shut-off nozzle.
- Avoid purchasing recreational water toys which require a constant stream of water.
- Consider purchasing a new water-saving swimming pool filter.
- Use a pool cover to reduce evaporation when pool is not being used.
- Do not install or use ornamental water features unless they recycle the water. Use signs to show the public that water is recycled. Do not operate during a drought.

## INTEXT QUESTIONS 28.3

1. State two ways each for saving water.

   (a) in bathrooms

   (b) at kitchen

2. Suggest two ways of judicious uses water while gardening and landscaping.

3. Give any two other judicious uses of water.

## 28.4 ARTIFICIAL RECHARGE

The increasing demand for water has increased awareness towards the use of artificial recharge to augment ground water supplies. Stated simply, **artificial recharge** is a process by which excess surface water is directed into the ground – either by spreading on the surface, by using recharge wells, or by altering natural conditions to increase infiltration. In other words, to replenish an aquifer. Recharge refers to the movement of water through man-made systems from the surface of the earth to underground water-bearing strata where it may be stored for future use. Artificial recharge (sometimes called planned recharge) is a way to store water underground in times of water surplus to meet the demand in times of shortage.

### 28.4.1 Direct artificial recharge

**a. Spreading basins**

This method involves surface spreading of water in basins which are excavated in the existing terrain. For effective artificial recharge highly permeable soils are suitable and maintenance of a layer of water over the highly permeable soils is necessary.

**b. Recharge pits and shafts**

Conditions that permit surface spreading methods for artificial recharge are relatively rare. Often areas of low permeability lie between the land surface and water table. In such situations artificial recharge systems such as pits and shafts could be effective.

Unfiltered runoff waters leave a thin film of sediment on the sides and bottom of the pits which require maintenance in order to sustain the high recharge rates. Shafts may be circular, rectangular, or of square cross-section and may be backfilled with porous material. Excavation for making pits and shafts may terminate above the water table level or may by hydraulic connectors extend below the water table. Recharge rates in both shafts and pits may decrease with time due to accumulation of fine grained materials and the plugging effect brought about by microbial activity.

**c. Ditches**

A ditch could be described as a long narrow trench, with its bottom width less than its depth. A ditch system can be designed to suit the topographic and geologic conditions that exist at a given site. A layout for a ditch and a flooding recharge project could include a series of ditches trending down the topographic slope. The ditches could terminate in a collection ditch designed to carry away the water that does not infiltrate. This would reduce the accumulation of fine material.

**d. Recharge wells**

Recharge or injection wells are used to directly recharge water into deep water-bearing zones. Recharge wells are suitable only in areas where a thick impervious layer exists between the surface of the soil and the aquifer to be replenished. They are also advantageous where land is scarce. A relatively high rate of recharge can be attained by this method.

### 28.4.2 Indirect methods of recharging

**a. Enhanced streambed infiltration (induced infiltration)**

This method of induced recharge consists of setting a gallery or a line of wells parallel to the bank of a river and at a short distance from it. Without the wells there would be unimpeded outflow of groundwater to the river. When small amounts of groundwater are withdrawn from the gallery parallel to the river, the amount of groundwater discharged into the river decreases. The water recovered by the gallery consists wholly of natural groundwater. Each groundwater withdrawal is accompanied by a drawdown in the water table. For high recovery rates this drawdown tends to lower the groundwater table at the shoreline below that at the river. Thus, surface water from the river will be induced to enter the aquifer and to flow into the gallery. In areas where the stream is separated from the aquifer by materials of low permeability, leakage from the stream may be so small that the system is not feasible .

**b. Conjunctive wells**

A conjunctive well is one that is screened in both a shallow confined aquifer and a deeper artesian aquifer. Water is pumped from the deeper aquifer and when its surface is lowered below the shallow water table, water from the shallow aquifer drains directly into the deeper aquifer. Water augmentation by conjunctive wells has the advantage of utilizing sediment-free groundwater which greatly reduces the damage of clogging well screens.

### 28.4.3 Advantages of artificial recharge

- While recharging, rain and surface water infiltrate the soil and percolate down through the various geological formations and get naturally cleansed.
- Very few special tools are needed to dig drainage wells.
- In rock formations with high, structural integrity few additional materials may be required (concrete, softstone or coral rock blocks, metal rods) to construct the wells.
- Groundwater recharge stores water during the wet season for use in the dry season, when demand is highest.
- Aquifer water can be improved by recharging with high quality injected water.
- Recharge can significantly increase the sustainable yield of an aquifer.
- Recharge methods are attractive, particularly in arid regions.
- Most aquifer recharge systems are easy to operate.
- In many river basins, control of surface water runoff to provide aquifer recharge reduces sedimentation problems.
- Recharge with less-saline surface waters or treated effluents improves the quality of saline aquifers, facilitating the use of the water for agriculture and livestock.

### 28.4.4 Disadvantages of artificial recharge

Artificial recharge has some disadvantages too:

- In the absence of financial incentives, laws, or other regulations to encourage land owners to maintain drainage wells adequately, the wells may fall into disrepair and ultimately become sources of groundwater contamination.

- There is a potential for contamination of the groundwater from injected surface water runoff, especially from agricultural fields and road surfaces unless the surface water runoff is not pre-treated before injection.
- Unless significant volumes are injected into an aquifer, groundwater recharge may not be economically feasible.
- The hydrogeology of an aquifer should be investigated and understood before any future full-scale recharge project is implemented.

## INTEXT QUESTIONS 28.4

1. What is artificial recharge?

   ______________________________

2. State two methods by which groundwater can be recharged artificially.

   ______________________________

3. Give two advantages and disadvantages of artificial recharge?

   ______________________________

## 28.5 GROUNDWATER QUALITY

Ground water plays an important role in India, particularly as a drinking water source. Groundwater has a number of unique features that render it particularly suitable as a water supply source. The unique features are:

1. Generally uncontaminated and thus can be consumed directly without any treatment;
2. It can be available in close proximity to place where it is required as it is widely distributed;
3. It is dependable and relatively less affected by drought;
4. Large storage, treatment and distribution can be avoided.
5. It is less expensive.

For the reasons mentioned above, nearly 85% of India's population today is dependent on groundwater for their domestic demands. Groundwater is particularly important as a source of drinking water in rural areas. Groundwater also plays an important role in agriculture, for both irrigation and bathing cattle.

Industrial demands for groundwater are also high, as many prefer to use groundwater for the unique features mentioned above.

Groundwater quality is being increasing threatened by agricultural, urban and industrial wastes, which leach or are injected into underlying aquifers. Once pollution has entered the sub-surface environment, it may remain concealed for many years and become dispersed over wide areas, rendering groundwater supplies unsuitable for human uses.

### 28.5.1 Reasons for declining ground water quality

A vast majority of groundwater quality problems are caused by contamination, over-exploitation, or combination of the two. Most groundwater quality problems are difficult to detect as they may be concealed below surface. They are also hard to resolve. The solutions are usually very expensive, time consuming and not always effective. Many times the contamination is not detected until noxious substances actually appear in water used, by which time the pollution has often dispersed over a large area.

All kinds of activities, urban, industrial or agricultural carried out on land have the potential to contaminate groundwater. Industrial discharges, landfills and subsurface injection of chemicals and hazardous wastes, are an obvious source of groundwater pollution. These concentrated sources can be easily detected and regulated but the more difficult problem is associated with diffuse sources of pollution like leaching of agrochemicals and animal wastes, subsurface discharges from latrines and septic tanks and infiltration of polluted urban run-off and sewage where sewerage does not exist or defunct. Diffuse sources can affect entire aquifers, which is difficult to control and treat. The only solution to diffuse sources of pollution is to integrate land use with water management. Table 28.1 presents land-use activities and their potential threat to groundwater quality.

***Table 28.1:*** *Land-use activities and their potential threat to groundwater quality*

| Land Use | Activities potential to groundwater pollution |
|---|---|
| Residential activities | • Unsewered sanitation.<br>• Land and stream discharge of sewage.<br>• Sewage oxidation ponds.<br>• Sewer leakage, solid waste disposal, landfill.<br>• Road and urban run-off, aerial fall out. |
| Industrial and Commercial activities | • Process water, effluent lagoon.<br>• Land and stream discharge of effluent.<br>• Tank and pipeline leakage and accidental spills.<br>• Well disposal of effluent.<br>• Aerial fall out.<br>• Landfill disposal and solid wastes and hazardous wastes.<br>• Poor housekeeping.<br>• Spillage and leakages during handling of material. |
| Mining | • Mine drainage discharge.<br>• Process water, sludge lagoons.<br>• Solid mine tailings.<br>• Oilfield spillage at group gathering stations. |
| In Rural areas | • Cultivation with agrochemicals.<br>• Irrigation with wastewater.<br>• Soil salinization.<br>• Livestock rearing. |
| Coastal areas | • Salt water intrusion. |

### 28.5.2 Common groundwater contaminants

1) **Nitrates:** Dissolved nitrates commonly contaminate groundwater. High level of nitrates can cause blue baby disease (Methaemoglobinaemia) in children, may form carcinogens and can accelerate eutrophication in surface waters. Sources of nitrates include sewage, fertilizers, air pollution, landfills and industries.

2) **Pathogens:** Poor hygiene of well and inadequate segregation of drainage charcoal from wells may cause pathogenic contamination of good water seepage from solid waste dumps and municipal drains may also cause pathogenic contamination. Bacteria and viruses cause water borne diseases such as typhoid, cholera, dysentery, polio, and hepatitis may pass into groundwater through discharges from sewage, landfills, septic tanks and livestock shelters.

3) **Trace metals:** Include lead, mercury, cadmium, copper, chromium and nickel. These metals can be toxic and carcinogenic. Seepage of industrial and mine discharges, fly ash ponds of thermal power plants can lead to metals in groundwater.

4) **Organic compounds:** Seepage of agricultural run off loaded with organic compounds like pesticides and may cause pesticide pollution of ground water.

## INTEXT QUESTIONS 28.5

1. How do mining activities affect groundwater?

______________________________

2. Name any two contaminants of groundwater.

______________________________

3. State two reasons for the decline of quality of groundwater.

______________________________

## 28.6 RISK OF DEPLETION OF GROUNDWATER

The demand for water has increased over the years and this has led to water scarcity in many parts of the world. About 2 billion people, approximately one-third of the world's population, depend on groundwater supplies, withdrawing about 20% of global water (600-700 km3) annually — much of it from shallow aquifers. The situation is aggravated by the problem of water pollution or contamination. Groundwater problems are becoming increasingly serious in many areas of the world. Rapid increase in the rates of pumping of groundwater in many aquifers has caused a steady lowering of water table levels where extraction of water has exceeded rates of recharge.

### 28.6.1 Causes of groundwater depletion

Groundwater crisis is not the result of natural factors:

1. It has been caused by human actions. During the past two decades, the water level in several parts of India has been falling rapidly due to an increase in extraction. The number of wells drilled for irrigation of both food and cash crops have rapidly and indiscriminately increased. India's rapidly rising population and changing lifestyles has also increased the domestic need for water.
2. The water requirement for the industry also shows an overall increase. Intense competition among users as an agriculture, industry, and domestic sectors is steadily lowering the groundwater table. The quality of groundwater is getting severely affected because of the widespread pollution of surface water. Besides, discharge of untreated waste water through bores and leachate from unscientific disposal of solid wastes also contaminate groundwater, thereby reducing the quality of fresh water resources.
3. Unlike surface storage, the groundwater is slow in accumulation. Groundwater has two components. One, a static part, and the other is dynamic, which comprises annual additions due to recharge. The quantum of yearly use needs to be limited. During deficit years, however, a part of static componnent is drawn for use expecting recuperation during the next surplus year. Dependence on static storage for long amounts to mining of groundwater. Ideally, the age of groundwater used should be as young as possible. Greater the age means longer the period for which mining has been carried out.

### 28.6.2 Risks

Groundwater depletion is a pressing challenge for India. Groundwater played an important role in sustaining India's green revolution. The high-yielding varieties of crops which all increasing agricultural productivity, depended on the timely application of water. This led to a spurt in groundwater structures with enterprising farmers making technological and institutional innovations not only to extract groundwater, but also to transport it to the fields of other farmers – giving rise to flourishing groundwater markets.

1. Falling water tables in several states now threaten agricultural sustainability. This has been encouraged by policies for cheap electricity and the absence of a property rights structure for water withdrawals.
2. During rainy season, availability of water from precipitation is far in excess of natural and man-made holding capacity which results in floods. During the non-rainy period, high evaporation rates coupled with high water demands cause drought conditions requiring import of water. Flood and drought thus constitute the extreme manifestations of hydrologic cycle. The situation is exacerbated due to depleting forest cover in the country.

3. The supply of groundwater is not unlimited, nor it is always available in good quality. In many cases, the abstraction of excessive quantities of groundwater has resulted in the drying up of wells, salt-water intrusion and drying up of rivers that receive their flows in dry seasons from groundwater.

4. The water found in groundwater bodies is replenished by drainage through the soil, which is often a slow process. Rates of groundwater recharge are greatest when rainfall inputs to the soil exceed evapotranspiration losses. When the water table is deep underground, the water of the aquifer may be exceedingly old. The water is being used extensively for water supply and irrigation purposes, which might be thousands of years old. The use of such water, which is not being recharged under the current climatic regime, is termed groundwater mining.

5. In India and Bangladesh, millions of people are exposed to groundwater contaminated with high levels of arsenic, a highly toxic and dangerous pollutant. It has been estimated that close to 5 million people in West Bengal, India are affected. In next-door Bangladesh, half the entire population of 120 million are exposed to elevated levels of arsenic in their drinking water.

## INTEXT QUESTIONS 28.6

1. State two reasons for reduction in water table.

___

2. Give two reasons for lowering of water table.

___

3. Mention two risks of reduced water table and contaminated groundwater.

___

## WHAT YOU HAVE LEARNT

- Source of all freshwater on earth is rainfall.
- The rain water which gets accumulated in ponds, lakes or flows in the rivers is called surface water.
- Part of rain water that infiltrates the Earth's surface slowly seeps downward into extensive layers of porous soil and rock. This water is called **groundwater**.
- The process of precipitation replenishing the groundwater is known as **recharge**.

- The depth at which the pore space in the soil is completely filled with water and the level at which this occurs is called the **water table.**
- Water from underground has been exploited for domestic use for livestock and irrigation since time immemorial.
- Surface water is exposed to atmosphere and can be easily contaminated, whereas the groundwater does not as it is hidden underground.
- Groundwater can be abstracted through dug-wells, tube-wells, hand-pumps, or springs.
- Artificial recharge is a process by which excess surface water is directed into the ground – either by spreading on the surface, by using recharge wells, or by altering natural conditions to increase infiltration – to replenish an aquifer.
- Artificial recharge can be achieved through recharge pits, shafts, wells, ditches or spreading basins. It can also be achieved through enhanced streambed infiltration or conjunctive wells.
- Recharge can significantly increase the sustainable yield of an aquifer.
- Artificial recharge may degrade the groundwater quality if the recharge water is contaminated.
- The demand for water has increased over the years and this has led to water scarcity in many parts of the world.
- Rapid increase in the rates of pumping of groundwater in many aquifers has caused a steady lowering of water table levels where extraction has exceeded rates of recharge.
- In India, the ground water levels are receding in some regions at an alarming rate.
- Depletion of groundwater increases pumping costs, causes wells and rivers to dry up, and in coastal regions seawater can intrude in groundwater

## TERMINAL EXERCISE

1. State three important differences between groundwater and surface water.
2. What is water table?
3. How can you obtain groundwater?
4. Describe in brief how water can be saved at home.
5. What are the main groundwater quality problems in India?
6. Explain the natural and anthropogenic contaminants of groundwater.
7. Describe the methods of artificially recharging groundwater.

8. What are the main causes of groundwater depletion?
9. What are the main adverse effects of groundwater depletion?
10. How can quality of recharge water be maintained?

## ANSWER TO INTEXT QUESTIONS

**28.1**

1. The water found on the surface of land and underneath.
2. Part of rain water that infiltrates the earth's surface slowly seeps downward into extensive layers of porous soil and rocks.
3. Under groundwater body is created called aquifer.
4. Water table is the upper level of an underground surface in which the soil or rocks are permanently saturated with water.

**28.2**

1. Because it comes through various levels of sub-soil and it is mostly uncontaminated and safer to consumer.
2. Refer to text.
3. Refer to text.

**28.3**

1. (a) i. Use mug while shaving or brushing teeth.

   ii. Take short showers

   iii. Turn off the water while soaping or shampooing.

   (b) i. Detect and repair all leaks in irrigation system.

   ii. Use properly treated water for irrigation (any other)
2. Refer to section 28.3.
3. • to designate a water efficiency coordination.
   - to Develop a water efficiency plan
   - to calculate and involved employees, residents & school children in water efficiency efforts. (Any two)

**28.4**

1. Artificial recharge is a process by which excess surface water is directed into the ground – either by spreading on the surface by using recharge wells, or by altering natural conditions to increase infiltration.
2. Through spreading basins, recharge pits and shafts, ditches and recharge wells.
3. Refer to text, section 28.4.3 and 28.4.4 respectively.

**28.5**

1. Mine drainage discharge, solid mine tailings, process water, sludge lagoons, oilfield spillage of group gathering stations.
2. Urban, industrial and agricultural activities (any two)
3. Unsewered sanitation, sewage leakage, solid waste disposal, aerial fall out, land fill waste, poor house keeping.

**28.6**

1. By human factor, overuse in industries, slow accumulation in surface (any other)
2. Rapid increase in the rates of pumping of ground water has caused a steady lowering of water table levels.
3. Refers to text section – 28.6

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# 28

# NON-RENEWABLE SOURCES OF ENERGY

In this lesson we are going to discuss about conventional or non- renewable or exhaustible energy resources. We fully depend on fossil fuel (oil, natural gas and coal) for power production to fulfill our daily energy needs. We in India even lag far behind the current demand of energy for growth in agriculture, and industry as well as in domestic sector. You must be aware of the fact that the world fossil fuel resources, which took millions of years to form, will soon be depleted thus affecting the energy supply. We cannot rely on fossil fuel as they are not a viable long- term option as an energy resource.

In this lesson you will learnt about fossil fuels and their uses. Nuclear energy is also gaining momentum as non-renewable source of energy and is used world wide but health and environmental hazards due to accidents are becoming matter of concern and puts a question mark on future use of nuclear eenrgy.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define non-renewable sources of energy;*
- *identify various non-renewable sources of energy;*
- *describe various forms of fossils fuels and list their uses;*
- *describe CNG as a cleaner fuel.*
- *define nuclear energy and list its uses;*
- *explain (in brief) the process of power generations in nuclear plants (nuclear fuel cycle) and its consequences on the environment.*

Notes

## 28.1 NON RENEWABLE ENERGY SOURCE

Since the discovery fossil fuels, they are one of the most important mineral energy sources. These are a finite energy resource that means they are non-renewable resources and once consumed they are lost for ever. There are three major forms of fossil fuels: coal, oil and natural gas and on worldwide basis they provide approximately 90% of energy consumed.

### 28.1.1 Fossil fuels

Since the industrial revolution, the major energy resources for the world have been fossil fuels formed from the remains of plants and animals lived in the distant past. Fossil fuels represent stored solar energy captured by plants in the past geological times. Coal, petroleum and natural gas are called **fossil fuels**, as they are the remains of prehistoric plants, animals and microscopic organisms that lived millions of year ago. These remain under the effect of intense heat and pressure underneath the earth's crust over long geological time and got transformed into fossil fuels. For example, the gas cylinder which you see in your kitchen or coal you burn was once the sunlight captured by phototrops. During the Carboniferous period 275-350 million years ago, conditions in the world were suitable for formation of large deposits of fossil fuels. Table 28.1 shows the estimates of the main fossil fuel reserves.

***Table 28.1:*** *Estimates of fossil fuel resources in the world*

| **Fossil fuel** | **Total resources** | **Known recoverable (Measured) reserves** |
|---|---|---|
| Coal (billion tons) | 12,682 | 786 |
| Petroleum (billion barrels) | 2,000 | 556 |
| Natural gas (trillion cubic feet) | 12,000 | 2100 |
| Shale oil (billion barrels) | 2,000 | - Not estimated so far |
| Uranium ore (thousand tons) | 4,000 | 1085 |

*Source:* Global 2000 Chiras; One barrel = 159 liters = 35 gallons

In this sub section we will focus on availability, the possibility of exhaustion and environmental consequences of exploitation of fossil fuels, which are most widely used mineral fuel resources.

> The terms 'resource' and 'reserves' are often used when discussing the amount of a mineral or fossil fuel resource a country has at its disposal. From a technical point of view the term resource when used as a measurement of mineral or fuel refers to the total amount of a mineral or fuel in a country or on earth. Generally only a small fraction can be recovered. On the other hand reserve means the deposits of energy fuel or minerals that are economically and geologically feasible to extract with current and foreseeable technology.

## 28.2 COAL

Coal is formed from plants and vegetation buried, '*in situ*' or drifted in from outside to a place, which got covered by deposits of sediments. (Fig. 28.1).

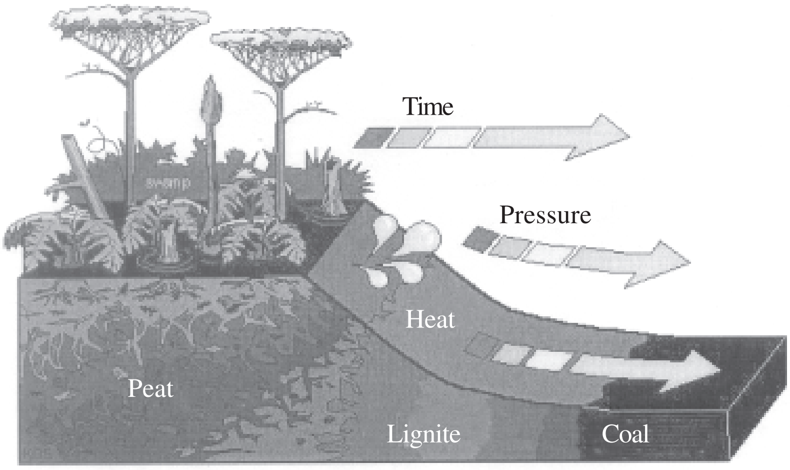


***Fig. 28.1:*** *Stages of formation of coal*

Coal is a solid fossil fuel and a sedimentary rock composed primarily of carbon. There are three basic grades of coal: i) lignite (brown coal), ii) bituminous (soft coal) and iii) anthracite (hard coal). Fig. 28.2.

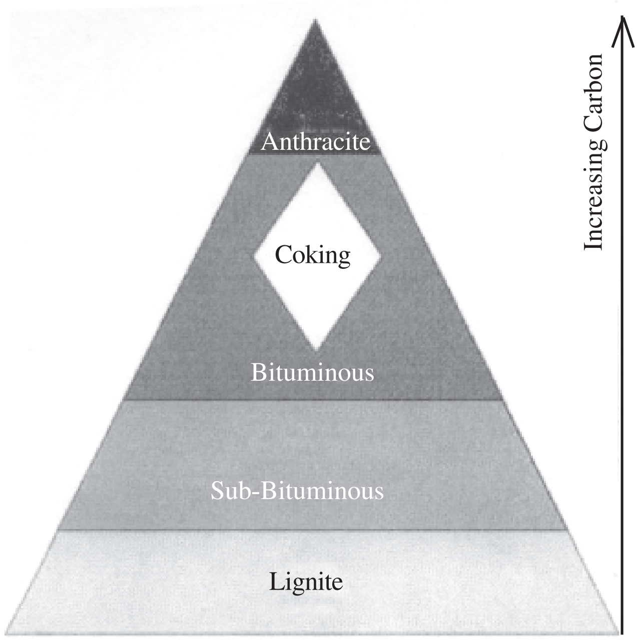


***Fig. 28.2:*** *The grades or quality of the type of coal depends on the pressure and heat*

An estimated nine metres of peat is needed to produce and form a 0.3 metre vein of coal and it would require 300 hundred years to accumulate that much of peat.

Notes

### 28.2.1 Formation of coal

Coal is the result of plant material that grew in fresh water swamps approximately three hundred million years ago. (Fig. 28.1). As this plant material died and accumulated, peat also called peat bog was formed. Since the plant material accumulated under water, in the swamps decay was inhibited due to lack of oxygen. Oceans inundated many of the areas of peat and sediments from the sea were deposited, over the peat. The weight of these sediments and the heat of the earth gradually changed the composition of the peat bog and coal was formed. Today peat also is used as source of fuel in some parts of the world though its high water content makes it a low-grade fuel.

Peat is changed into coal after many centuries of being compressed by the weight of sediments. It first changes into a low-grade coal known as **lignite** (brown coal).

The percentage of carbon in the lignite is higher than in peat. Continued pressure and heat from the earth changes **lignite** into **bituminous soft coal**. If the heat and pressure were great enough then **anthracite** coal (hard coal) would be formed which has the highest heat and carbon content. Accordingly energy content is greatest in anthracite coal and lowest in lignite. The sulphur content of coal is important because on burning low sulphur coal emits less sulphur dioxide ($SO_2$) so more desirable as a fuel for power plants.

The coal is used as a source of energy for domestic uses, locomotive engines, various types of furnaces in the industries, thermal power generation, extraction of metals and minerals, production of gas, tar etc. The type of coal determines its use. In India coal supplies nearly 63% of commercial energy as electrical energy generation by coal fired thermal power stations. In industry coal is used principally to purify iron, manufacture of steel.

### 28.2.2 Problems

Coal is most abundant fossil fuel on earth, but there are problems associated with its mining, transportation and use. Coal is mined from both (i) surface mines, and (ii) underground mines.

(a) **Surface mining**

Surface mining disrupts and drastically changes the natural landscape (Fig. 28.3.) and destroys the natural vegetation and the habitat of many species, some of which may already be endangered. Mining operations, involving digging, blasting, removal of rocks and soil lying over the coal seam, cause serious problems of air and noise pollution. Surface mining may also cause soil erosion and silt loading (the discharge of silts into streams) and nallas that disrupt and pollute the aquatic ecosystems as well as ground water in places where aquifers are located near or associated with coal seams.

***Fig. 28.3:*** *Open pit coal mine- Coal mining defaces the land and disturbs the habitat of plants and animals*

(b) **Underground mining**

Underground mining may cause collapse or land subsidence in the mining areas during or after mining operations are over. In case of some mines acid mine drainage from the mine waste and OBD piles polluted long stretches of streams. Coal fires in underground mines may happen which naturally caused give out much smoke and hazardous fumes caused several respiratory disease to people living nearby.

Apart from these problems, burning of coal in thermal power plants for generation of electricity and in industry is the prime source of air pollution.

## INTEXT QUESTIONS 28.1

1. Mention the method of coal formation.

   ______________________________

2. State the major uses of coal.

   ______________________________

## 28.3 PETROLEUM OR MINERAL OIL

Oil and gas were formed from the remains of plants and animals that once lived in the sea. For over millions of years these remains remained buried under mud and rock under great pressure and at high temperatures. Under these conditions marine biomass gradually changed into oil and gas (Fig.28.4) .Oil and gas are primarily found along geologically young tectonic belt at plate boundaries, where large depositional basins are more likely to occur.

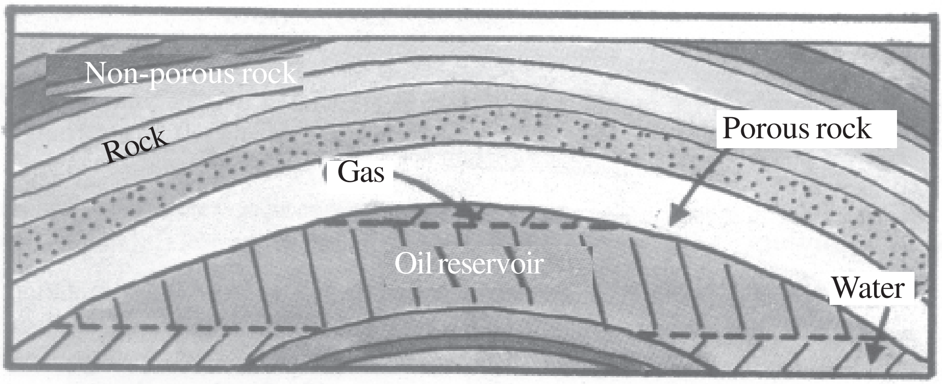


***Fig. 28.4:*** *Some oil and gas makes its way to the earth's surface is escapes. Large amounts of oil and gas are trapped below ground in certain areas of rocks, forming oil reservior*

Petroleum or crude oil (oil as it comes out of the ground), is a thick dark liquid consisting of a mixture hundreds of combustible hydrocarbons along with small amounts of sulphur, oxygen and nitrogen impurities. It is also known as **conventional oil or light oil**. Deposits of crude oil and natural gas are usually trapped together under the sea floor or earth's crust on land. After it is extracted, crude oil is transported to a refinery by pipelines, trucks or ships (oil tanker). In refineries oil is heated and distilled to separate it into components with different boiling points. The important components are gases, gasoline, aviation fuel, kerosene, diesel oil, naphtha, grease and wax and asphalt. Some of the products of oil distillation are called **petro-chemicals** which are used as raw material for the manufacture of pesticides, plastics, synthetic fibers, paints and medicines etc.

The consumption of petroleum products is rising worldwide. In India the demand has risen from 57 million tonnes in 1991-1992 to 107 million tonnes in year 2000. **'The India Hydrocarbon Vision 2025'**, gives the projected need for petroleum products for India to be 368 million tonnes by 2025.

## 28.4 NATURAL GAS

Natural gas, primarily consist of methane, is often found above reservoirs of crude oil. The natural gas is a mixture of 50 to 90% by volume of methane ($CH_4$), the simplest hydrocarbon. It also contains small amounts of heavier gaseous hydrocarbons such as ethane ($C_2H_6$), propane ($C_3H_8$) and butane ($C_4H_{10}$) and also small amounts of highly toxic hydrogen sulphide ($H_2S$). Natural gas is formed through geological processes similar to the processes of crude oil formation described earlier except the organic material gets changed to more volatile hydrocarbons than those found in oil.

Notes

Almost every oil well produces liquid petroleum along varying amounts of natural gas. However, there are large gas deposits without any liquid petroleum being associated with them.

### 28.4.1 Conventional natural gas

It lies above most reservoirs of crude oil. These deposits can be tapped/used only through pipeline. But the natural gas that comes out along with oil is often looked as unwanted by product and is burned off. Burning of associated natural gas represents a waste of a valuable energy resource and emissions carbon dioxide into the atmosphere from its burning. But after the gas is processed it is piped or compressed into cylinders for use by consumers. This gas is also used for the production of petrochemicals and fertilizers.

### 28.4.2 Unconventional natural gas

It is found by itself in other underground reservoirs. So far it is very expensive to get natural gas from such unconventional sources but technology is being developed to extract the gases economically.

When a natural gas field is tapped, propane and butane gases, present in natural gas are liquefied and removed as liquefied petroleum gas (LPG). LPG is stored in pressurized tanks or cylinders for use as cooking gas. At a very low temperature natural gas can be converted to liquefied natural gas (LNG). This highly inflammable liquid can be shipped to other countries in refrigerated tanker ships. The production and consumption demand of natural gas has been rising in India for both industrial and domestic uses. After the gas is processed it is piped or compressed into cylinders for use by the consumers

### 28.4.3 Problems associated with oil and gas

Leakage of natural gas from pipelines, storage tanks and distribution tanks is potential cause of explosion. Methane being major component of natural gas, happens to be a green house gas and its leakage contributes to global warming. But being a clean fuel has advantages over coal and oil and preferred as a better fuel option or energy resource.

Extraction of oil and gas may cause sinking of land or subsidence. For example, in Long Beach Harbor area, in Los Angeles, USA, intensive oil extraction beginning in 1928 caused severe land subsidence. Over the well sites, the ground dropped 9 metres. Extensive subsidence created a need for flood control measures along the coastline. Damage to buildings, roads and other structures were estimated at 100 million dollars. Another major problem in the past with onshore oil wells has been brine (salt water). Typically, for every barrel of oil production ten barrels of brine are also extracted. In early days the brine was simply discarded into nearby streams or on the soil. Today most brine is reinjected into the well. However, brine can contaminate fresh water aquifers if the casing lining the well is missing or corroded.

Apart from these two problems, oil also contaminates the oceans. About half of the oil that contaminates the ocean comes from natural seepage from offshore deposits (annually approximately 600,000 metric tonnes of oil seeps into the ocean from natural sources). 20% of the oil contaminating the ocean comes from oil well, blowouts, pipeline breaks and tankers. The rest comes from oil disposed off inland and carried into the ocean by rivers. Leakage from offshore wells also occurs during the transfer of oil to shore and also during normal operations.

The harmful effects of oils contamination are felt both in fresh water and marine water environments. Oil kills aquatic plants and animals. After a major spill it may take two to ten years for the organisms to recover. Combustion of oil and gas also cause air pollution.

Even though the natural process of fossil fuel formation is continuing today, but the rate of production is very low. For all practical purposes the world's supply of fossil fuels is limited to what was formed 300 million years ago. When this supply is exhausted we will have no more supply. As a result of realization, people have started exploring and use alternative sources of energy.

### 28.4.4 Location of fossil fuel deposits in India

India has large reserves of coal and lignite is found in West Bengal, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh as well as in Assam and Tamil Nadu. Oil and natural gas are exploited both from inland and offshore sites. Some of the major oil reserves are located in West coast, Gujarat, Godavari and Krishna delta on the East coast, Assam and Rajasthan. Fossil fuel deposits are also found in India in limited amounts

### 28.4.5 Uses of natural gas

1. Natural gas is a relatively clean fuel burns readily to produce large amount of heat that is why natural gas is used as the main fuel for domestic and industrial heating purposes. It is used as a fuel in thermal power plants for generating electricity and a feedstock for manufacture of fertilizers.
2. Compressed Natural Gas (CNG) is being increasingly used as a fuel in transport vehicles (buses, trucks and cars). CNG is a good alternative to petrol and diesel because it causes less pollution. These days in Delhi and some other cities are using since the use of CNG as an alternative fuel for automobiles has started, air pollution levels have decreased perceptibly.
3. Natural gas is used as a source of hydrogen gas needed in fertilizer industry. When natural gas is heated strongly, the methane present in it decomposes to form carbon and hydrogen. This hydrogen gas is combined with nitrogen gas to manufacture of ammonia ($NH_3$). Reaction of ammonia with acids, forms ammonium salts. These ammonium salts are used as fertilizers.
4. Natural gas is used as a source of carbon used in tyre industry. When natural gas is strongly heated, then methane gets in it decomposed to form carbon and hydrogen.

Notes

The carbon thus formed is called carbon black and used as filler in the manufacture of tyres.

### 28.4.6 Advantages of natural gas

Natural gas is a clear and environmental friendly fuel and used directly for cooking purpose in homes. It can be supplied directly to the homes and factories through a network of underground pipelines thus eliminate the need for additional storage and transport. Natural gas burns with smokeless flame and on burning does not produce any poisonous gas or pollute the environment friendly gas.

## INTEXT QUESTIONS 28.2

1. Which are the major fractions obtained from the distillation process of crude oil?

   ______________________________

2. What is the composition of conventional natural gas? Mention any one of its advantages as fuel?

   ______________________________

## 28.5 NUCLEAR ENERGY SOURCES

Nuclear energy is the energy of the atomic nucleus. Radioactive minerals are used to generate nuclear energy through high technological methods.

### 28.5.1 Radioactive minerals

Radioactive minerals used for generating energy are alternative to fossil fuels. Similar to other minerals, availability of ore of radioactive material is finite and limited. However, a very small quantity of radioactive minerals can generate large amounts of energy.

> Antoine Henri Becquerel discovered radioactivity in 1896 and his name lives on in the units used to measure it – Becquerel's (Bq). One Becquerel = 1 radioactive decay which is a very small amount. It may surprise you to know that every substance is radioactive to some extent. For example,
>
> One loaf of bread = 70 Bq
>
> One kg of coffee = 1000 Bq
>
> One adult human = 3000 Bq
>
> Ten kilogram of granite = 1200 Bq
>
> One kilogram of 50 year old high level radioactive waste = 10,000,000,000,000 Bq.

There are two methods (Fig. 28.5a and b)which can be used to release energy from radioactive minerals:

**i) Nuclear fission** – In this process, the nucleus of heavy atom namely of uranium ($U_{235}$) or plutonium ($P_{239}$) breaks apart into smaller fragments, releasing an enormous amount of energy.

**ii) Nuclear fusion** – In this process, small nucleus like those of isotopes of hydrogen, namely deuterium and tritium etc. fuse or join together to form heavier nuclei, releasing vast amounts of energy.

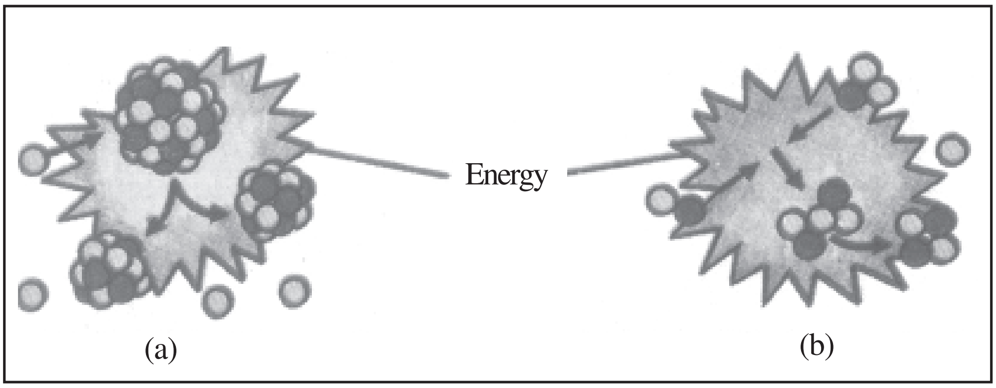


***Fig. 28.5:*** *a) Fission: This happens inside a nuclear reactor at a nuclear power station, and when there is a fission, or atom ("A"), bomb explodes. (b) Fusion: This is happening all the time in the sun. It also happens when the most powerful nuclear weapon, a fusion, or hydrogen ("H"), bomb explodes*

### 28.5.2 Nuclear fission

Radioactive mineral, which generates nuclear energy through fission, may be considered a non-renewable alternative source of energy as it is an ore and is found in limited quantities. Nuclear fission occurs because the atom of radioactive minerals contains nuclei that are unstable and break or split apart releasing energy (Fig. 28.6). Whenever a neutron strikes a nucleus of U-235, energy is released, krypton and barium are produced, and several neutrons are released. These new neutrons may strike other atoms of U-235 to produce a chain reaction. When this nuclear disintegration takes place particles from the nucleus including neutrons fly out. The neutron may cause other atomic nuclei to split releasing more neutrons and more energy. Once begun this chain reaction continuous to release energy until the fuel is spent or the neutrons are prevented from striking other nuclei (Fig. 28.7).

In the reactor of a nuclear power plant, the rate of nuclear chain reaction is controlled and the heat generated is used to produce high pressure steam, which spins turbine that generate electricity. Heat produced here is carried away by water coolant and transferred by way of heat exchanger to the water in a steam-generating unit. The steam produced powers a turbine that produces electricity. Cooling water is used to condense the steam after it has gone through the turbine

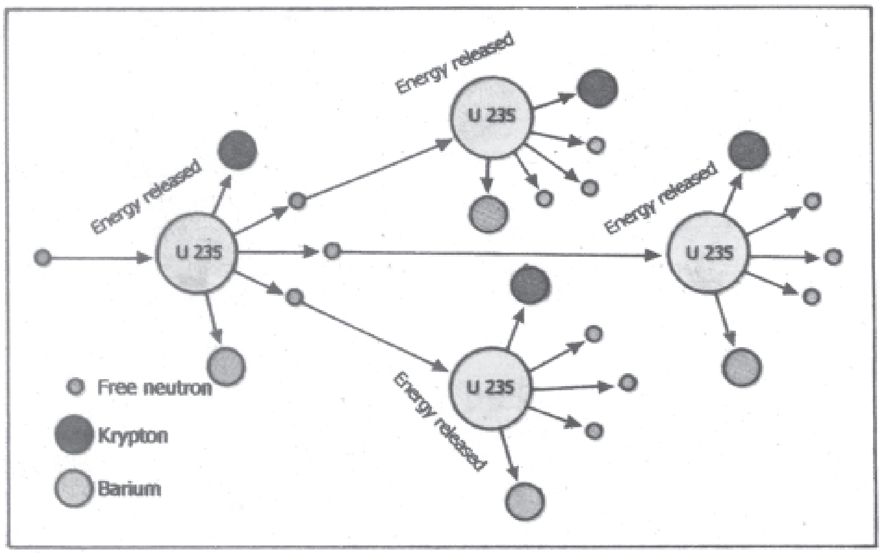


*Fig. 28.7: Nuclear fission showing chain reaction*

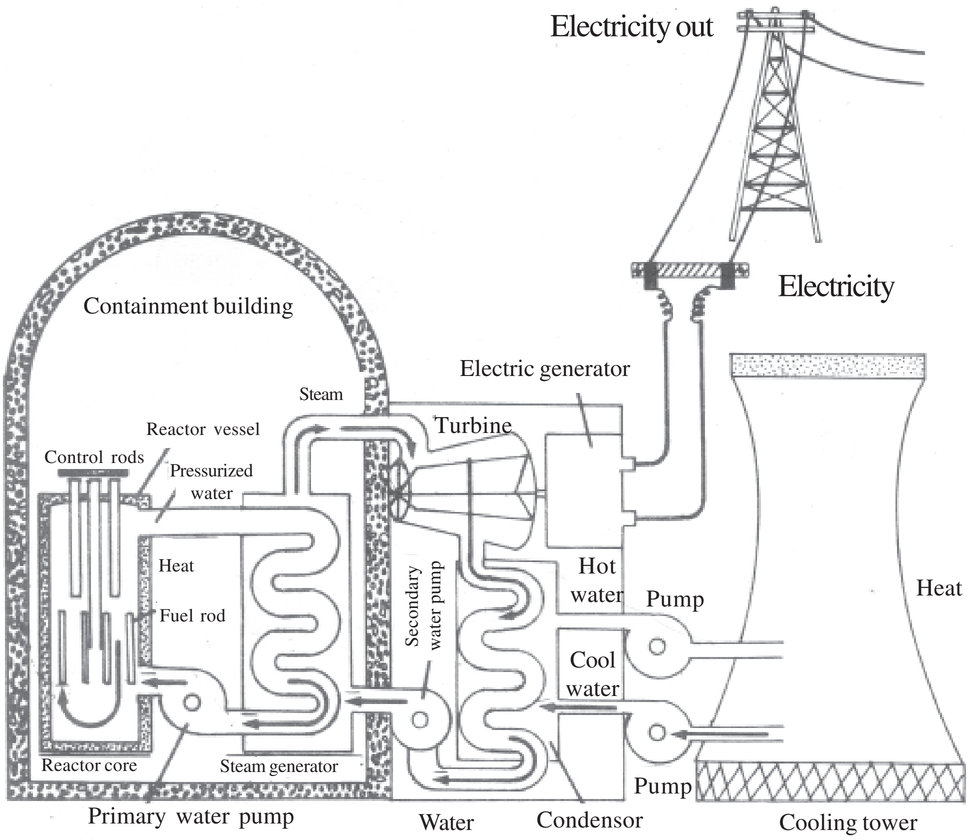


***Fig. 28.8:** Conversion of nuclear energy into electrical energy*

Two other nuclear technologies for generating electricity from nuclear fuel in a safe and economic way have also been proposed, but so far they have not proved operationally successful. These are: (i) nuclear breeder reactor, (ii) fusion reactor.

(i) **Nuclear breeder reactor**

The nuclear reactors operating today use uranium very inefficiently. About 1% uranium is actually used to produce steam for generating electricity. A nuclear reactor that can utilize between 40% and 70% of its nuclear fuel is called a **breeder reactor**. Breeder reactors convert more abundant uranium -238 or thorium -232 fissionable isotopes, Plutonium-239 or Uranium -233 respectively, that can sustain a nuclear chain reaction.

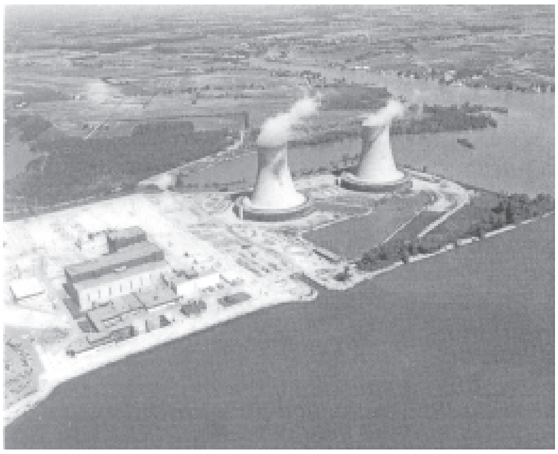

***Fig. 28.9:*** *A breeder reactor*

(ii) **Nuclear fusion reactor**

The principle for nuclear fusion involves, as you are aware, uniting two small atoms to form a large atom with the release of an enormous amount of energy. The energy produced by stars and the sun is the result of nuclear fusion. Generation of energy by this method so far, however, has not been possible though lot of research has focused on the fusion reaction of deuterium (D) and tritium (T) (two isotopes of hydrogen) which fuse at about 100 million degrees.

The advantage of using nuclear material for energy generation instead of coal and oil, is that it produces very little pollution. It requires less strip-mining as nuclear fuel have highly concentrated form of energy. Moreover the cost of transportation of nuclear fuels is much lower than that for coal and oil required for generation of an equivalent amount of energy.

### 28.5.3 Problems related to nuclear energy generation

Radioactive elements if not disposed properly cause radioactive pollution. However, the major problems associated with the generation of nuclear power are disposal of nuclear waste, contamination of environment with long lasting radioactive materials (radioactive pollution) thermal pollution, health effects from exposure to low levels of radiation, limited supplies of uranium ore, high construction and maintenance costs, questionable reactor safety, human or technical error that could result in a major accidents and vulnerability to sabotage, developing nuclear weapons by processing reactor waste.

Problems of dismantling of a nuclear plant's, after their useful life of 30-40 years is over. There are some very important questions left unanswered related to nuclear energy generation. The Chernobyl disaster in USSR and Three Mile Island plant in USA accident have raised serious concern about the safety of nuclear power plants.

**Location of radioactive mineral ore in India**

In India, monazite that is the main source of thorium, is found in commercial quantities on the Travancore coast between Kanya Kumari and Quilon, while uranite or pitchblende mineral of uranium is found in Gaya (Bihar), Ajmer (Rajasthan) and Nellore (Andhra Pradesh). Utilisation of radioactive minerals is expanding and investigations are being carried out on such deposits to provide definite indications of magnitude, and potential for exploitation.

It is, important to realize that none of these resources can last for ever. It has become, necessary to rely on replenishable and regenerative resource base as well as on those types of technologies, which improve energy use efficiency.

> Mostly of the conventional energy sources which are replenishable are called **inexhaustible or renewable** energy sources that include firewood, cattle dung, farm or agricultural wastes etc. Since these energy sources are generally of plant and animal origin, they can be grown and produced. But if they are used recklessly and irresponsible manner, they may get exhausted and may become non renewable.

## INTEXT QUESTIONS 28.3

1. What is meant by radioactive pollution?

2. Distinguish between nuclear fission and nuclear fusion reactions.

3. What advantage does nuclear material has as energy source over coal and oil?

Notes

## WHAT YOU HAVE LEARNT

- The exhaustible non-renewable or finite resources of the earth include fuel mineral resources such as coal, oil and natural gas are collectively called fossil fuels. These non renewable resources are formed over time from the remains of organisms.
- Coal is a solid fossil fuel found under the ground. It is actually fossilized plants turned into sedimentary rocks. The basic grades of coal are lignite, bituminous and anthracite. They are mined and transported to different places.
- Nuclear power is a fuel mineral resource and so is exhaustible resource however only a small quality can generate large amount of electricity.
- It offers many advantages over coal and oil power such as little air pollution, less mining, less disturbance of land.
- But the major problems with nuclear power are disposal of radioactive wastes, contamination of the environment, thermal pollution, health impact from radiation, limited supply of ores, security of nuclear reactors and theft of nuclear materials.
- Another important fossil fuel is natural gas; it burns very easily and produces a lot of heat. Natural gas is found under the earth. Main constituent of natural gas is methane ($CH_4$), which constitutes up to 95% and remaining is ethane and propane. It can be used directly in homes for cooking purposes.

## TERMINAL EXERCISE

1. What actions can you take at a personal level to reduce consumption of fossil fuels?
2. How were fossils fuels formed?
3. Discuss advantages and disadvantages of nuclear energy.
4. Speculate which one of the fossil fuel will run out first.
5. Discuss the importance of energy consumption to the society. What major concerns does it basis?
6. Describe the pros and cons of the following types of fossil fuel.
   i) Coal
   ii) Oil
   iii) Natural gas

Notes

7. Describe the environmental degradation caused by the use of fossil fuel in 20th century.
8. Explain fusion and fission and differentiate them.
9. Give your view on "Nuclear power and energy source".

## ANSWER TO INTEXT QUESTIONS

**28.1**

1. Plant material of swamps died and accumulated under water many centuries ago called peat. Sediments of sand and soil were deposited over the peat. The weight of sediments and heat from the earth change peat into soft coal (bituminous coal) to hard coal (anthracite).
2. Coal is used as a fuel for domestic use. It is used in locomotive engines and various types of furnaces in the industries. It is used as a fuel in thermal power plants for generation of electricity.

**28.2**

1. The products or fractions obtained from crude oil distillation are gases, gasoline (petrol), aviation fuel, kerosene, diesel oil, naptha, grease and asphalt.
2. Natural gas is a mixture of methane, with small amounts of heavier hydrocarbon such as ethane and butane.

   Advantages of natural gas are : a) It is used directly for cooking purposes at home, (b) It burns with smokeless and does not produce any poisonous gases on burning.

**28.3**

1. The advantage of nuclear material for energy generation is that produces very little pollution, it requires less mining as nuclear fuel is a concentrated form of energy and cost of transportation of nuclear fuel is lower than that for an equivalent amount of coal.
2. Nuclear fission occurs because atoms of radioactive mineral contains nuclei that are unstable and break or split apart releasing energy. Nuclear fusion involves uniting two small atoms to form a large atom with the release of enormous amount of energy.
3. Radioactive elements if not disposed properly cause disintegration in soil and water causing radioactive pollution which has long lasting effects in human health and the environment.

# 29

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# FRESH WATER RESOURCES

You have already learnt about the importance of fresh water without which there would be no life on earth. In this lesson you will learn about fresh water resources, its use and the significance of maintaining the quality of fresh water.

## OBJECTIVES

After completing this lesson you will be able to:

- *describe the distribution of fresh water resources;*
- *describe the ways by which water is collected, processed and distributed for household consumption;*
- *describe the common methods of purifying fresh water for domestic uses (potable water), in view of the consequences of drinking raw water;*
- *explain the concept of water quality;*
- *describe the manner in which water is used for domestic, industrial and agricultural purposes;*
- *describe the importance of water as raw material and consequences of using it as dumping medium for effluents (domestic and industrial).*

## 29.1 DISTRIBUTION OF FRESH WATER

The fresh water which is so essential for life is only a small portion about 2.7 % of the total water available on this earth. Nearly all of this fresh water is locked in the masses of ice caps, glaciers and clouds. The remaining small fraction of fresh water has accumulated over centuries in the lakes and underground sources. Surprisingly it is the salt water of the oceans that is the ultimate source of fresh water on this earth. About 85% of the rain water falls on directly into the sea and never reaches the land. A small remainder of the total global precipitation on that falls on the land fills up the lakes and wells, and keeps the river flowing. Thus, the fresh water is available to mankind is a scarce and precious commodity.

Water covers about three quarters of the earth's surface. The total amount of water has been estimated to be more than 1400 $mkm^3$, enough to cover the entire earth with a layer of water of 300 meter depth. About 97.3% of this water is in the oceans. Of the 2.7% that is fresh, 2.14% lies frozen in the polar regions. Thus, all the water in the lakes and rivers, all the moisture in the atmosphere, soil, vegetation and all the water underground amounts to about 0.5% of the total. Of this 0.5% (that is liquid fresh water), more than 98% is in the form of ground water, half of which may lie more than 1000 meters below the surface and thus only 0.1% is in the rivers.

***Table 29.1:*** *World water distribution*

| Location | Volume $10^{12}m^3$ | % of Total |
|---|---|---|
| Reservoirs | | |
| • Oceans and seas | 1370 | 94 |
| • Lake/ponds/reservoirs | 125 | 0.01 |
| • Swamps and marshes | 1.25 | 0.0001 |
| • Rivers (average instantaneous volume) | 67 | 0.005 |
| • Soil moisture | 8350 | 0.38 |
| • Ground water (below 2200 ft) | – | 0.30 |
| • Ice caps and glaciers | 29,200 | 2.05 |
| • Atmospheric water | 37,800 | 2.75 |
| Atmosphere (water vapour) | 13 | 0.001 |
| Oceans | 1,320,000 | 97.25 |
| Grand total | 1,360,000 | 100 |

*Source: Schmitz (1996)*

## 29.2 WATER RESOURCE DISTRIBUTION IN INDIA

The annual rainfall over India is 1170 mm. It is more than any where else in the world for a country of comparable size. From **precipitation** alone, India receives 4000 billion cubic meters (BCM), including snow fall. Of this ¾ part occurs only during the monsoon. A good part of it is lost through the process of evaporation and plant transpiration, leaving only half of it on the land for us to use. After allowing for evapotranspiration losses the country's surface flow is estimated as 1880 BCM. Due to topographical, hydrological and other constraints, it is assessed that only about 700 BCM of surface water can be put to beneficial use. The annual replenishable ground water resources are assessed to be about 600 BCM of which the annual usable resources are estimated at 420 BCM. Since independence, the country has been planning to best utilize this water by prolonging its stay on land by using engineering innovations such as dams and barrages.

*Table 29.2:* *Estimated distributed of water resources of India*

| Compartment | Quantity, billion cubic meter (BCM) |
|---|---|
| Total precipitation | 4000 |
| • Immediate evaporation | 700 |
| • Percolation in soil | 2150 |
| -Soil moisture | 1650 |
| -Ground water | 500 |
| • Surface water | 1150 |

There are three main sources of fresh water in our country. These are: rivers, lakes and ground water. A brief description of these sources of water is provided below:

(i) **Rivers**

The rivers are characterized by unidirectional current with a relatively high, average flow ranging from 0.1 to 1 m/s. The river flow is highly variable with time depending on climatic situation and the drainage pattern. In general, thorough and continuous vertical mixing is achieved in rivers due to prevailing currents and turbulence.

(ii) **Lakes**

The lakes are characterized by low average current velocity of 0.001 to 0.01 m/s (surface value). Current within lakes are multidirectional. Many lakes have alternating period of stratification and vertical mixing; periodicity of which is regulated by the climatic conditions and depth of the lake.

(iii) **Ground water**

The ground water are characterized by a rather steady flow pattern in terms of direction and velocity. The average flow velocities commonly found in aquifers (groundwater reservoirs) range from $10^{-10}$ to $10^{-3}$ m/s and are largely governed by the porosity and the permeability of the geological material. As a consequence, mixing is rather poor and, depending on local hydro- geological features, the groundwater dynamics can be highly diverse.

## INTEXT QUESTIONS 29.1

1. What fraction of total water available on earth is fresh water?

   ________________________________________

2. Water covers about three quarters of the earth's surface but how much of it is fresh water?

   ________________________________________

3. Name the three resources of fresh water.

   ________________________________________

## 29.3 WATER COLLECTION

Water is collected and distributed for various uses, domestic and industrial purposes and for irrigation. The domestic water is mostly used for drinking, bathing, washing, cleaning and flushing the toilets. Since domestic water is used for drinking, it requires high purity. The major sources of drinking water are **rivers, lakes** and **groundwater**. Drinking water or potable water is either directly collected from sources as in most of our rural areas or supplied by different agencies like municipal authorities or public health departments. The surface water generally requires treatment before supply for drinking as they are often found contaminated. Ground water, on the other hand, is usually free of microbes and suspended solids because of natural filtration as the water moves through soil, though it often contains relatively high concentrations of dissolved minerals from its direct contact with soil and rock. (Recall from Lesson 28).

The large cities and towns and villages where ground water is not fit for drinking, the **surface water** is used for drinking. Those cities and towns located along the rivers and lakes directly draw water from them and supply for domestic use after treatment. Those cities located away from any surface water sources transport it though canals or pipelines. Large cities like Delhi draws water from multiple sources like Bhakra reservoir, Upper Ganga Canal, Western Yamuna Canal and Yamuna river. The raw water is probably treated before supply for domestic use.

## 29.4 WATER TREATMENT

Water in river or lakes has to be treated or purified before it is supplied for human consumption. Groundwater, too, often needs treatment to render it potable. The primary objective of water treatment is to protect the health of the community. Potable water must be free of harmful microorganisms and chemicals. The water should be crystal clear, with almost no turbidity, and it should be free of objectionable colour, odour, and taste. For domestic supplies, water should not be corrosive, nor should it deposit troublesome amounts of scale and stains on plumbing fixtures. Industrial requirements may be even more stringent; many industries provide special treatment in their own premises.

The type and extent of treatment required to obtain potable water depends on the quality of the source. Surface water usually needs more extensive treatment than does ground water, because most streams, rivers and lakes are polluted to varying extent. Even in areas far away from human settlements, surface water contains suspended silt, organic material, decaying vegetation, and microbes from animal wastes.

### 29.4.1 Methods of water treatment

Water is treated by a variety of physical and chemical methods. Treatment of surface water begins with intake screens to prevent fish and debris from entering the treatment plant and damaging pumps and other components. Conventional treatment of water primarily involves clarification and disinfections. Clarification removes most of the turbidity, making water crystal clear. Disinfection, usually the final step in the treatment of drinking water, destroys pathogenic microbes. In addition, to clarification and disinfection, the processes of softening, aeration, carbon adsorption, and defluridation may be used for certain public water sources. Desalination processes i.e. removal of excess salt from water are used in areas where fresh water supplies are not readily available or the ground water is saline.

(a) **Clarification or sedimentation**

Impuries in water are either dissolved or suspended. The suspended material reduces clarity, and the easiest way to remove it is to let suspended particles settle.

- **Coagulation and flocculation**

Suspended particles cannot be removed completely by plain settling. Large, heavy particles settle out readily, but smaller and lighter particles do not settle easily. Such particles are called colloidal particles. To remove such smaller particles, alum is added. Alum causes flocculation. Flocculation is a process through which all the finer insoluble particles form large particles called **flocs**. These flocs then can easily settle and thus are removed from water. Aluminium sulphate (alum) is the most common coagulant used for water purification. Other chemicals, such as ferric sulphate or sodium aluminate, may also be used. The flocculation tank has wooden paddle-type mixers that slowly rotate on a horizontal motor-driven shaft. After flocculation the flocs are allowed to settle in a settling tank. From here the supernatant is passed through sand filters. Microstrainers are used mainly to remove algae from surface water supplies before conventional **gravity-flow filtration**.

- **Filtration**

Even after coagulation and flocculation, sedimentation does not remove enough suspended impurities from water to make it crystal clear. Filtration is a physical process that removes these impurities from water by percolating it downward through a layer or bed of porous, granular material such as sand. Suspended particles become trapped within the pore spaces of the filter media, which also remove harmful protozoa and natural colour. Most surface water supplies require filtration after the coagulation and sedimentation steps.

When clogged by particles removed from water, the filter bed must be cleaned by backwashing. In the backwash process, the direction of flow through the filter is reversed. Clean water is forced upward through the media, expanding the filter bed slightly and carrying away the impurities in wash troughs. The backwash water is distributed uniformly across the filter bottom by an under drain system of perforated pipes or porous tile blocks.

Because of its reliability, the **rapid filter** is the most common type of filter used to treat public water supplies. However, other types of filters may be used, including pressure filters, diatomaceous earth filters, and microstrainers. As pressure filter has a granular media bed, but, instead of being open at the top like gravity-flow rapid filter, it is enclosed in a cylindrical steel tank. Water is pumped through the filter under pressure. In diatomaceous earth filters a natural powder like material composed of the shells of microscopic organisms called diatoms is used as a filter media. The powder is supported in a thin layer on a metal screen or fabric, and water is pumped through the layer. Pressure filters and diatomaceous earth filters are used most often for industrial applications or for public swimming pools.

**Microstrainers** consist of a finely stainless steel wire cloth mounted on a revolving drum that is partially submerged in the water. Water enters through an open end of the drum and flows out through the screen, leaving suspended solids behind. Captured solids are washed into a hopper when they are carried up out of the water by the rotating drum. Microstrainers are used mainly to remove algae from surface water supplies before conventional gravity-flow filtration.

(b) **Disinfection**

**Disinfection** destroys pathogenic bacteria and is essential to prevent the spread of water borne disease. Typically the final process in drinking water treatment, it is accomplished by applying either chlorine, ozone or ultraviolet radiation to clarified water.

- **Chlorination**

The addition of chlorine or chlorine compounds to drinking water is called **chlorination**. Chlorine compounds may be applied in liquid and solid forms-for instance, liquid sodium hypochlorite or calcium in tablet or granular form, however, the direct application of gaseous chlorine from pressurized steel containers is usually the most economical methods for disinfecting large volumes of water.

Taste or odour problems are avoided with proper dosages of chlorine at the treatment plant, and a residual concentration can be maintained throughout the distribution system to ensure a safe level at the points of use. Chlorine can combine with certain naturally occurring organic compounds in water to produce chloroform and other potentially harmful by-products. The risk of this is very small, however, when chlorine is applied after coagulation, sedimentation, and filtration.

- **Ozone**

Ozone gas may also be used for disinfection of drinking water. However, since ozone is unstable, it cannot be stored and must be produced on-site, making the process more expensive than chlorination. Ozone has the advantage of not causing taste or odour problems. It also leaves no residue in the disinfected water. The lack of an ozone residue, however, makes it difficult to monitor its continued effectiveness as water flows through the distribution system.

### 29.4.2 Traditional methods of water treatment

In ancient times there was appreciation and regard for the importance of water purity. Sanskrit writings from as early as 2000 BC tell how to purify foul water by boiling and filtering. But it was not until the middle of the $19^{th}$ century that a direct link between polluted water and disease (Cholera) was proved. And it was not until the end of that same century that the German bacteriologist Robert Koch proved the germ theory of disease, establishing a scientific basis for the treatment and disinfection of drinking water.

Water treatment is the alteration of a water source in order to achieve a quality that meets specified goals. The end of the $19^{th}$ century and the beginning of the $20^{th}$ century, the main goal was elimination of deadly water borne diseases. The treatment of public drinking water to remove pathogenic, or disease-causing, microorganisms began about that time. Treatment methods included sand filtration as well as use of chlorine for disinfection.

In developing countries, water borne disease is still the main water quality concern. In industrialized nations, however, concern has shifted to the chronic health effects related to chemical contamination. For example, trace amounts of certain synthetic organic substances in drinking water are suspected of causing cancer in humans. The added goal of reducing such health risks is seen in the continually increasing number of factors included in drinking water standards.

### 29.4.3 Other methods of water purification

Sometimes natural contaminants like fluorides, iron or arsenic are present in water. These impurities are harmful to human health. There are methods to remove these impurities.

- **Removal of fluoride**

Fluoride is generally present in all natural water. Its concentration up to certain level is not harmful. Beyond that level, the bones start disintegrating. This disease is called **fluorosis**. We have fluoride problem in many parts of our country. Bureau of Indian Standards prescribes 1.0 mg/l as desirable and 1.5 mg/l as maximum permissible limit for drinking water. Any water containing high level of fluoride needs to be treated for removal of fluoride in order to make it safe. The simple treatment technique which can be adopted at house hold level is described below:

- **Domestic defluoridation**

Defluoridation at domestic level can be carried out in a container (bucket) of about 60 litre capacity. The bucket should have a tap 3-4 cm above the bottom for withdrawal of treated water after treatment. The water for treatment is taken in the container, is mixed within adequate amount of aluminum sulphate (alum) solution, lime or sodium carbonate and bleaching powder depending upon its alkalinity (concentration of bicarbonates and carbonates in water) and fluoride contents. Alum solution is added first and mixed well.

Lime or sodium carbonate solution is them added and water is stirred for 20 minutes, then it is allowed to settle for nearly one hour and then withdrawn through tap for consumption. The settle sludge is discarded. Normally 100 to 600 ml of alum solution is required to be added in 40 litres of water containing fluoride ranging from 2 to 9 mg/l in order to remove it to acceptable level.

**• Defluorodation at community level**

The community used technique for community water supply is called **Nalgonda Technique** developed by National Environmental Engineering Research Institute (NEERI), Nagpur. It has following components:

- Reactor(s)
- Sump well
- Sludge drying bed.

This is a batch method for community upto 200 population. The tank is equipped with mechanical agitator operated manually or by electric motor. Water is pumped or poured into the tank and required amount of alum, lime or sodium bicarbonate and bleaching powder is added with constant stirring. The contents are stirred slowly for ten minutes and allowed to settle for two hours. The defluridated supernatant water is withdrawn and supplied. The sludge from the bottom is discarded.

**• Removal of iron**

In many parts of our country we have problem of excess iron in drinking water especially in North-East regions. Iron causes bad taste and odour to the drinking water. Bureau of Indian Standards prescribes desirable limit for iron as 0.3 mg/l. Removal of iron is essential.

**• At domestic level**

This is the simplest unit developed by NEERI . It involves aeration of raw water over a series of coke, marble/calcite bed followed by slow sand filtration. No chemical is required for treatment. Upto 200 l/hr of water can be treated.

**• At community level**

The treatment is a sequential processes of aeration, reaction-cum-setting and filtration. The main part of the treatment plant is a vertical cylindrical vessel having following chambers:

1. aeration-cum-oxidation chamber
2. settling-cum-filtration chamber
3. final collection chamber for treated water

Water from the hand pump is sprinkled from the top. This will ensure contact with air for complete aeration. A major part of iron is oxidized here. Then the water is made to react with oxidizing media (lime stone). The remaining iron is oxidized in this chamber. By aeration and further oxidation the dissolved iron is converted to insoluble ferric hydroxide. The insoluble iron can thus be easily removed through filtration. Then it is passed through filter media (sand and gravel filter). The filtrate water contains iron in an acceptable range.

- **Removal of arsenic**

Arsenic is found in ground water in some parts of West Bengal. Arsenic is highly toxic in nature,. It may cause a number of skin disorders or even cancer. Bureau of Indian Standards prescribes desirable limit for arsenic as 0.05 mg/l. Removal of arsenic is essential. The treatment technology developed by Institute of Public Health and Hygiene, Kolkata is commonly used. The technology is based on oxidation, coagulation, flocculation, sedimentation and filtration. Bleaching powder and alum are used for removal of arsenic. It consists of three chambers. In the first chamber the chemicals are added. The mixture is then passed to next chamber called settling tank, where it is allowed to settle for 2 hours. The supernatant is then passed through a slow sand filter. The filtrate water generally contains arsenic in the acceptable range.

## INTEXT QUESTIONS 29.2

1. Why does usable water require treatment?
2. Name the steps in water treatment.
3. What is fluorosis?
4. How is water rid of iron at the community level?
5. What harm does arsenic cause if consumed with water contaminated with it?

## 29.5 CONCEPT OF WATER QUALITY

Water being the best solvent available on earth, is seldom found in pure state. Water in nature is most nearly pure in its vapour state. Water may acquire impurities at the very moment of condensation. In hydrological cycle, water comes in contact with atmosphere, soil and other materials lying on land and also the minerals underground. During this contact water acquires impurities. Human activities contribute further impurities in the form of industrial and domestic wastes, agriculture chemicals and other contaminants.

The term quality therefore, must be considered relative to the proposed use of water. Thus, water quality is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example for the sake of human health, we require that water supply be pure, wholesome, and potable. Similarly for agriculture, we require that the sensitivity of different crops to dissolved minerals and other toxic materials is known. Textiles, paper, brewing, and dozens of other industries using water, have their specific water quality needs.

For management of water quality of a water body, one has to define the water quality requirements or water quality objectives for that water body. As mentioned above, each water use has specific water quality need, therefore, for setting water quality objectives of a water body, it is essential to identify the uses of water in that water body. In India, the Central Pollution Control Board (CPCB), an apex body in the field of water quality management, has developed a concept of "designated best use". Accordingly out of several uses a particular water body is put to, the use which is highest quality of water is called its "designated best use", and accordingly the water body is designated as A, B, C, D, E. On the basis (1) pH, (2) dissolved oxygen, mg/1 (3) BOD, ($20^0$C) mg/l(4) total coliform (MPN/100ml) (5) free ammonia mg/l, (6) electrical conductivity etc. The CPCB has identified 5 such "designated best uses" as given in Table 29.3.

***Table 29.3:*** *Use based classification of surface waters in India*

| *Designated best use* | *Quality class* |
|---|---|
| Drinking water source without conventional treatment, but with chlorination | A |
| Outdoor bathing (organized) | B |
| Drinking water source with conventional treatment | C |
| Propagation of wildlife and fisheries | D |
| Irrigation, industrial cooling and controlled waste disposal | E |

The CPCB, in collaboration with the concerned State Pollution Control Boards, has classified all the water bodies including coastal waters in the country according to their "designated best uses". This classification helps the water quality managers and planners to set water quality targets and identify needs and priority for water quality restoration programmes for various water bodies in the country. The famous Ganga Action Plan and subsequently the National River Action Plan are results of such exercise.

## 29.6 WATER QUALITY REQUIREMENT FOR DIFFERENT USES

Inherently water is a multiple use resource. With the advent of industrialization and increasing population, the range of requirement for water has increased. The main uses of water are public supply, outdoor bathing and recreation, fisheries and wildlife propagation, irrigation and other agricultural uses, cooling in power plants, navigation and disposal of wastes. Drinking water needs highest purity of water, whereas disposal of wastes can be done in any quality of water. In recent years as the demand for water has nearly approached in magnitude the available supply, the concept of "management of the quality of water" has become very important throughout the world.

## 29.7 ECOLOGICAL WATER REQUIREMENTS

Maintaining ecological quality often requires significant amount of water to flow in a river. Each river has developed a well-established ecosystem in its course having different habitats and seasonality. All the biological processes are highly timed and spaced. To accomplish these processes, a minimum level of water is required. Water quantity has ecological impact in a number of ways. Flood flows flush out spawning areas, leaving clean new gravels, sand washed out of the hills. Controlling flows by dams prevents both cleaning and renewal. High flow rates sweep debris from river channels and wash down new gravels and sand needed for spawning of many fish.

In the past and even now, dilution was considered to be an acceptable "solution to pollution" and self-purifying capacity of a stream. This has been included in most of the effluent standards (Minimum National Standards, MINAS) notified under Environment (Protection) Act, 1986 by the Government of India. It is assumed that atleast ten times dilution is available in a stream where the effluent is going to be discharged. Because all deleterious material is not removed in waste water treatment, the role of dilution is very significant in protecting the health of a river. In our country, the need for fresh water is growing at a fast rate. Thus, the focus is laid on utilization of every drop of water. This has resulted in drastic reduction in flow conditions of many rivers in the country. Reduced flow followed by increased waste load have rendered many rivers almost ecologically dead. Thus, special attention is required in water resource planning.

## 29.8 MAJOR WATER QUALITY ISSUES OF INDIA

The major water quality issues in Indian context can be summarized as follows:

(a) **Water scarcity**

- Due to un-even distribution of rainfall in time and space and ever-increasing demand of water for agricultural, industrial and domestic activities, the water resources are over-exploited. This is resulting in shrinking or even drying up of many water bodies for considerable periods in a year.
- **Targets for conservation:** Reducing demands by optimum use, minimization of wastage, efforts to reduce the percolation and evaporation losses, conservation efforts in domestic uses, groundwater recharging, rain water harvesting, afforestation, recycling and reuse are important to combat this problem (See Lesson 28).

(b) **Pathogenic pollution**

- Water borne diseases are the most important water quality issues in India. This is mainly due to inadequate arrangements for transport and treatment of wastewaters. Thus a major portion of the wastewater generated from human settlements is not properly transported and treated before discharging into natural waters. This results in contamination of both surface and ground waters. Moreover, contribution of pathogens through diffuse sources is also quite significant. Thus, most of the surface water bodies and many ground water sources are contaminated.
- A large population of the country still uses water directly for drinking or bathing without any treatment, thus, exposed to water borne diseases. This is the single major cause for mortality due to water pollution.

(c) **Oxygen depletion**

- As indicated above a large portion of wastewater is discharged into water resources without any treatment. A major portion is from domestic sources. Such waste water contains high amount of organic matter. The industries e.g. agro-based industries also discharge effluents containing high organic matter. This organic matter when oxidized in water through microbial activities, consumes dissolved oxygen. Since water has limited availability of oxygen, if consumption exceeds the availability, oxygen depletion results and survival of aquatic life becomes difficult.
- In many water bodies massive input of organic matter set off a progressive series of chemical and biological events in the downstream water. The stretch is characterized by high bacterial population, cloudy appearance, high BOD and strong disagreeable odour-all indicating general depletion of oxygen. Masses of gaseous sludge rising from the bottom are often noticed floating near the surface of the water. During monsoon due to flood the sludge deposited in such stretches is flushed and stay in suspension, causing rise in oxygen uptake in the downstream. Due to such sudden oxygen depletion, heavy fish mortality occurs every year during first flushing after onset of monsoon.
- As per the water quality monitoring results of CPCB, a large number of rivers and some lakes are already facing such problem for a significant period in a year.

(d) **Eutrophication**

The discharge of domestic wastewater, agricultural return water or run-off water and many industrial effluents contribute nutrients like phosphates and nitrates. These nutrients promote excess growth of algae in water bodies (algal blooms). This is not desirable for balanced aquatic ecosystem (See lesson 10).

(e) **Salinity**

- There are number of cases where salinity is increasing in both surface water and groundwater. The increase in groundwater salinity is mainly due to increased irrigation activities or sea water intrusion in coastal areas. The salinity in surface water is increasing mainly due to discharges of industrial wastewater or agricultural return water.

- Salinity reduces the fitness of water for drinking or irrigation. It may also affect the ecosystem in surface water.
- Salinity is increasing in many water bodies especially groundwater due to leaching of salts build-up in agricultural areas under intense irrigation.
- A number of industrial activities discharge wastewater with high dissolved solids, cause increase in salinity of water.

(f) **Toxic pollution**

- Due to discharge of toxic effluents from many industries and increased use of chemicals in agriculture and their subsequent contribution to the water bodies, many water bodies in the country are polluted due to presence of toxic substances.
- Presence of toxic substance impairs the water quality by making it unfit for human consumption, aquatic life and irrigation.

(g) **Ecological health**

A large number of areas in our aquatic environment support rare species of aquatic and amphibious plants and animals and are, therefore, ecologically very sensitive. They need special protection.

## INTEXT QUESTIONS 29.3

1. What is meant by 'water quality'?

______________________________

2. State one example to express that concept of water quality differs with the purpose of using water.

______________________________

3. Name any two major water quality issues of our country.

______________________________

4. What is eutrophication?

______________________________

5. Why do certain aquatic areas require special protection?

______________________________

## 29.9 WATER USE IN INDIA

The uses of water in India are divided into two categories i.e. **abstractive uses** and **in stream uses**. A brief description of these uses is given below.

(1) **Abstractive Uses**

The different abstractive uses include domestic water supply, irrigation, industrial use of water. The details are as follows:-

(a) **Domestic water supply**

The cities located along the water bodies use the water for drinking and other domestic purpose after conventional treatment. About 14 billion cubic meter (BCM) of water per annum is used for domestic water supply in India.

In India nearly 85% of the population depends on ground water as a source of water for domestic use. Some of the urban and rural population also uses surface water after conventional treatment for domestic purposes.

(b) **Irrigation**

Irrigation is the most important use of water in India. Nearly 84% of the water is used only for irrigation. The total water used for irrigation is estimated as 460 BCM per annum.

(c) **Industrial use**

A large amount of water is used for industrial purpose. As per the estimation of CPCB about 30 BCM per annum is used as cooling water in thermal power plants.

(2) **In-stream use**

The in-stream uses of water are as follows:

(a) **Hydro-power**

The total potential for hydropower (energy from water) development in India has been estimated at 84,000 MW at 60% load factor. So far a potential of about 13400 MW has already been created and three schemes with a total power potential of about 5420 MW are under construction.

(b) **Fisheries**

Indian water resources are extensively utilized for fish production through out the country. India has the distinction of being the seventh largest producer of fish in the world and second largest producer of inland fisheries after China.

(c) **Navigation**

At present the river systems are not fully utilized for navigation, but there are plans to use the several stretches of our river system for navigation. Inland waterways in public sector is managed by government owned Central Inland Water Transport Corporation (CIWTC). In addition, the private sector companies operate a major chunk of Inland Waterways Traffic (IWT) (traveling or cruising by ship, boat etc.). The inland waterways traffic constitutes only a very small part of total transport network in the country which is dominated by rail and road transport. IWT traffic is adversely affected by withdrawal of water for domestic, agricultural and industrial uses etc.

(d) **Community bathing and washing**

The entire surface water sources are being used for bathing and washing. On particular religious and cultural occasions, when millions of people take holy dip in several stretches of our riverine system e.g. "Ganga snan", "Kumbh mela" etc.

(e) **Cattle bathing and watering**

Most of the towns and villages along the surface water sources have been using them for cattle bathing and watering/washing.

(f) **Water as raw material and not dumping ground for wastes**

With the advent of industrialization and increasing populations, the ranges of requirements for water have increased. This has resulted in gradual depletion of water from its sources and degradation in its quality. Each water use, including abstraction of water and discharge of wastewater leads to specific and generally predictable impact on quality of aquatic environment. In addition, to these intentional uses, there are several human activities which have indirect and undesirable, if not devastating, effects on water quality. Examples are uncontrolled land uses, deforestation, accidental (or unauthorized) release of chemicals, discharge of untreated or partially treated wastes or leaching of noxious liquids from solid wastes deposits. Similarly, the uncontrolled and excessive use of fertilizers and pesticides has long-term effects on ground and surface water resources.

Structural interventions in the natural hydrological cycle through construction of canals and dams on rivers, diversion of water within or among basins, and the over-pumping of aquifers are resulting in serious long term environmental damage.

## INTEXT QUESTIONS 29.4

1. State an abstractive use and an instream of water.

______________________________________________

2. Of what benefit are dams and canals drawn from rivers?

_______________________________________________

3. State two causes of long-term ecological damage to our river.

_______________________________________________

## WHAT YOU HAVE LEARNT

- Fresh water is only a small fraction of total water available on this earth. India receives about 4000 billion cubic meter (BCM) of rainwater annually. However, usable water is estimated as 1150 BCM. So far we are able to use only about 600 BCM of water.
- Fresh water resources are mainly rivers, lakes and ground water.
- For drinking water supply surface water are treated whereas groundwater can be used directly with disinfection.
- The drinking water treatment involves coagulation, filtration followed by disinfection.
- Coagulation involves addition of alum, which helps fine suspended particles to form flocs, which can easily settle or filtered out.
- Disinfection kills the harmful germs from water, thus water becomes free from pathogens.
- The treated water is then supplied through the distribution network in the residential areas.
- For specific pollutants like fluoride, iron or arsenic specific chemical treatments are given.
- Water quality is term used to define fitness of water for a particular use. For each water use specific water quality is required. Water quality in India is regulated under Water Act, 1974.
- Water uses are ether abstractive or in stream.
- Domestic, industrial and irrigation uses are abstractive uses whereas hydro-power generation, fisheries, navigation and outdoor bathing are in stream uses.
- Pathogenic pollution is the most important form of water pollution in India
- Some water bodies are facing oxygen depletion, eutrophication and salinity or toxicity problems.
- A large number of human activities including agriculture, industrial and urban have marked impact on water quality.

## TERMINAL EXERCISE

1. Describe the distribution of freshwater on earth.
2. Explain in brief the water resource distribution of India
3. How water is purified for drinking?
4. Why water is required to be purified for drinking?
5. Why ground water is safe for drinking?
6. How excess fluoride is removed from water?
7. How in stream uses affect water quality?
8. What are the main water quality issues in India?
9. How an agricultural activity affects water quality?
10. How water quality is altered due to dumping of wastes?

## ANSWER TO INTEXT QUESTIONS

**29.1**

1. About 2.7%
2. More than 1400 million $km^3$
3. Lakes, rivers, ground water

**29.2**

1. Because water used for drinking, bathing, washing, cleaning etc. and to protect the health of the community.
2. Step of water treatment

   I. Clarification or sedimentation

   Coagulation and fluoridation

   Filtration

   II. Disinfection

   Chlorination

   Ozone
3. Fluorisis is a crippling and painful disease caused by intake of fluoride.
4. By using a sequential process of aeration, reaction-cum-setting and filtration.
5. It may cause number of skin disorders of even cancer.

**29.3**

1. Those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water.
2. It is based on the physical, chemical or biological quality of water, removal of toxic substances for sake of human health, we require water supply by pure wholesome and potable.
3. Water scarcity wholesome and potable. Pathogenic pollution, oxygen depletion etc. or any other.
4. Enrichment of nutrients like phosphates and nitrates. Promotes excess growth of algae in water bodies.
5. Because for protection of rare species and survival of aquatic environment.

**29.4**

1. (i) Domestic water supply, irrigation (any other)

   (ii) Hydropower, fisheries and navigation (any other)
2. Ample water for irrigation, production of electricity.
3. Diversions of river stream and long term environment damage, pollution.

29

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# RENEWABLE SOURCES OF ENERGY-I

You have already known about non-renewable or exhaustible sources of energy. Most of us rely heavily on the use of non-renewable energy resources such as coal, oil and natural gas for our daily need but we know that these resources are finite in nature and eventually the day will come when they will vanish for ever. Before that they will become too expensive and also damaging for the environment. Sooner or later we have to think about using alternative energy resources which are renewable, may last forever.

The increasing population and change in our life style make great demand for energy resources. This ever increasing demand puts great pressure on non-renewable conventions energy sources and makes it necessary that we should look for other alternative energy resources. The sources like sun and wind can never be exhausted and are thus known as renewable sources of energy; they cause no emission of poisonous gases and are available locally. They are widely available and potential source of clean and limitless sources of energy. In this lesson you will study about such renewable sources of energy.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define renewable sources of energy;*
- *distinguish between renewable and non-renewable energy sources;*
- *list different renewable sources of energy;*
- *explain the importance of solar energy;*
- *describe the functioning of solar cooker, solar heater and solar cell;*
- *explain the methods of harnessing hydro energy and wind energy.*

Notes

## 29.1 ENERGY SOURCES

Humans have always been using some source of energy for a variety of purposes - cooking, warming, ploughing, transportation, lighting etc. To start they used fire wood and later kerosene or coal or rather lately the electricity. He used animal power (horse, bullock, camel, yak etc.) for transportation and for running minor mechanical devices like the persian wheel for irrigation or for running "kolhu" for extracting oil from oil seeds. During the last century or so, electricity has been produced from thermal plants (using coal) or from hydroelectric plants (using water current).

We can broadly categorise the source of energy according to periods of usage as follows-

(a) Conventional source of energy, which are easily available and have been in usage for long time.

(b) Non conventional source of energy, that are other than the usual or that are different from those in common practice.

**Sources of energy**

| **Conventional** | | **Non conventional** |
|---|---|---|
| **Conventiona non-renewable energy** | **Conventional renewable energy** | 1. Solar energy<br>2. Hydro power |
| Mostly fossil fuels found under the ground.<br>Coal, oil, natural gas etc. are the examples. | Mostly non-fossil fuels seen above the ground.<br>Fire wood, cattle dung from vegetable wastes, wood charcoal etc. are the examples. | 3. Wind energy<br>4. Nuclear energy<br>5. Hydrogen energy<br>6. Geothremal energy<br>7. Bio gas<br>8. Tidal energy<br>9. Bio-fuel |

Details of Non-renewable source of energy has been discussed in lesson-28.

Most of the renewable resources of energy are directly or indirectly related to sun or solar energy. Renewable sources of energy or non-conventional energy sources include sunlight, wind, water and biomass (firewood, animal dung, crop residue, agricultural wastes, biodegradable waste from cities and towns).Energy received from sun is known as **solar energy**, energy generated by water is **hydel energy** and energy obtained from underground hot dry rocks, magma, hot water springs or natural geysers etc is called **geothermal energy**. **Tidal energy** is derived from waves and tidal waves of oceans and seas.

## INTEXT QUESTIONS 29.1

1. What do you consider sun the single most important natural energy resource? Why?

______________________________________________

2. Give three examples of conventional and non-conventional sources of energy.

______________________________________________________________

3. Give one point of difference between conventional and non-conventional sources of energy.

______________________________________________________________

4. Differentiate between non-renewable and renewable energy sources.

______________________________________________________________

## 29.2 RENEWABLE OR NON-CONVENTIONAL SOURCES OF ENERGY

The rapidly depleting fossible fuel sources of energy and escalating demand of energy have made it necessary to look for alternative sources of energy that are known as renewable or inexhaustible.

We can define inexhaustible energy resources as 'those resources which can be harnessed without depletion'. Most of these resources are free from pollution and some of them can be used at all places. These renewable energy resources are also known as non-conventional or inexhaustible or alternate energy sources.

These energy sources are solar, flowing water, wind, hydrogen and geothermal. We get renewable solar energy directly from the sun and indirectly from moving water, wind and biomass. Like fossil fuels and nuclear power, each of these alternatives renewable sources of energy has their own advantages and disadvantages. We are going to discuss some of them in detail.

## 29.3 SOLAR ENERGY

Sun is an abundent source of energy and it is inexhaustible. In the broadest sense, solar energy supports all life on earth and is the basis for almost every form of energy we use. The sun makes plants grow, which are burned as fuel or rot in swamps and are compressed underground for millions of years to become coal and oil. Heat from the sun causes temperature differences between areas, causing the wind to blow. Water evaporates because of the sun, water vapours are carried to high elevations, and when the water vapours condense and precipitate as rainfall. The water rushes down towards the sea through rivers, spin turbines is too made for generating electricity. It thus becomes clear that hydroelectricity is an indirect form of solar energy. However direct solar energy can be used as heat, light, and electricity through the use of solar cells.

The sun is often regarded as the ultimate answer to our energy problems. Sun provides a continuous supply of energy that far exceeds our current energy demand. It is free of cost, available in plenty, found everywhere and has no political barrier. Actually fossil fuels also represent sunlight stored millions of years ago. However, we are only able to trap and make use of a very small fraction of this abundant energy source. Solar energy use can be classified as: i) direct solar energy use; solar energy is captured directly as sunlight and used for heating, generating electricity and cooling ii) indirect use of solar energy derived from natural processes driven by the sun, for example wind, biomass, waves, hydroelectric power.

> 5,000 years ago, people "worshipped' the sun. Ra, the sun-god, who was considered the first king of Egypt. In Mesopotamia, the sun-god shamash was a major deity and was equated with justice. In Greece there were two sun deities, Apollo and Helios. The influence of the sun also appears in other religions-Zoroastrianism, Mithraism, Roman religion, Hinduism, Buddism, the Druids of England, and Aztecs of Mexico, the incase of Peru, and many Native American tribes.

### 29.3.1 Direct solar energy

Solar energy is abundant, everlasting and available free of cost. Direct use of solar energy can be used through various devices broadly directed into three types of systems a) passive, b) active c) photovoltaic.

(a) **Passive solar energy**

As you know some of the earliest uses of solar energy were passive in nature such as to evaporate sea water for producing salt and to dry food and clothes. In fact solar energy is still being used for these purposes. The more recent passive uses of solar energy is for cooking, heating, cooling and for the daylighting of homes and buildings. The effectiveness of passive solar energy depends on good building design; no mechanical means are employed in passive use of solar energy.

**Passive use of solar energy for cooking**

The energy from the sun can be harnessed, to cook food without any large, complex systems of lenses or mirrors. We all know that when sunshine falls on a dark surface, it is absorbed and transformed into heat energy. Glass is bad conductor of heat but if a shallow glass covered chamber painted black inside and insulated all around is exposed to sun for some time the inside temperature would soon exceeds upto 100$^{o}$C which is sufficient to cook food. On a hot summer day the temperature inside the solar box cooker will easily becomes140$^{o}$C. Solar cooker takes 5-6 hours to cook food. The solar box cooker is the poor man's device for direct use of renewable source of energy. In Indian conditions with plentiful sunshine we can use a solar box cooker for cooking of food. The great advantage of solar cooking is its convenience because the food will never get overcooked or burnt. Apart from its "load-and-forget" quality, the food cooked in the solar cooker is also more tender and retains most of the nutritive values. But this comes at a cost is a slow process and take longer time i.e. solar cooking (Fig 29.1).

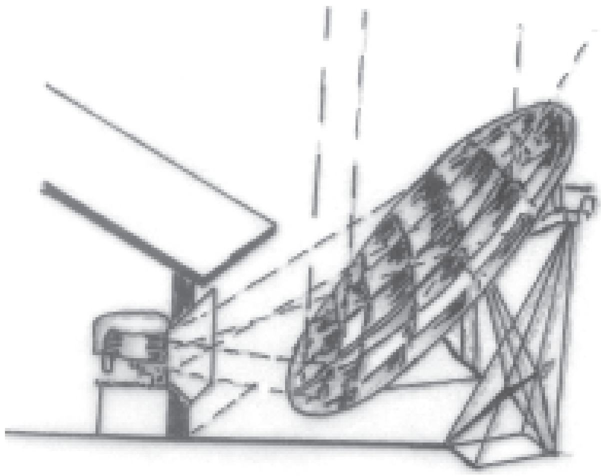


***Fig. 29.1:*** *Solar Cooker*

India may be justifiably proud that the world's largest solar steam cooking system is operating in the Brahmakumaris' Ashram at Mount Abu in India. Here the solar energy is concentrated by a battery of concentrators /mirrors to convert water into superheated steam. The system can cook for 10,000 people. It was constructed at a costs one crore of rupees excluding the labour of the ashram inmates.

**Passive use of solar energy for daylighting**

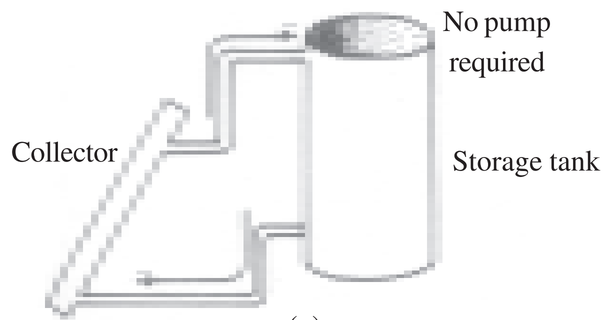
Daylighting is using natural sunlight to light building interiors. Day lighting technologies are designed to maximize natural light for illuminating the interior of buildings. These may be in the form of core lighting when the building may have a central atrium to allow entry of maximum sunlight.

The most recent technology is hybrid solar lighting which collects sunlight and send it though optical fibres into buildings where it is combined with electric light in "hybrid" light fixtures. There are sensors in the room which keep a steady lighting level by adjusting the electric lights based on the sunlight available. This new generation of color lighting combines both electric and solar power.

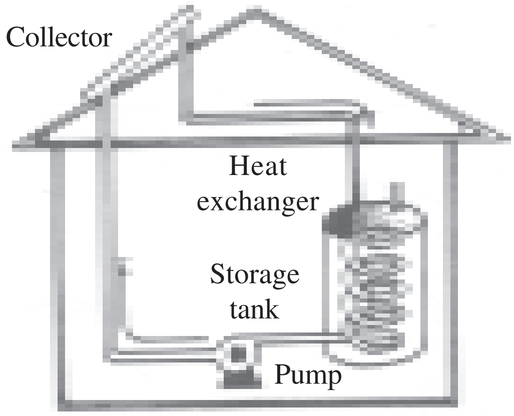
Passive solar systems are maintenance free. There are no moving parts and so no energy is expended for heating or cooling a building and hence, there are no operating costs. The only major problem is that passive solar heating, cooling and lighting system can be used only in specially designed buildings. Daylighting of business and commercial buildings provides a higher quality of light and improves productivity and health and at the same time results in substantial saving on electric bills.

(b) **Active use of solar energy**

Active solar heating and cooling systems rely on solar collectors which are usually mounted on roofs. Such systems also requires pumps and motors to move the fluids or blow air by fan in order to deliver the captured heat. (Fig.29.2 a and b). A number of different active solar heating systems are available. The main application of these systems is to provide hot water, primarily for domestic use. Active solar heating is extensively used in India, Japan, Israel, Australia and Southern United States having sunny climate.




(a)




(b)

***Fig. 29.2**: Two active solar systems for heating water: (a) thermo siphon system. (b) direct pump system.*

**Solar energy to produce electricity**

Solar energy is used to generate high temperature heat or electricity. Solar collectors in sunny deserts can produce high temperature heat to spin turbines for producing electricity but cost of such devices are high. Several solar thermal systems can collect and transform radiant energy received from the sun into high temperature thermal (heat) energy, which can be used directly or converted into electricity. Huge arrays of computer-controlled mirrors called **heliostats** track the sun and focus sunlight on a central heat collection tower.

Notes

**Solar energy for cooling**

A solar collector can also be used for cooling. In this system, energy from the sunlight powers a small heat engine similar to an electric motor of a refrigerator. The heat engine drives a piston that compresses a special vapour into a liquid; the liquid then revapourizes and draws heat out of the surrounding air.

(c) **Solar cells or photovoltaic technology**

Solar energy can be converted directly into electrical energy (direct current, DC) by photovoltaic (PV) cells commonly called solar cells. Photovoltaic cells are made of silicon and other materials. When sunlight strikes the silicon atoms it causes electrons to eject. A typical solar cell is a transparent wafer that contains a very thin semi conductor. (Fig. 29.3). Sunlight energizes and causes electrons in the semiconductor to flow, creating an electrical current. Solar cells can provide electricity to remote villages. India is the world's largest market for solar cells.

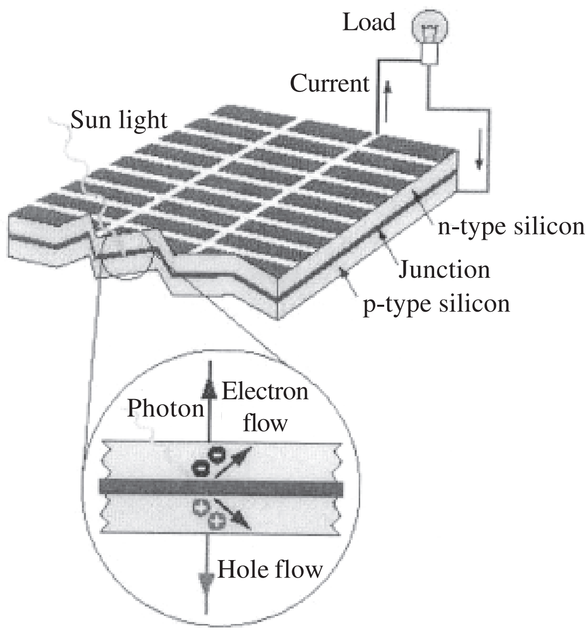



***Fig. 29.3:** Photovoltaic cell*

PV cells can be used for -

(i) domestic lighting.

(ii) street lighting.

(iii) village lighting.

(iv) water pumping.

(v) electrification.

(vi) desalination of salty water.

(vii) powering of remote telecommunication repeater stations and

(viii) railway signals.

## INTEXT QUESTIONS 29.2

1. Why solar energy is most important renewable type of energy.

2. Describe the various uses of solar energy.

3. What are photovoltaic cell and how they work?

## 29.4 INDIRECT SOLAR ENERGY

A large number of energy sources such as wind, tide and hydroelectric ultimately depend on solar energy. In this lesson out of the various type of indirect solar energy sources. We will discuss (a) wind energy, (b) tidal energy and (c) hydroelectric energy and (d) biomass energy.

### 29.4.1 Wind energy

About 2% of the sunlight striking the earth is converted into the kinetic energy of moving air called wind. The uneven absorption of the solar radiation by the earth's surface causes differences of temperature, density and pressure which produce air movements at local, regional and global levels powered by wind energy. The kinetic energy of the wind can be harnessed by converting it into mechanical energy or electrical energy using suitable devices.

As early as 4000 - 3500 BC, the first sailing ship and wind mills were developed by harnessing wind energy. The wind has been used to power ships, grind grains, pump water for irrigation and do other types of work (Fig. 29.4a).

In present times the greatest potential for using wind is for the production of electricity. Wind turbines, like wind mills are mounted on a tower to capture the most of the wind energy. Wind mills can be used to drive generators to producing electricity.

To produce electricity wind is used to turn the shaft of a turbine which is attached to a generator that produces electricity. Thus wind turbines transform wind energy into mechanical power which can be used to generate electricity. (Fig. 29.4b).

(a)

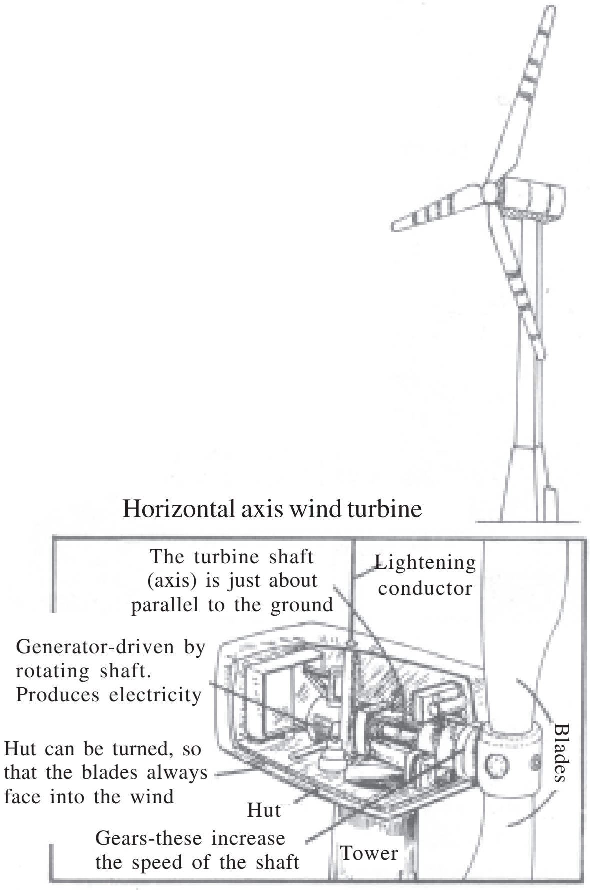



***Fig. 29.4:*** *(a) Wind mill used for pumping water (b) Wind mill used for generating electricity showing detail of shaft*

Wind turbines can be used single or in clusters. When wind turbines occur in clusters they are called 'wind farms' (Fig. 29.5). Small wind turbines called aero generators and can be used to charge large batteries.

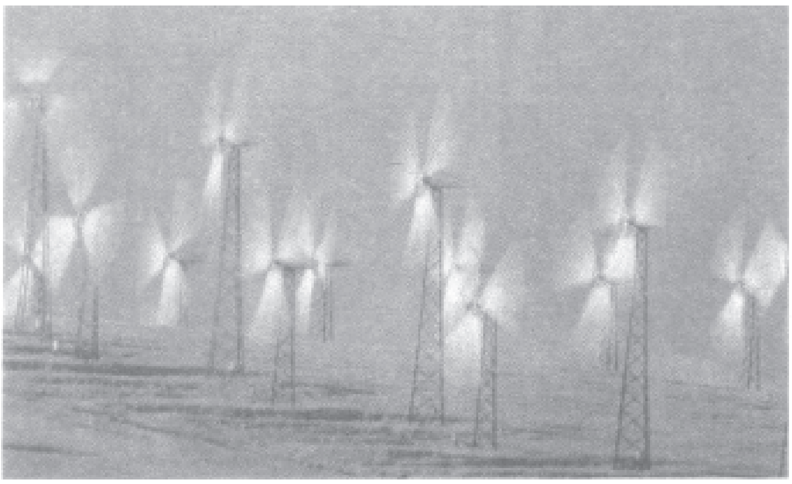


***Fig.29.5:*** *Wind farms*

Five nations - USA, Germany, Denmark, Spain and India - account for 80% of the world's installed wind energy capacity.

> India rank 5th in the world with a total wind power capacity if 1080 MW out of which 1025 MW have been established in commercial projects.

In India the states of Tamil Nadu and Gujarat lead in the field of wind energy. At the end of March 2000 India had 1080 MWs capacity wind farms, of which Tamil Nadu contributed 770 MW capacity, Gujarat has 167 MW followed by Andhra Pradesh, which has 88 MW installed wind farms. There are about a dozen wind pumps of various designs, which provide water for afforestation, irrigation, domestic purpose, used in various tasks of the country.

Recently, there has been a renewed interest in wind as a source of energy. India is the fifth largest producer of wind power in the world. Countries engaged in development of wind energy include Great Britain, Netherlands, Greece, Spain, Denmark, USA (California) and India. Andhra Pradesh generates maximum energy through wind power. Other states generating energy through wind are Tamil Nadu, Gujarat, Karnataka, Kerala, Madhya Pradesh and Maharashtra. A total of 26 project sites have been developed in these states resulting in a capacity of 57MW.

### 29.4.2 Tidal energy

Tidal power projects attempt to harness the energy of tides as they flow in and out. The main criteria for a tidal power generation site are that the mean tidal range must be greater than 5 metres.

The tidal power is harnessed by building a dam across the entrance to a bay or estuary creating a reservoir. As the tide rises, water is initially prevented from entering the bay. Then when tides are high and water is sufficient to run the turbines, the dam is opened and water flows through it into the reservoir (the bay), turning the blades of turbines and generating electricity.

Again when the reservoir (the bay) is filled, the dam is closed, stopping the flow and holding the water in reservoir when the tide falls (ebb tide), the water level in the reservoir is higher than that in the ocean. The dam is then opened to run the turbines (which are reversible), electricity is produced as the water is let out of the reservoir.

The dams built to harness the tidal power adversely effect the vegetation and wildlife.

A dam is built across an estuary or bay, allowing the incoming and outgoing waters to flow through small openings fitted with propellers that run electric turbines (Fig. 29.6). To date the numbers of tidal electric plants are limited to forty. La Rance in France is the only commercial power station operating in the world. In India a major power project costing Rs. 5000 crores is proposed to be set up in the Hanthal Creek in the Gulf of Kutch in Gujarat.

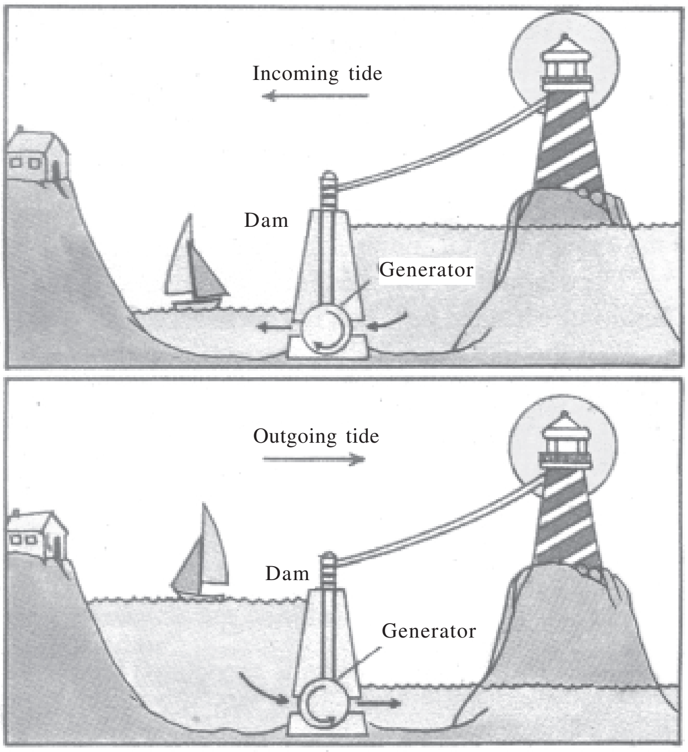



*Fig. 29.6:* Tidal power station

### 29.4.3 Hydropower Energy

The energy in moving waters is one of the most widely used renewable energy source. Humans have harnessed waterpower since the times of the Roman Empire. In earlier times the kinetic energy of flowing rivers and streams was trapped by means of water wheels that were used to grind grain, saw wood and manufacture textiles. It was only in 1800s that the energy of water was converted into electricity. Hydroelectric power uses the kinetic energy of moving water to make electricity.

Generation of electricity by using the force of falling water is called **hydro electricity or hydel power**. It is cheaper than thermal or nuclear power. Dams are built to store water at a higher level; which is made to fall to rotate turbines that generate electricity.

Hydroelectricity or hydropower is the fourth largest source of commercial energy production and consumption globally.

The basic principle behind hydropower energy is the damming of rivers to create artificial in waterfalls, sometimes natural waterfalls are also used. The falling water is used to turn the turbines that drive electrical generators. One of the greatest advantages of hydropower is that once the dam is built and turbines become operative, it is relatively cheap and clean source of energy.

Notes

Hydropower also has some disadvantages, building of dam seriously disturbs and damages the natural habitats and some of them are lost forever. Human habitations also get disturbed making people homeless.

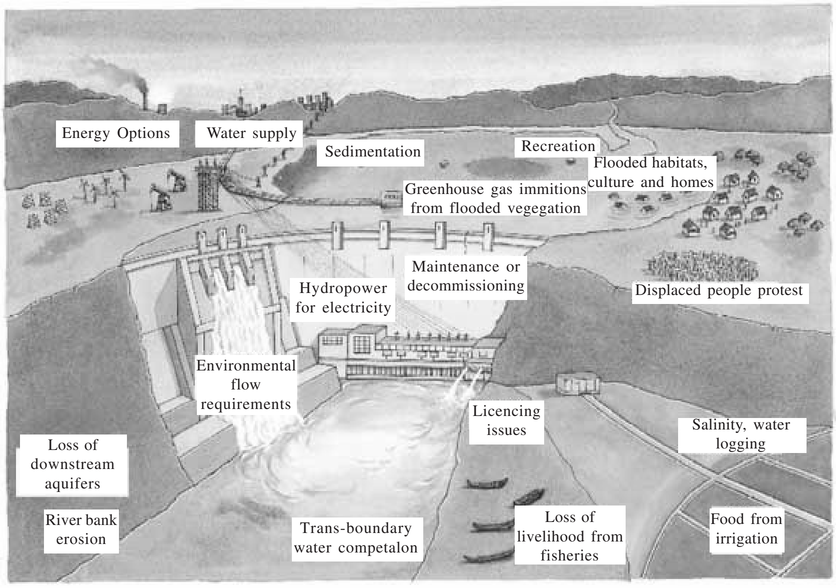



***Fig. 29.7:*** *Environmental effects of hydropower*

## INTEXT QUESTIONS 29.3

1. What is the difference between air and wind?

   ______________________________

2. Why wind energy is called indirect solar energy?

   ______________________________

3. What is significance of dams in the production of hydroelectricity?

   ______________________________

## WHAT YOU HAVE LEARNT

- Presently there is focus on alternative source of energy that are renewable or inexhaustible in nature such as solar, wind, water and tidal energy. They are inexhaustible sources of energy and do not cause air pollution, health problem, or climatic changes.
- Solar energy is one of the most important sources of energy, which is used for heating, and cooling of buildings, for cooking food and generating electricity. The limitation

with solar energy is that on a cloudy day or in winters it is not available and the current technologies are fairly limited.

- Passive solar energy system often involves architectural designs that enhance absorption of solar energy without requiring mechanical power.
- Active solar energy system uses solar collectors are used to heat waters for houses and keep the buildings warms.
- Photovoltaic is a technology that is used to convert sunlight directly into electricity. And is used for various purposes.
- Hydroelectric power is used for generating energy, It is also indirect form of solar energy and has several advantages but the high construction cost and silting of reservoirs which lesson the life of power station are the main drawbacks.
- Tidal power is another renewable energy resource, but suitable sites for harnessing this energy are limited and technologies are few.

## TERMINAL EXERCISE

1. List the various uses of solar energy and describe the advantages and disadvantages of solar energy.
2. Why photovoltaic cells are considered to be an ideal solar energy collection device? What are some of their limitations?
3. What are the limitations of tidal power as a source of electricity?
4. Discuss the advantages and disadvantages of hydropower energy.
5. Which has greater future potential for energy production wind or water power also discuss which one of these you think has more environmental problem?
6. Discuss why our country is not utilizing the renewable resources at their fullest potential.

## ANSWER TO INTEXT QUESTIONS

**29.1**

1. Sun is one of the most important natural energy source. All other energy sources are directly derived from the sun.
2. Coal, oil and natural gas are the examples of conventional energy while solar, hydro power, wind, nuclear, biogas, geothermal energy are the examples of non-conventional source of energy (any three examples)
3. -have been in usage for a long time

   -are other than the usual or that are different from those in common practices.

4. -Mostly fossil fuels found under the ground

   -Mostly non-fossil fuels seen above the ground.

**29.2**

1. Solar energy is the most important renewable energy because it is most abundantly present, it is present all the time and is everlasting and available free of cost.
2. Solar energy is used in a passive manner that is directly in drying food and clothes, to evaporate sea water to get salt. Solar cookers use solar energy for cooking, solar energy used directly for heating and lighting buildings. Solar energy used in active way for producing hot water for domestic use.
3. Photovoltaic cell is a solar cell to produce electricity from solar energy. It is a thin wafer like semi conductor. Sunlight energizes and causes electrons to flow in the semi conductor producing an electrical current.

**29.3**

1. Moving air is called wind. Uneven absorption of solar radiation by earths surface causes difference of temperatures, density and pressure which produces air movements or wind.
2. It is the solar energy of sun which causes the kinetic energy of wind.
3. Dams are built on rivers to store water at a higher level, which is made to fall to rotate turbines that generate electricity. Generation of electricity by using the force of falling water is called hydro electricity.

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# 30

# METHODS OF WATER HARVESTING

Water is “elixir of life”. In the previous lesson you have learnt about the various sources of fresh water. We need to conserve the water for the present and for the future generations. In this lesson you shall learn about the need for water conservation and the different methods of water harvesting.

## OBJECTIVES

After completing this lesson, you will be able to:

- *describe the need and importance of water conservation;*
- *explain the need for water harvesting;*
- *categorize and describe different methods of traditional water harvesting;*
- *categorize and describe different methods of modern water harvesting.*

## 30.1 NEED FOR WATER CONSERVATION

Water is the most essential natural resource for life. It is likely to become a critical scarce resource in many regions of the world in the coming decades. Although water is the most abundant substance on earth, it is not equally distributed. Variations in latitude, rainfall patterns, topography, etc. affect its availability.

Water is a resource which cannot be produced or added as and when required by any technological means. The total fresh and sea water content of the earth is essentially fixed.

The fresh water which is so essential for our life is only a small portion of the total water available on this earth- about 2.7%. Nearly all of this 2% is locked in the masses of ice caps, glaciers and clouds. The remaining small fraction of fresh water has accumulated over centuries in the lakes and underground sources of the world. Surprisingly it is the salt water of the oceans that is the ultimate source of fresh water on this earth. Almost 85% of the rain water falls on directly into the sea and never reaches the land. The small remainder that precipitates on the land fills up the lakes and wells, and that keeps the river flowing. For every 50,000 grams of ocean water only one gram of fresh water is available to mankind making water a scarce and thus a precious commodity.

The condition in India is still worse. Although India is one of the wettest country in the world, the availability of water with time and space is highly uneven. On an average, it receives about 1150 mm of rainfall annually, which is highest in the world for a country of similar size. However, its distribution is highly uneven. For example, the average number of rainy days in a year is only 40. Thus there is a long spell of dry period in a year. Also, the rainfall is as high as 13 m in some areas of North-East regions and as a low as 20 cm in certain parts of Rajasthan. This uneven distribution of rainfall results in severe water scarcity in many parts of our country.

With increasing demand for domestic, industrial and agriculture purposes the water availability is decreasing and likely situation is going to worsen in future. Moreover, for the past few decades efforts have been made to increase irrigation in the country. This has resulted in over exploitation of our water resources. Our increasing urbanization and industrialization has also put additional demand for water. All the above factors have resulted in severe water scarcity in many parts of the country. Hence, it is important to prevant waste and conserve water. To feed our growing population we need to grow more food. In order to increase food production we need more and more water for irrigation. Thus, there is an urgent need for conservation of water.

In ancient times, water was acknowledged and regarded as a valuable resource. In fact, almost every ancient culture has regarded water as sacred. In 20$^{th}$ century, however, the advent of the industrial revolution and the consequent dawn of western materialism have led to a non-traditional commodity based perception of nature's resources.

Just as the 20$^{th}$ century focused on the importance of oil, the 21$^{st}$ century is likely to be focused on issues concerning safe and adequate drinking water. The most important step in the direction of finding solutions to issues of water and environmental conservation is to change people's attitudes and habits. If the world continues to treat water as a cheap resource that can be wasted, then not even the best policies and technologies can help to solve water scarcity.

At the current rate of population growth in India, combined with the growing demand on available water resources, India could well have the dubious distinction of having the largest number of water-deprived persons in the world in the next 25 years. This is the scenario if the available resources are not managed judiciously and with care. Urbanization rapid industrialisation and an ever- increasing population have polluted most of the surface water bodies, making their wastes unfit for human use. These coupled with growing needs, have led to increasing dependency on ground water. Excessive tapping of ground water, through numerous boreholes, has led to a decline in the water table. It is estimated that by the year 2050, half of India's population will be living in urban areas and will face acute water problems. Furthermore, there are serious inequities in the distribution of water.

Throughout the world, shortage of water is growing due to increasing:

- droughts,
- irrigation demand,
- industrial demand,
- pollution, reducing usability of water resources, and
- wastage and irresponsible attitude towards water.

As mentioned earlier, we have long dry period in our country. During dry period our demand for water is fulfilled through the water stored in lakes, reservoirs or underground water. With increasing demand for water these sources are becoming increasingly inadequate. Hence, efforts are required to retain more and more rain water for use during the dry period. Rain water harvesting at local level by either storing in ponds, tanks and lakes or by recharging ground water are simple methods of augmenting water supply. In the following sections some important methods of rainwater harvesting are described.

## INTEXT QUESTIONS 30.1

1. India is the wettest country in the world and yet certain parts of it suffer from severe water scarcity. What causes this water scarcity? (one reason)

   ______________________________________________

2. What is the average number of rainy days in India?

   ______________________________________________

3. "Water harvesting is a wise step towards water conservation". Justify giving reasons.

   ______________________________________________

4. List any three reasons for water shortage in the world.

   ______________________________________________

## 30.2 TRADITIONAL METHODS OF WATER HARVESTING

Rain water harvesting is an enjoying a renaissance of sorts in the world, but it traces its history to biblical times. Extensive rain water harvesting apparatus existed 4000 years ago in the Palestine and Greece. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rain water to augment water from city's aqueducts. As early as the third millennium BC, farming communities in Baluchistan and Kutch impounded rain water and used it for irrigation.

Our ancient religious texts and epics give a good insight into the water storage and conservation systems that prevailed in those days. Over the years rising populations, growing industrialization, and expanding agriculture have pushed up the demand for water. Efforts have been made to collect water by building dams and reservoirs and digging wells; some countries have also tried to recycle and desalinate (remove salt) water. Water conservation has become the need of the day. The idea of ground water recharging by harvesting rainwater is gaining importance in almost all societies.

In forests, water seeps gently into the ground as vegetation breaks the rain fall. This ground water in turn feeds wells, lakes, and rivers. Protecting forests means protecting water catchments. In ancient India, people believed that forests were the mothers of rivers and worshipped the sources of these water bodies.

### 30.2.1 Ancient Indian methods of water harvesting

Water has been harvested in India since antiquity, with our ancestors perfecting the art of water management. Many water harvesting structures and water conveyance systems specific to the different cultures were developed. The Indus Valley Civilization, that flourished along the banks of the river Indus and other parts of western and northern India about 5000 years ago, had one of the most sophisticated urban water supply and sewage systems in the world. The fact that the people were well acquainted with hygiene can be seen from the covered drains running beneath the streets of the ruins at both Mohanjodaro and Harappa. Another very good example is the well planned city of Dholaviras, on Khadir Bet, a low plateau in the Rann in Gujarat. One of the oldest water harvesting systems is found about 130 km from Pune along Naneghat in the Western Ghats. A large number of tanks were cut in the rocks to provide drinking water to tradesmen who used to travel along this ancient trade route. Each fort in the area had its own water harvesting and storage system in the form of rock cut cisterns, ponds, tanks and wells that are still in use today. A large number of forts like Raigad had tanks that supplied water.

- In ancient times, houses in parts of western Rajasthan were built so that each had a roof top water harvesting system. Rainwater from these rooftop was directed into underground tanks, this system can be seen even today in all the forts, palaces and houses of the region.
- Underground baked earthen pipes and tunnels to maintain the flow of water and to transport it to distant places, are still functional at Burhanpur in Madhya Pradesh, Golkunda and Bijapur in Karnataka, and Aurangabad in Maharastra.
- They harvested the rain drop directly. From rooftop, they collected water and stored it in tanks built in their courtyards. From open community lands, they collected the rain and stored it in artificial wells.

- They harvested monsoon runoff by capturing water from swollen streams and rivers during the monsoon season and stored it various forms of water bodies.

## INTEXT QUESTIONS 30.2

1. Mention any two instances that prove that water harvesting existed in ancient India.

______________________________________________________________

2. How do forests help in recharging ground water?

______________________________________________________________

3. Mention how in ancient times houses in western Rajasthan conserved water.

______________________________________________________________

## 30.3 MODERN METHODS OF WATER HARVESTING

**Rain water harvesting techniques:** There are two main techniques of rain water harvesting:

1. Storage of rain water on surface for future use
2. Recharge to ground water

The storage of rain water on surface is a traditional technique and structures used were tanks, ponds, check dams, weirs etc. recharge to ground water is a new concept of rain water harvesting and the structures generally used are:

- **Pits:** Recharge pits are constructed for recharging the shallow aquifer.
- **Aquifer:** The aquifer is porous, water saturated layers of sand, gravel or bed rock that can yield significant or usable amount of water. These are constructed 1 to 2 m wide, 1 to 1.5 m deep which are back filled with boulders, gravels, coarse sand.
- **Trenches:** These are constructed when the permeable rock is available at shallow depth. Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending upon the availability of water. These are back filled with filter materials.
- **Dug wells:** Existing dug wells may be utilized as recharge structure and water should pass through filter media before putting into dug well.
- **Hand pumps:** The existing hand pumps may be used for recharging the shallow/deep aquifers, if the availability of water is limited. Water should pass through filter media to avoid chocking of recharge wells.

- **Recharge wells:** Recharge wells of 100 to 300 mm diameter are generally constructed for recharging the deeper aquifers and water is passed through filter media to avoid choking of recharge wells.
- **Recharge Shafts:** For recharging the shallow aquifer which is located below clayey surface, recharge shafts of 0.5 to 3 m diameter and 10 to 25 m deep are constructed and back filled with boulders, gravels and coarse sand.
- **Lateral shafts with bore wells:** For recharging the upper as well as deeper aquifers lateral shafts of 1.5 to 2 m wide and 10 to 30 m long depending upon availability of water with one or two bore wells is constructed. The lateral shaft is back filled with boulders, gravels and coarse sand.

### 30.3.1 Diversion of run-off into existing surface water bodies and its benefits

Construction activity in and around the city is resulting in the drying up of water bodies and reclamation of these tanks for conversion into plots for houses. Free flow of storm run off into these tanks and water bodies can be used as harvesting system. The storm run off may be diverted into the nearest tanks or depression, which will create additional recharge.

In urban areas, the construction of houses, footpaths and roads has left little exposed earth for water to soak in. In parts of the rural areas of India, floodwater quickly flows to the rivers, which then dry up soon the rains stop. If this water can be held back and allowed to seep into the ground for recharging the ground water supply.

This becomes a very popular method of conserving water especially in the urban areas. Rainwater harvesting essentially means collecting rainwater on the roof of building and storing it underground for later use. Not only does this recharging arrest groundwater depletion, it also raises the declining water table and can help augment water supply. Rain water harvesting and artificial recharging are becoming very important issues. It is essential to conserve surface water runoff during the rainy season and stop the decline in ground water levels, arrest sea water ingress in coastal areas, i.e. prevent sea water from moving landward excessive withdrawal of ground water pulls sea water that spoils coastal ground water resources by them salty.

All you need for a water harvesting system is rain, and a place to collect it. Typically, rain is collected on rooftops and other surfaces, and the water is a carried down to where it can be used immediately or stored. You can direct water run-off from this surface to plants, trees or lawns or even to the aquifer.

Realizing the importance of recharging of ground water, the government of India and many state governments, non-government organizations and other institutions are taking steps to encourage rain water harvesting in the country. A number of government buildings have been asked to go take up water harvesting in Delhi and in some other cities of India.

Town planners and civic authority are introducing bylaws making rainwater harvesting compulsory in all new structures. No water or sewage connection would be given if a new building did not have provisions for rain water harvesting. Such rules should also be implemented in all the other cities to ensure a rise in the ground water level.

Some of the benefits of rainwater harvesting are as follows:

- Increases water availability;
- Check the declining water table;
- It is environmentally friendly;
- Improves the quality of groundwater through the dilution of fluoride, nitrate, and salinity;
- Prevents soil erosion and flooding especially in urban areas.

**Case Study**

**Rainwater harvesting: a success story**

In the area surrounding the River Ruparel in Rajasthan is a good example of proper water conservation. The site receives very little rainfall, but proper management and conservation have ensured the water availability through out the year. The water level in the river began declining due to extensive deforestation and agricultural activities along the banks and, by the 1980s, a drought-like situation began to spread. Under the guidance of local peoples, the women living in the area were encouraged to take the initiative in building johads (round ponds) and dams to hold back rain water. Gradually, water began coming back as proper methods of conserving and harvesting rainwater were followed. The revival of the river has transformed the ecology to the place and the lives of the people living along its banks. Their relatioinship with their natural environment has been strengthened. It has proved that mankind is not the master of the environment, but a part of it. If human beings put in an effort, the damage caused by us can be undone.

### 30.3.2 Rainwater harvesting and water conservation in agriculture

Conservation of water in the agricultural sector is essential since water is necessary for the growth of plants and crops. A depleting water table and a rise in salinity due to irrigation is a serious matter. Various methods of water harvesting and recharging have been and are being applied all over the world to tackle the problem. In areas where rainfall is low and water is scarce, the local people have used simple techniques that are suited to their region and reduce the demand for water.

- In India’s arid and semi arid areas, the tank system is traditionally the backbone of agricultural production. Tanks are constructed either by building or by excavating the ground and collecting rainwater.

- Rajasthan, located in the Great Indian Desert, receives hardly any rainfall, but people have adapted to the harsh conditions by collecting whatsoever rainfalls. Large bunds to create reservoirs known as khadin, dams called johads, tanks, and other methods were applied to check water flow and accumulate run off. At the end of the monsoon season, water from these structures was used to cultivate crops. Similar systems were developed in other parts of the country. These are known by various local names jal talais in Uttar Pradesh, the haveli system in Madhya Pradesh, ahar in Bihar, and so on.

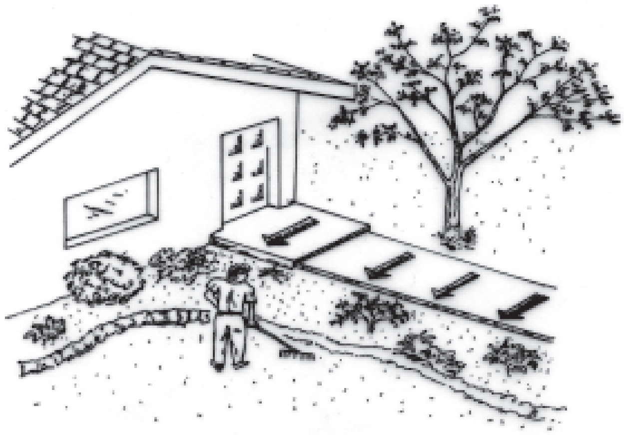

***Fig. 30.1:*** *Rain water harvesting and water conservation in agriculture*

## INTEXT QUESTIONS 30.3

1. List any three structures that can be constructed to recharge the ground water.

______________________________

2. Mention the new bylaws being introduced by the civic authorities in many cities to ensure water conservation.

______________________________

3. List any four benefits of rain water harvesting at any place of the states.

______________________________

4. Name some of the structures that are used in Rajasthan, U.P. and Madhya Pradesh to collect rain water for cultivating crops during dry seasons.

______________________________

## 30.4 RAINWATER HARVESTING AT HOUSEHOLD LEVEL

Water harvesting is simply collecting rainwater that falls over ones property and then putting it to use around ones home or yard—that's all! Many homeowners in our country already use rainwater to irrigate trees, lawns and for landscaping. One can substantially lower water bill, help reduce local flooding and reduce landscaping and property maintenance needs—all by putting water harvesting ideas to use around ones home. Building a new home on a single plot, designing a major subdivision, or just making a few improvements around, water harvesting can be easily incorporated into the plans.

Water harvesting systems can range from the simple to complex, depending on the area, need and budget. It can be helpful to think of rain water harvesting system as having **four main** components.

(a) **Rainwater collection**

One can capture rainwater from any rooftop area, **patio**, driveway or other impermeable surface. Make sure that collected water is kept at least three feet away from the foundation of your house. The amount of water you will be able to harvest depends on the size of your catchment area. To determine the amount of water you can collect, multiply the area of your roof (catchment) in square metre times the amount of rain received each year in metre. (average rainfall in India is 1.17 m). Next, multiply that value by 0.909 to account for evaporation and other losses, and then multiply this result by 1000 to determine the number of litres. As an example, a square metre catchment area will yield about 105300 litres of water per year (1.17x100x0.90x1000=105300)

(b) **Storage**

Storage systems can vary in complexity depending on ones needs. An effective system can involve a 250 litre drum fed by rooftop gutters and downspouts. A more involved system might include **buried cisterns**, plumbing and a timed watering system. Debris and leaves should be filtered before storing the water by placing screens over gutters or downspouts. Water kept in tanks or cisterns should also be covered to minimize algal growth and eliminate the potential for mosquito breeding. Placing floating lids on storage tanks is an effective solution.

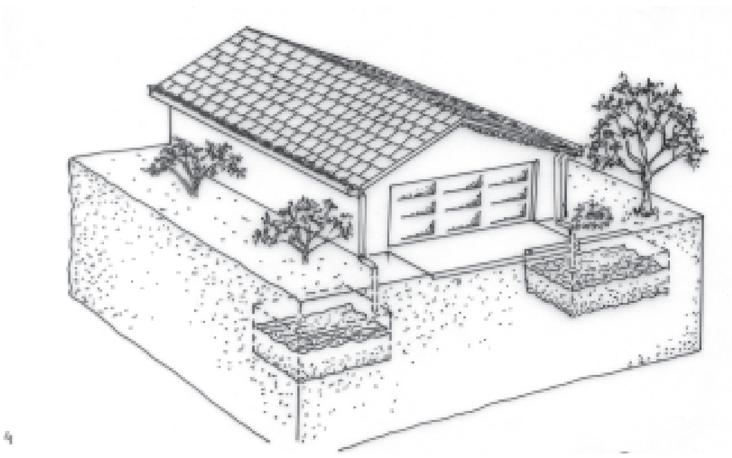

***Fig. 30.2:*** *Storage of water*

(c) **Distribution**

Gutters (a narrow channel which collects rainwater from the roof of a building and diverts it away from the structure, typically into a drain) and downspout (is a vertical pipe for carrying rainwater from a rain gutter to ground level)or berms ( is a level space, shelf or raised barrier separating two areas) and swales(is a low tract of land, especially one that is moist or marshy) can be designed to catch rainwater and distribute it directly to landscape plants or into the soil. Many people store harvested rainwater and then distribute it later through their regular drip irrigation system.

(d) **System maintenance**

Water harvesting systems require occasional maintenance, but this is easily accomplished. Debris screens over gutters should be cleaned periodically and storage tanks should be drained and cleaned when it is convenient to do so.

### 30.4.1 Benefits of rainwater harvesting

While many people may not realize it, those few inches of annual rainfall is valuable resource. Harvesting rainwater not only helps reduce the possibility of flooding, but it also decreases the community's dependence on groundwater. Unlike groundwater, however, rainwater is remarkably pure with virtually no dissolved salts or minerals. Because of this, rainwater is perfectly suited for landscape irrigation, use in evaporative coolers, washing and many needs, hardness deposits do not accumulate and there is no problem with soap scum. Imagine not having to scrap your evaporative cooler every year! By reducing runoff and using rainwater that falls on your evaporative cooler every year! By reducing runoff and using rainwater that falls on your property, you can put a valuable water resource to work around your house and yard.

- Conserves valuable ground water and reduces your monthly water bill.
- Reduces local flooding and drainage problems.
- Flushes salt build up from soils- your plants and notice the difference.
- Decreases landscaping and property maintenance needs.
- Provides excellent quality water for various uses.

**Some activities for the learners**

**Activity 1**: **Do an audit of your home/your work place. Can you see any of the following?**

- Leaks and drips.
- Toilets and urinals that do not have a water saving device installed.
- Garden hoses that are left on during the day.
- Taps that are left on while teeth are brushed or dishes etc. are washed.

Choose one issue and brainstorm some ways to prevent it. Here are some examples of action projects which help to reduce water wastage.

**Activity 2: Some ideas for action projects**

(a) **Design leaflets** about being water-wise; it's an easy and effective way to get information across. Create enough leaflets to do a drop to your local community.

(b) **Retrofit the school's toilet** with a cheap and low-tech solution: a 1 litre plastic bottle filled with water placed in the toilet cistern. This displaces water and saves 1 litre per flesh-which can be a huge saving where toilets are used frequently, such as in schools.

(c) As a technology project, your class could invent a system or technology to collect roof water so that it can be reused to water the garden. A bucket catching the down pipe overflow might work.

Or you could invent a home made sprinkler to water specific parts of the garden rather than wasting water where it is not needed. Installing a strong hosepipe with holes pierced in strategic places works well.

(d) **Organize a water wise week** at your study centre/work place. You could read the water meter to find out how much water your study centre/workplace uses each week, then attempt to reduce that amount by a quarter (on average, these places can reduce their water consumption by at least a third). Get the whole organization involved by running an event each day to show ways to reduce water wastage.

(e) **Plant natives instead of exotics:** (Native plants use less water than exotics). Ask the caretaker to water the plants in the cool of the day (early morning or better still, late afternoon). You could set up your own water-wise gardening club. Some work places have very successful gardening clubs and mulch all their plants to save water.

## INTEXT QUESTIONS 30.4

1. List the four main components required for harvesting water at household level.

______________________________________________

2. List any two precautions to be taken while storing rain harvested water in cisterns/ tanks.

______________________________________________

3. How do we benefit by harvesting water at household level? (any three)

______________________________________________

## WHAT YOU HAVE LEARNT

- Earth has plenty of water but freshwater is only a small fraction of it.
- With growing demand for water, its resources are over-exploited.
- Although plenty of rain occurs in India, due to its un-even distribution over time. and space, it faces severe water scarcity in its many parts.
- For feeding ever growing population, India need to grow more food grains.
- Since, duration of rainfall is short, the agricultural activities depend on irrigation.
- Irrigation consumes nearly 85% of the total water used in India.
- With increasing demands for agriculture and other developmental activities, water resources are over-exploited.
- Urbanization and industrialization further aggravate the situation by over-exploiting and polluting the water resources.
- Thus, conservation is one of the most important and simple methods of water conservation.
- Rainwater harvesting is one of the most important and simple methods of water conservation.
- Rainwater harvesting is collection of rainwater and its storage for direct use or for percolating in the ground to artificially recharge the ground water.
- Traditionally rainwater is harvested through various means all over the world.
- There are evidence of rain water harvesting in Indus Valley, Palestinian, Greek and Roman Civilizations.
- They had wisdom of conserving water.
- Rainwater harvesting is getting significant importance in recent past due to severe scarcity being faced in many parts of the world including India.
- Several initiatives are taken by the government of India and various state governments to promote rainwater harvesting in the country.
- Many local bodies are considering making it mandatory to install rainwater harvesting system in housing complexes, large buildings and offices.

## TERMINAL EXERCISE

1. Why we should go for rainwater harvesting?
2. Explain traditional methods of rainwater harvesting.
3. Which methods of rainwater harvesting prevailed in ancient India?
4. How rainwater harvesting helps in overcoming water scarcity?
5. Explain in brief roof-top rainwater harvesting.
6. How ground water is artificially recharged?
7. Narrate a success story of rainwater harvesting in India.
8. Explain in brief the important benefits of rainwater harvesting.
9. Describe the steps involved in rainwater harvesting.
10. Provide in brief initiatives taken by the government on rainwater harvesting in India.

## ANSWER TO INTEXT QUESTIONS

**30.1**

1. Uneven distribution of rain in time and space.
2. 40 days
3. There is scarcity of fresh water and increasing population, unequal distribution of rain in certain parts of our country, increasing industrialization and urbanization but excessive demand on this scarce resource. Therefore harvesting rain water and storing it for dry spells of times is a very step.
4. Drought, expanding population, increasing irrigation demand, pollution which is reducing usability of water, abuse of available water. (any three)

**30.2**

1. One of the oldest water harvesting system is found near Pune in the Western Ghats where large number of tanks were cut out in the rocks to provide drinking water to the tradesmen, forts like Raigad had tanks, ponds, rock cut cisterns to harvest and store water. These ponds and wells are still in use; well planned system of urban water supply and sewage in the ruins of Mohanjodaro and Harappa of Indus Valley Civilization. (Any two) or any other.

2. In the forests the vegetation helps in seepage of water into the ground and thus recharges the water table.

3. Each house in this region was built in such a way that they could harvest rain water and this rain water was stored in underground tanks. This system can be seen even today.

**30.3**

1. Recharge wells shafts, trenches, pits, check dams or bunds, lateral shafts with bore wells (any three)

2. No water or sewage connection would be given if a new building did not have provision for rain water harvesting.

3. Increases water availability, checks declining water table, improves the quality of ground water through the dilution of salts, prevents soil erosion and flooding specially in urban areas.

4. Khadin, Johad, talai, haveli (any three).

**30.4**

1. Place/area to collect rain water, storage unit, distribution component, system maintenance.

2. Storage structures should be covered to prevent mosquito breeding and minimize algal growth.

3. a) Conserve ground water and reduce the monthly water bill

   b) Reduce local flooding and drainage problem.

   c) Flushes salt build up from soils.

   d) Prove excellent quality water for gardening in water codes. (any three)

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# 30

# RENEWABLE SOURCES OF ENERGY-II

In the previous lesson you studied about some of the important non-conventional or renewable sources of energy such as solar energy, wind energy and hydel power, tidal and hydrogen etc. but now gaining momentum as alternative resources such as biomass, geothermal and hydrogen as a source of vast energy resources. These energy sources are renewable because they are regenerated within a reasonable time period. Moreover these energy resources can be used with minimal environmental degradation and offer us a chance to develop a truly sustainable energy policy. Its for these reasons there is growing interest in renewable energy resources. This lesson deals with these renewable energy resources.

## OBJECTIVES

After completing this lesson, you will be able to:

- *define biomass and explain its uses including biogas;*
- *describe the concept of bio fuels (ethanol, biodiesal/ petro crops) and list their uses;*
- *describe geothermal energy;*
- *explain hydrogen energy and its uses;*
- *explain fuel cell technology;*
- *describe the limitations of the alternative sources of energy and*
- *state the thrust areas of renewable energy programmes in India.*

## 30.1 BIOMASS

Energy from biomass is the oldest fuel used by human's .Our ancestors burned wood to keep the cave warm. Biomass is a renewable energy resource derived from plants and animal waste. The energy from biomass (biomass conversion) is released on burning or

Notes

breaking the chemical bonds of organic molecules formed during photosynthesis. Thus biomass represents an indirect form of solar energy. Biomass fuels can be used directly or they can be transformed into more convenient form and then used.

> More than one million people in the world still use wood as primary source of energy for cooking.

### 30.1.1 Sources of biomass

It is derived from numerous sources, including the by-products from the timber industry, agricultural crops and their by products, raw material from the forest, major parts of household waste and wood.

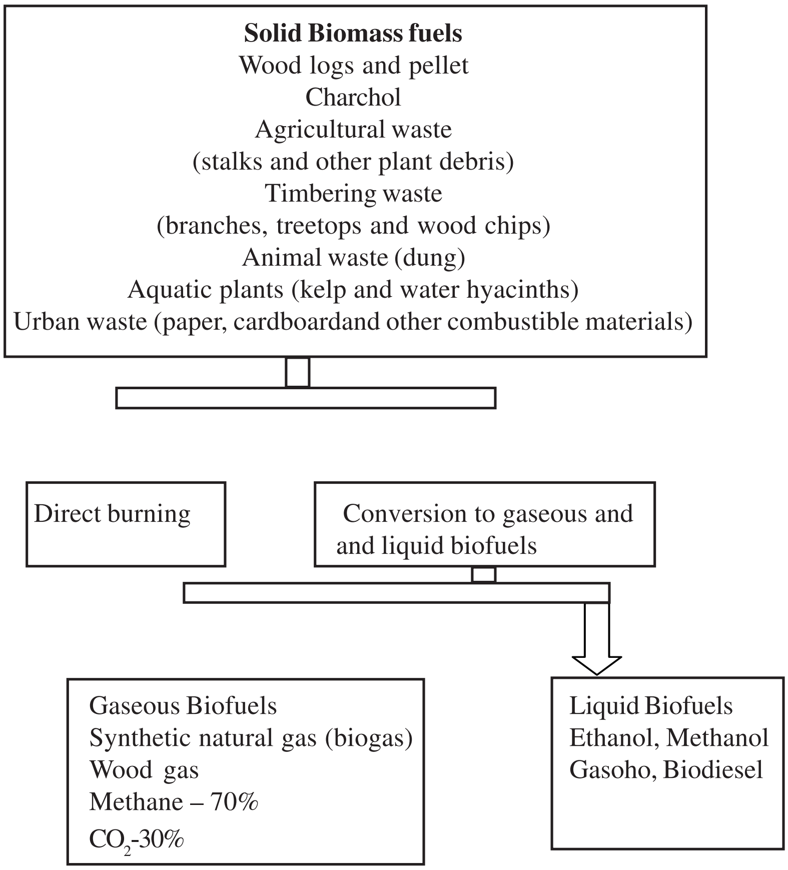



***Fig. 30.1**: Principal types of biomass*

- biomass can be burnt directly as a source for cooking, heating, lighting, generating steam, for industrial use for producing electricity.
- can be used to generate gaseous fuels (gasification).
- can be converted into alcohol (liquid biofuels) by distillation.

Methane and biogas can be produced from urban wastes in landfills and sewage at waste water treatment plants. In some facilities, manure from livestock and other organic waste is converted by microorganisms in specially designed digestion chamber to form methane ($CH_4$), which is burned to produce electricity, used in fuel cell, or used as fuel for vehicles. Molasses obtained from sugarcane is fermented to produce ethanol, that can be used in automobiles.

| |
|---|
| Half a kilo of dry plant tissue can produce as much as 1890 K Cal of heat which is equivalent to the heat available from a quarter of kilogram of coal. |

### 30.1.2 Uses of biomass

- Traditional use of biomass is more than its use in modern application. In the developed world biomass is once again becoming important for applications such as combined heat and power generation.
- In addition, biomass energy is gaining significance as a source of clean heat for domestic heating and community heating applications. In fact. in countries like Finland, USA and Sweden use of biomass energy is increasing biomass fuels used in India account for about one third of the total fuel used in the country, and it amount to 90% of the rural households.
- Instead of burning loose biomass directly, it is more practical to compress it into briquettes (compressing them into blocks of a chosen shape) improve its utility and convenience of use. Such biomass in the biomass briquettes can be used as fuel in place of coal in traditional chulhas and furnaces or in a gasifier. A gasifier converts solid fuels into a more convenient-to-use gaseous fuel called producer gas.

> **Form of Energy**: Chemical energy
>
> **This energy is being used for**: Cooking, mechanical, applications/pumping, power generation, transportation
>
> **Some of the gadgets and other device**s: Biogas plant/gasifier/burner, gasifier engine pump sets, sterling engine pump sets, producer gas/ biogas based engine generator sets, ethanol/methanol

### 30.1.3 Advantages of biomass energy

Burning of biomass does not increase atmospheric carbon dioxide because to begin with biomass was formed by atmospheric carbon dioxide and the same amount of carbon dioxide is released on burning. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biomass is renewable and free from net $CO_2$ (carbon dioxide) emissions and is abundantly available on the earth in the form of firewood, agricultural residues, cattle dung,city garbage etc. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development.

### 30.1.4 Bagasse as biofuel

Indian sugar mills are rapidly turning to **bagasse**, the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up the environment, cut down power costs and earn additional revenue. According to current estimates, about 3500 MW of power can be generated from bagasse in the existing 430 sugar mills in the country. Around 270 MW of power has already been commissioned and more is under construction.

### Biogas plant

The biogas plant consists of two components: a digester (or fermentation tank) and a gas holder. The digester is a cube-shaped or cylindrical waterproof container with an inlet into which the fermentable mixture is introduced in the form of liquid slurry. The gas holder is normally an airproof steel container that, by floating like a ball on the fermentation mix, cuts off air to the digester (anaerobiosis) and collects the gas generated. In one of the most widely used designs, the gas holder is equipped with a gas outlet, while the digester is provided with an overflow pipe to lead the sludge out into a drainage pit.

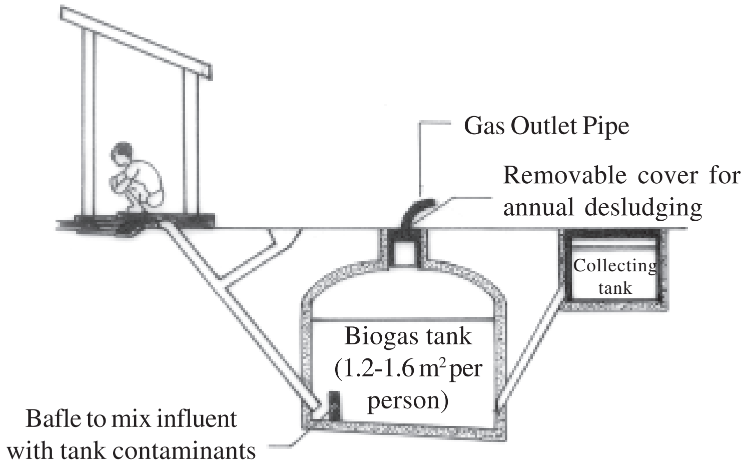



***Fig. 30.2:*** *Biogas Plant*

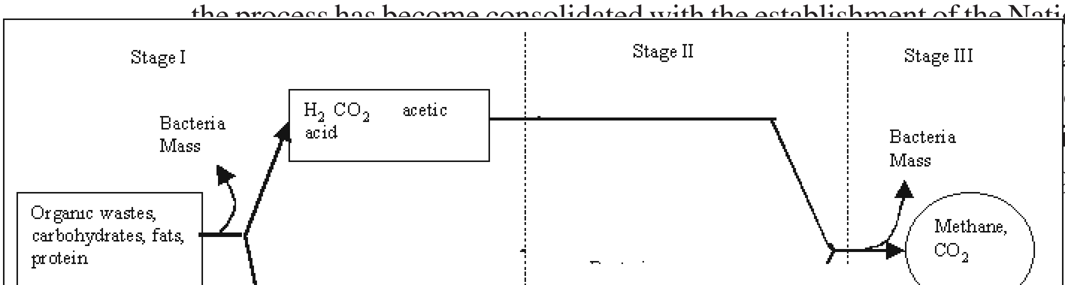
Any biodegradable (that which can be decomposed by bacteria) substance can be fermented anaerobically (in absence of oxygen) by methane-producing (methanogenic) bacteria. Cowdung or faeces are collected and put in a biogas digester or fermenter (a large vessel in which fermentation can take place). A series of chemical reactions occur in the presence of methanogenic bacteria ($CH_4$ generating bacteria) leading to the production of $CH_4$ and $CO_2$.

Methanogenesis is a microbial process, involving many complex, and differently interacting species, but most notably, the methane-producing bacteria. The biogas process is shown below in figure 30.3, and consists of three stages; hydrolysis, acidification and methane formation.

*Fig. 30.3: The process of methanogenesis (After GTZ, 1999).*

### 30.1.5 Potential of biogas in India

In India, the dissemination of large–scale biogas plants has began in the mid-seventies and the process has become consolidated with the establishment of the National Project on ... 2 million biogas ... oil-based plants ... in a saving of 3 ... quivalent to 0.7



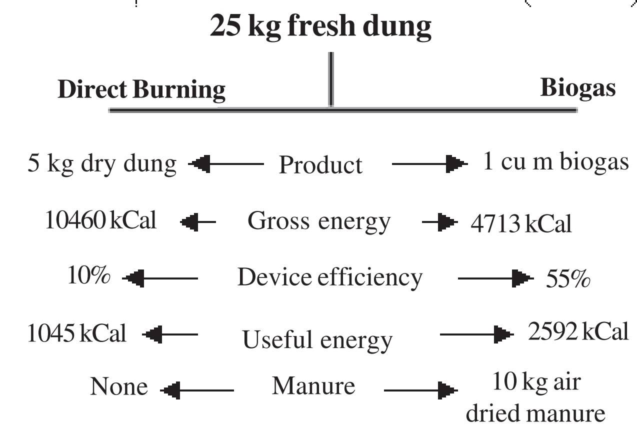




*Fig. 30.4: Energy from fresh dung*

However, in terms of total dung that is available in the country, the potential is much more. The bovine population in India is 260 millions. As an adult, bovine produces an average of

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10 kg of dung per day. If it is assumed that 75% of the dung is collected, nearly 2 millions tonnes of dung would be available everyday. This dung can feed as many as 40 millions biogas plants which can be considered the ultimate potential for biogas technology.

But even this high potential of biogas is based on animal dung only. However, all organic matter can technically be used to generate methane; if the scientific experiments that are going on in the country to develop alternative feedstocks (such as water hyacinth, kitchen waste, and poultry waste) become successful, potential for biogas generation could be virtually unlimited. It can be mentioned in this context that human waste is an excellent source of biogas which would enhance the potential; substantially. With such high potential, which can be routed to hitherto unemphasized applications of shaft power and electricity generation, biogas can make a significant contribution to the development of small industries and agriculture, and thus to the overall advancement of the rural areas.

**Biogas in Rashtrapati Bhavan**

GOING Green starts from the top, and in the capital the President's Estate is taking the lead. Besides lighting an entire auditorium wing with solar power, the Rashtrapati Bhavan is using cow dung-fuelled biogas in its kitchen for the President's bodyguards.

### 30.1.6 Petro crops (Plants)

Petroleum and wood are chief energy resources from time immemorial, but they have been overused and not being replenished fast enough. This is cause for concern. There is a need for alternative energy providing sources that can be regenerated. Recent researches suggest that hydrocarbon producing plants can become alternative energy sources, which can be inexhaustible and ideal for liquid fuel. These plants called petroplants/petrocrops can be grown on land which are unfit for agriculture and not covered with forests.

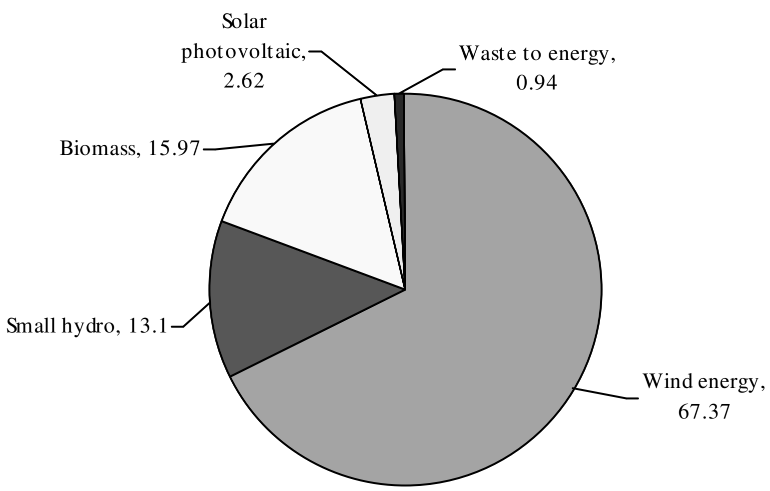



*Fig. 30.5: Use of non-conventional energy source in India.*

The most critical step in bioenergy production is the selection of plant species that produce substances from which useful products can be extracted in an economically viable way. Many such promising species belong to the families Asclepiadaceae, Asteraceae, Anacardiaceae Euphorbiaceae, Convolvulaceae, Caprifoliaceae, Lamiaceae, and Moraceae. *Jatropa curcas* is an important petro plant (Fig. 30.6)

***Fig. 30.6:*** *Jatropha curcas*

This biocrude can be obtained by tapping the latex, followed by coagulation, or by extraction of the dry biomass using a suitable solvent in cases where latex tapping is not possible. Biocrude is a complex mixture of liquids, terpenoids, triglycerides, phytosterols waxes, and other modified isoprenoid compounds. It can be catalytically upgraded for use as liquid fuels. Hydro cracking of biocrude can convert it into several useful products like gasoline (automobile fuel), gas oil and kerosene. Some potential Petro-crop species are:

| *PLANT SPECIES* | *FAMILY* |
|---|---|
| *Calotropis procera* | Asclepiadaceae |
| *Calotropis gigantea* | Asclepiadaceae |
| *Cryptostegia grandiflora* | Asclepiadaceae |
| *Asclepias curassavica* | Asclepiadaceae |
| *Euphorbia antisyphilitica* | Euphorbiaceae |
| *Euphorbia caducifolia* | Euphorbiaceae |
| *Pedilanthus tithymaloides* | Euphorbiaceae |
| *Jatropa curcas* | Euphorbiaceae |
| *Pittosporum resiniferum* | Pittosporaceae |
| *Copaifera longsdorfii* | Fabaceae |
| *Parthenium argentatum* | Asteraceae |
| *Simmondsia chinensis* | Simmondsiaceae |

Notes

## INTEXT QUESTIONS 30.1

1. Define biomass and list various sources of biomass.
2. What is biomass conversion?
3. Why is biomass considered as an indirect form of solar energy?
4. Give two advantages of using biomass fuel.
5. What are petro crops? List any two such plants.

## 30.2 GEOTHERMAL ENERGY

We live between two great sources of energy, the hot rocks beneath the surface of the earth and the sun in the sky. Our ancestors knew the value of geothermal energy; they bathed and cooked in hot springs. Today we have recognized that this resource has potential for much broader application. Geothermal energy is natural heat from the interior of the earth that can be used to generate electricity as well as to heat up buildings.

The core of the earth is very hot and it is possible to make use of this geothermal energy. These are areas where there are volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas. In some countries, such as in the USA water is pumped from underground hot water deposits and used for heating of houses. The utilization of geothermal energy for the production of electricity dates back to the early part of the twentieth century. For 50 years the generation of electricity from geothermal energy was confined to Italy and interest in this technology was slow to spread elsewhere. In 1943 geothermal hot water was used for the first time in Iceland. At present in 21 countries the internal heat of earth is used to produce electricity. However, at the global level, geothermal energy supplies less than 0.15% of the total energy supply

**Form of Energy**: Thermal energy
**This energy is being used for**: Heating/power generation
**Some of the gadgets and other devices**: Heat exchanger, steam turbines

*Fig. 30.7:* Geothermal energy

Geothermal resource falls into three major categories:

i) Geopressurized zones, ii) hot-rock zones and iii) Hydrothermal convection zones. Of these three only the first is currently being exploited on a commercial basis:

### 30.2.1 Geothermal energy in India

In India, Northwestern Himalayas and the western coast are considered geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Puga valley in the Ladakh region has the most promising geothermal field. An experimental 1-kW generator is already in operation in this area. It is being used mainly for poultry farming, mushroom cultivation, and pashmina-wool processing, all of which need higher temperature.

| |
|---|
| Geothermal manifestations are wide spread in India in the form of 340 hot spring sites. |

### 30.2.2 Environmental impact of geothermal energy

Geothermal energy can pose several environmental problems which includes on-site noise, emissions of gas and disturbance at drilling sites, disposal sites, roads and pipelines and power plants during its development.

The steam contains hydrogen sulphide gas, which has the odour of rotten eggs, and cause air pollution. The minerals in the steam are also toxic to fish and they are corrosive to pipes, and equipment, requiring constant maintenance.

## 30.3 HYDROGEN ENERGY

Many scientists believe that the fuel for the future is hydrogen gas. When hydrogen gas burns in the air or in fuel cells, it combines with oxygen gas to produce non-polluting water vapour and fuel cells directly convert hydrogen into electricity. Widespread use of hydrogen as fuel would greatly reduce the problem of air pollution and danger of global warming because there will not be any $CO_2$ emission.

Hydrogen may be a clean source of energy but getting large amount of pure hydrogen for commercial purposes is a problem because hydrogen is present in combination with other elements such as oxygen, carbon and nitrogen thus hydrogen has to be produced from either water or organic compounds like methane etc. requiring large amounts of energy that is hydrogen as a fuel has to be produced using energy present. This is a very costly proposition.

Producing hydrogen from algae in large scale cultures will be a good idea. You have studied about the process of photosynthesis where green (plant) cells break down water molecule in the presence of sunlight to produce oxygen gas and hydrogen thus produced go to reduce $CO_2$ to carbohydrate. Hydrogen produced via photosynthesis. $CO_2$ will not emit. Carbon dioxide in future it may be possible to control photosynthesis so that green algae are able to produce hydrogen through the process of photosynthesis.

Hydrogen is a pollution free, cost effective manner and if technologies such as fuel cells can be made cost effective, then hydrogen has the potential to provide clean, alternative energy for diverse uses, including lighting, power, heating, cooling, transportation and many more.

## 30.4 FUEL CELL TECHNOLOGY

Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel (hydrogen) and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

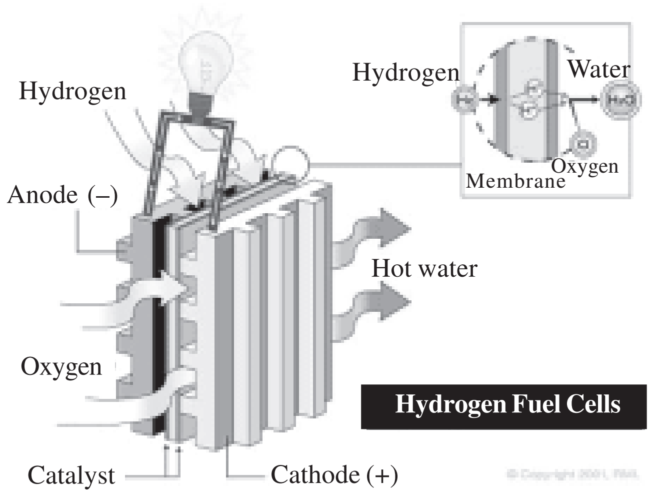
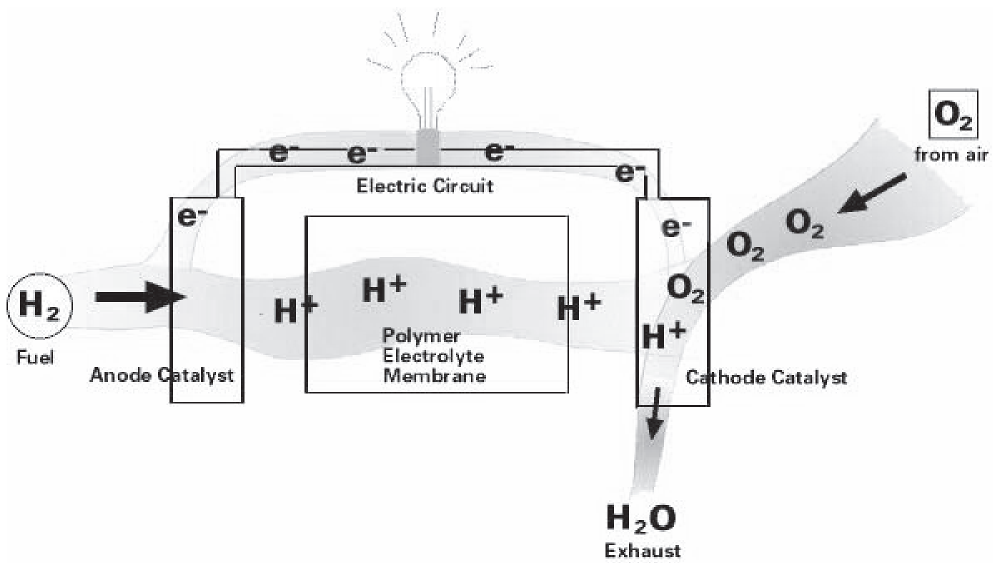



***Fig. 30.8:** Structure and function of fuel cell*

Hydrogen and phosphoric acid are the most common type of fuel cells, although fuel cells that run on methanol, ethanol, and natural gas are also available. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. A fuel cell consists of an electrolyte sandwiched between two electrodes. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water, and heat. Traditional methods generating electricity require combustion of fuel and the resultant heat is used to produce steam to run turbines which generate electricity. This method involves loss of heat and thus not very efficient. In chemical fuel cells on the other hand, chemical energy is converted directly into electricity, thus are more efficient and do not produce harmful gases.

Basic components of a hydrogen-burning fuel cell are shown in fig 30.9. Both oxygen and hydrogen are added to the fuel cell in an electrolyte solution. The reactants remain separated from one another and, upon ionization, migrate through the electrolyte solution from one electrode to another. The flow of electrons from the negative to the positive electrode is diverted along its path into an electrical motor, supplying current to keep the motor running. In order to maintain this reaction, hydrogen and oxygen are added as needed. Waste products are only oxygen and water when hydrogen is used in a fuel cell. Using natural gas methane ($CH_4$) in fuel cells produces some pollutants, but the amount is only about 1% of what would be produced by burning fossil fuels in an internal combustion engine or a conventional power plant




***30.9:*** *Working of a hydrogen fuel cell (Source: Fuel cell 2000and US department of energy)*

Additionally, the efficiency of a fuel cell is largely independent of its size and energy output. For these reasons, fuel cells are well-suited for automobiles, homes, and large-scale power plants. They can also be used to store energy to be used as needed. Fuel cells are in use particularly in Canada's Ballad's Power Systems in Canada and Germany's Dailmer-Benz in Germany are world leaders in the application of fuel cell technology for meeting transportation needs. Such buses are already in operation in Vancouver in Canada and in Illinois in USA. Though rapid progress has been made; high initial cost is still the biggest hurdle in the widespread commercialization of fuel cells.

### 30.4.1 Fuel cell technology in India

Fuel cell systems are excellent options for small-scale decentralized power generation. Fuel cells can supply combined heat and power to buildings, hospitals, airports and military installations at remote locations. Fuel cells have efficiency levels up to 55% as compared to 35% of conventional power plants. The emission of green house gases is significantly low $CO_2$ as water vapor is being the only emission. Fuel cell systems are modular (i.e. additional capacity can be added whenever required with relative ease) and can be set up wherever power is required.

### 30.4.2 Fuel cell technology and environment

Fuel cells are efficient and clean energy producer. Fuel cells have been used in space flights and being introduced in electric vehicles for reducing urban air pollution. Compared to vehicles powered by the internal combustion engine, fuel cell powered vehicles have very high-energy conversion efficiency, (almost double that of currently used engines) and near-zero pollution. Fuel-cell-powered EV's (electric vehicles) score over battery operated EV's in terms of increased efficiency and easier and faster refueling.

## INTEXT QUESTIONS 30.2

1. Define geothermal energy and list its uses. Give some examples from where this form of energy can be trapped.

   ______________________________

2. Describe the disadvantage and advantage of use of geothermal energy.

   ______________________________

3. "Hydrogen energy is called fuel for next generation", Comment on the statement.

   ______________________________

4. Where in India is the most promising geothermal field located.

   ______________________________

Notes

## WHAT YOU HAVE LEARNT

- Biomass is one of the oldest forms of fuel used by human's .In India it is used by as primary source of fuel in rural areas. Recently, there have been efforts to produce ethanol from crops such as sugarcane. There are several environmental impacts of burning wood such as deforestation, soil erosion, water pollution and air pollution.
- The use of petro crops are still in their nascent years but lots of research has been done in this area. In coming years petro crops will become a major resource of fuel for vehicles.
- Geothermal energy is natural heat from earth's interior that is used as an energy source.
- Hydrogen gas can become an important fuel of the future especially when used in fuel cell.
- Fuel cells are electro-chemical devices that operate at a high level of efficiency with little noise or air pollution.
- Fuel cells are highly efficient power-generating systems that produce electricity by combining fuel and oxygen in an electrochemical reaction or fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity (DC) and heat, thus doing away with combustion.

## TERMINAL EXERCISE

1. List the renewable sources of energy which are ideal for the coming times.
2. Describe the advantages of hydrogen as a fuel. Do you think hydrogen will become a major source of energy? Give reasons for your answer.
3. Describe fuel cell technology and its advantages.
4. Why are fuel cells more efficient in generating electricity in comparison to traditional systems?
5. Draw a schematic representation of a biogas plant and label its parts.
6. What are the limitations of (i) fuel cells (ii) geothermal energy? (any two)
7. How is the fuel obtained from petrocrops?
8. Discuss advantages and disadvantages of geothermal energy.

Notes

## ANSWER TO INTEXT QUESTIONS

**30.1**

1. Biomass is an accumulation of organic matter such as plant and animal materials (living or dead). It is a renewable energy source. Eg. agricultural wastes and residues.
2. Biomass conservation is the process of obtaining energy or fuel from the chemical energy stored in biomass.
3. Biomass consists of green plants which convert solar energy to chemical energy by photosynthesis, animals which feed upon plants and store chemical energy. Biomass can be burned directly as solid fuel or converted into alcohol or into biogas. So the fuel energy of biomass is actually locked up solar energy.
4. Uses of biomass energy –
   - does not add $CO_2$ to the atmosphere.
   - it can be used to generate electricity easily.
   - it constitutes a major form of renewable resource of energy.
5. Plants that produce hydrocarbons in substantial amount and can act as alternative energy source are called petrocrops. Examples *Jatropa curcas, Calotropis procure* (or any other).

**30.2**

1. It is the natural heat from the interior of the earth that is converted to heat building and generate electricity. Examples of such sites are volcanoes, hot springs, geysers and methane under the water in the process.
2. Advantages of geothermal energy- Most energy efficient, cost effective and environmentally clean.

   Disadvantages –
   - Steam contains $H_2O$ which has the odour of rotten eggs.
   - The minerals in the steam are also toxic to fishes and also corrosive to the pipes and equipments.
3. Hydrogen is available in plenty and when it burns in presence of oxygen it produces non-polluting water vapour. it is a clean source of energy. Technology is needed to get free hydrogen as fuel and cost effective fuel cells need to be developed.
4. Puga valley in the Ladakh region.

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# 31

# WATER CONSERVATION AT DIFFERENT LEVELS

You have already learnt how important water is for survival of all living beings. You have also learnt that usable water is becoming scarce. In this lesson you will learn some important methods of conserving water and the role of individuals, community and government in conservation of water.

## OBJECTIVES

After completing this lesson, you will be able to:

- *discuss the various methods to overcome water scarcity (concept of water use efficiency may be included);*
- *explain water shed management;*
- *cite examples of individual actions towards preventing water scarcity (case study);*
- *discuss community action required for protecting fresh water resources;*
- *enlist and explain government action (existing and required) for conservation of fresh water;*
- *describe the role of an individuals for conservation of water.*

## 31.1 DIFFERENT METHODS OF WATER CONSERVATION

### 31.1.1 Conservation and management

India is a developing country with a vast territory, complex topography, varied climate and a large population. The precipitation and runoff in the country is not only unevenly distributed, but also uneven with regard to time of distribution of water during the year. Frequent floods, drought and unstable agricultural production have always been a serious problem. According to Indian Meteorological Department (IMD), there are only 40 rainy days in India, and hence a long dry period. India, being an agricultural country, its economic development is linked with agriculture. The major limiting factor for agriculture is water. A growing population and consequent need for increase in food production requiring increasing area of agricultural fields and irrigation are resulting in over use of water. Due to overexploitation of water resources, it has become scarce in many parts of our country. Needless to say, water conservation is of great importance to the economic,social and cultural development in India.

### 31.1.2 Conservation techniques

Primary source of water in India is south-west and north-east monsoons. Monsoon, however, is erratic and as you have already studied the duration and the amount of rain fall is highly variable in different parts of our country. Hence, surface runoff needs be conserved. The techniques for conservation of surface water are:

(a) **Conservation by surface water storage**

Storage of water by construction of various water reservoirs have been one of the oldest measures of water conservation. The scope of storage varies from region to region depending on water availability and topographic condition. The environmental impact of such storage also needs to be examined for developing environment friendly strategies.

(b) **Conservation of rain water**

Rain water has been conserved and used for agriculture in several parts of our country since ancient times. The infrequent rain if harvested over a large area can yield considerable amount of water. Contour farming is an example of such harvesting technique involving water and moisture control at a very simple level. It often consists of rows of rocks placed along the contour of steps. Runoff captured by these barriers also allows for retention of soil, thereby serving as erosion control measure on gentle slopes. This technique is especially suitable for areas having rainfall of considerable intensity, spread over large part i.e. in Himalayan area, north east states and Andaman and Nicobar islands.

In areas where rainfall is scanty and for a short duration, it is worth attempting these techniques, which will induce surface runoff, which can then be stored.

(c) **Ground water conservation**

**Attributes of groundwater**

- There is more groundwater than surface water.
- Groundwater is less expensive and economic resource and available almost everywhere.

- Groundwater is sustainable and reliable source of water supply.
- Groundwater is relatively less vulnerable to pollution.
- Groundwater is a free of pathogenic organisms.
- Groundwater needs little treatment before use.
- There is no **conveyance losses** in underground based water supplies.
- Groundwater has low vulnerability to drought.
- Groundwater is the key to life in arid and semi arid regions.
- Groundwater is source of dry weather flow in some rivers and streams.

As highlighted earlier, out of total 4000 BCM (billion cubic meters) precipitation that occurs in India, about 45 mhan (million hectares meters) percolates as ground water flow. It may not be possible to tap the entire ground water resources. The ground water potential is only 490 BCM. As we have limited ground water available, it is very important that we use it economically and judiciously and conserve it to the maximum. Some of the techniques of ground water management and conservation are described below.

**(i) Artificial recharge**

In water scarce areas, there is an increased dependence on ground water. The water table declines quickly due to low and erratic rainfall. The only alternative is to replenish the ground water by artificial means. As you have studied in the previous lesson, there are various techniques to develop and manage ground water artificially. In one of the methods, water is spread over ground to increase area and length of time for water to remain in contact with soil. So as to allow maximum possible opportunity for water to enter into the ground. Try to recollect the other methods of recharging ground water.

**(ii) Percolation tank method**

Percolation tanks are constructed across the water course for artificial recharge. The studies conducted in a Maharastra indicates that on an average, area of influence of percolation of 1.2 $km^2$, the average ground water rise was of the order of 2.5 m and the annual artificial recharge to ground water from each tanks was 1.5 hec m.

(d) **Catchment area protection (CAP)**

Catchment protection plans are usually called **watershed protection** or management plans. These form are an important measure to conserve and protect the quality of water in a watershed. It helps in withholding runoff water albeit temporarily by a **check bund** constructed across the streams in hilly terrains to delay the run off so that greater time is available for water to seep underground. Such methods are in use in north-east states, in hilly areas of tribal belts. This technique also helps in soil conservation. Afforestation in the catchment area is also adopted for water and soil conservation.

(e) **Inter-basin transfer of water**

A broad analysis of water and land resources and population statistics of various river basins in our country reveals that areas in western and peninsular regions have comparatively low water resources/cultivable land ratio. Northern and eastern region which are drained by Ganga and Brahmaputra have substantial water resources. Hence, the scheme of diverting water from region with surplus water to water defecit region can be adopted Ganga-Cauveri link would enable to transfer of vast quantities of Ganga basin flood water running out to sea, to west and south west India. The transfer of the surplus Ganga water would make up for the periodical shortage in Sone, Narmada, Godaveri, Krishna and Cauveri. The National Grid Commission envisages diversion of part of the surplus discharge in the Ganga near Patna during the high flood period.

(f) **Adoption of drip sprinkler irrigation**

Surface irrigation methods, which are traditionally used in our country, are unsuitable for water scarce areas, as large amount of water is lost through evaporation and percolation. Drip irrigation is an efficient method of irrigation in which a limited area near the plant is irrigated by dripping water. It is suitable method for any area and specially for water scarce areas. This method is particularly useful in row crop. Similarly sprinkler method is also suitable for such water scarce areas. About 80% water consumption can be reduced by this method, whereas the drip irrigation can reduce water consumption by 50 to 70 %.

***Fig. 31.1:*** *Sprinklers irrigation fields*

(g) **Management of growing pattern of crops**

In water scarce areas, the crop selection should be based on efficiency of the crop to utilize the water. Some of the plants suitable for water scarce areas are (i) plants with shorter growth period; (ii) high yielding plants that require no increase in water supply; (iii) plants with deep and well trenched roots and (iv) plants which cannot tolerate surface irrigation.

(i) **Selection of crop varieties**

Crop performance and yield are the results of genotype expression as modulated by continuous interactions with the environment. Generally, the new varieties of crop do not require more water than the older ones. However, they require timely supply of water because their productivity is high. Frequent light irrigation is more conductive than heavy irrigation at large intervals for obtaining high yields.

(ii) **Nutritional management**

Potassium plays a major role under stress conditions. It improves the tissue water potential by osmoregulation, ultimately increasing the water use efficiency. Experiments conducted at the Water Technology Centre, Coimbatore, indicated that foliar application of 0.5% potassium chloride can reduce the moisture stress in soyabean, sorghum and groundnut.

(iii) **Role of antitranspirants**

Application of antitranspirants reduces transpiration maintaining thereby the tissue water potential. Plants then take up less water from soil. Antitranspirants can prolong the irrigation intervals by slowing down soil water depletion. Application of Kaolin (3%) and lime wash (2%) was found to maintain the water balance of plant and resulted in normal yield of sorghum under moisture stress conditions. Certain growth regulators reduce the plants susceptibility to water stress. Application of cycoel, a growth retardant increases the ability to withstand drought. Cycoel application also reduces production of gibberellic acid which leads to closing of stomata. Transpiration loss of water gets reduced.

(h) **Reducing evapotranspiration**

Evapotranspiration losses can be reduced by reducing the evaporation from soil surface and transpiration from the plants, in arid zones, considerable amount of water is lost in evaporation from soil surface. This can be prevented by placing water tight moisture barriers or water tight mulches on the soil surface. Non-porous materials like papers, asphalt, plastic foils or metal foils can also be used for preventing evaporation losses. Transpiration losses can be reduced by reducing air movement over a crop by putting wind breaks and evolving such types of crops which possess xerophytic adaptations.

(i) **Reducing evaporation from various water bodies**

The quantity of water lost through evaporation is very high in many areas in our country. It is estimated that 10000 hectares of land loses about 160mm$^3$ of water each year. The water losses through evaporation from storage tanks, reservoirs, irrigation tanks, rivers and canals reduce the water available for various uses. The methods that reduce evaporation from water bodies are- installing wind breaks, reducing energy available for evaporation, constructing artificial aquifers, minimizing exposed surface through reservoir regulation, reducing ratio of area/volume of water bodies, locating reservoirs at higher altitudes and applying monomolecular firms.

(j) **Recycling of water**

The wastewater from industrial or domestic sources can be used after proper treatment, for irrigation, recharging ground water, and even for industrial or municipal use. If agricultural lands are available close to cities, municipal waste water can be easily used for irrigation.

### 31.1.3 Conservation of water in domestic use

There is a large scope of conserving water at house hold level. A general awareness among the people about the importance of water and its availability, and need for conservation can help in minimizing wastage to a large extent. Losses during water supply also need to be prevented by reducing the leakages.

Some of the ways for improving the efficiency of water use at household level are:

- Reduce wastage-leaking pipes mean that lot of water never reaches to the people. In Delhi estimated losses are 35-40 %.
- Closing of taps while not in use.
- Better irrigation techniques – irrigation systems waste up to 70% water used. In drip irrigation water loss is significantly less.
- Use low flush toilets-reducing the amount of water used each time the lavatory is flushed.
- Build latrines and compact toilets which can turn human waste into clean, useful manure- this is much cheaper than connecting toilet to a piped sewage line.
- Use bowls to wash vegetables, dishes instead of running tap.
- Greater use of recycled water 'grey water' in the home. Instead of using potable or treated water use bath and shower water for watering the plants.
- Use washing machine or dish washer when it is fully loaded.

### 31.1.4 Reduce the loss of water

There are numerous methods to reduce losses due to evaporation and to improve soil moisture. Some of them are listed below:

- Mulching i.e. the application of organic or inorganic materials such as plant debris, compost, etc., slows down the surface run-off, improves soil moisture, reduces evaporation losses and improves soil fertility.

- Soil covered by crops, slow down run-off and minimize evaporation losses, hence, fields should not be left bare for long periods of time.
- Ploughing helps to move the soil around. As a consequence it retains more water thereby reducing evaporation.
- Shelter belt of trees and bushes along the edge of agricultural fields slow down the wind speed and reduce evaporation and erosion.
- Planting of trees, grass, and bushes breaks the force of rain and helps rainwater penetrate the soil.
- Fog and dew contain substantial amounts of water that can be used directly by adapted plant species. Artificial surfaces such as netting-surface traps or polythene sheets can be exposed to fog and dew; the resulting water can be used for crops.
- Contour farming is adopted in hilly areas and in lowland areas for paddy fields. Farmers recognize the efficiently of contour based systems for conserving soil and water.
- Salt-resistant varieties of crops have been also developed recently. Because these grow in saline areas, overall agricultural productivity is increased without making additional demands on fresh water sources. Thus, this is a good water conservation strategy.
- Desalination technologies such as distillation, electro-dialysis and reverse osmosis are available;

### 31.1.5 Reuse of wastewater

Wastewater contains lots of nutrients. Its use for irrigation saves these nutrients. It improves the productivity of crops and soil fertility. General utilization of wastewater through reuse and recycling improves water use efficiency. In fact, wastewater is a resource rather than a waste since it contains appreciable amount of nitrogen, phosphorus and potash. Stabilization ponds can be used for fish aquaculture. The effluent can also be used for cultivation of short-term and long term, ornamental, commercial and fodder crops.

### Benefits of reuse

Practical experience has shown that wastewater reuse not only reduces the demand for fresh water but also can improve environmental quality; reuse of treated wastewater has the following benefits:

- Make up for the shortage of water supply (reduces demand on good quality water)
- Reduces the wastewater discharge thus reducing water pollution.
- Results in cost reduction.

The potential applications of reusing of treated wastewater are in the following fields or areas:

- Agricultural use through irrigation of crops as well as for improving river amenity;
- Industrial cooling especially in large industrial enterprises;
- Reuse in municipal public areas such as watering lawns, parks, play grounds and trees;
- Flushing toilets in hotels and residential districts;
- Reuse of the treated wastewater for urban landscape purposes.
- Treated waste water can also be used for groundwater recharging.

**Untreated water:** Water or grey water can also be reused for various purposes.

**Grey water is defined as untreated household wastewater, which has not come into contact with toilet waste.** It can originate from the shower, bath, bathroom, washing basin, clothes washing machine and laundry trough.

In our country nearly half of the wastewater is used for irrigation. Many municipalities sell their wastewater to the farmers. Many industries are buying the wastewater and using it.

## INTEXT QUESTIONS 31.1

1. List at least three reasons why water conservation is important.

   ______________________________

2. List two irrigation practices which reduce water requirement.

   ______________________________

3. List two benefits of reuse of water.

   ______________________________

4. How can transpirational loss be reduced?

   ______________________________

5. What are the benefits of contours farming?

   ______________________________

## 31.2 WATERSHED MANAGEMENT

Watershed is an area that contribute water to a stream or a water body through run-off or underground path. That is the region from which surface water draws into a river, a lake, wet land or other body of water is called its watershed or drainage basin. Watershed management is a technique for conservation of water and soil in a watershed. The presence of water in soil is essential for the growth of plants and vegetation. Forests and their associated soils and litter layers are excellent filters as well as sponges, and water that passes through this system is relatively pure. Various kinds of forest disturbances can speed up the movement of water from the system and in effect, reduce the filtering action.

In mountainous terrain the forests play a prominent role in prevention of soil erosion. Erosion threat can be tackled by the maintenance of continual cover. Ideally, this is achieved by single stem harvesting; only one tree is felled at any one point, and the small gap so created is soon sealed by the outward growth of its neighbours.

Despite the uncertain balance of water gain and loss, forests offer the most desirable cover for water management strategies. In constrast to the rapid flows of short duration characteristics of sparsely vegetated land water yields are gradual, reliable and uniform in forests. Deforested land sheds water swiftly, causing sudden rises in the rivers below. Over a large river system, such as that of the Ganga and the Yamuna, forests are a definite advantage since they lesson the risk of floods. They also provide conditions more favourable to fishing and navigation than does un-forested land. All natural streams contain varying amounts of dissolved and suspended matter, although streams contain varying amounts of dissolved and suspended matter, although streams issuing from undisturbed watershed are ordinarily of high quality. Waters from forested areas are not only low in foreign substances, but they also are relatively high in oxygen and low in unwanted chemicals.

The belief that forests increase rainfall has not been substantiated by scientific inquiry. Local effects can, however, prove substantial, particularly in semiarid regions where every millimeter of rain counts. The air above a forest, as contrasted with grassland, remains relatively cool and humid on hot days, so that showers are more frequent. Many areas in India used to get significant rainfall when they were forested are now facing severe draught due to denudation (example Rajasthan desert).

## INTEXT QUESTIONS 31.2

1. What is watershed?

2. How do forests reduce the risk of flood?

3. List any two ways in which forests help in maintaining the quality of water.

4. What is achieved by single stem harvesting?

## 31.3 ROLE OF INDIVIDUAL AND COMMUNITY IN OVERCOMING WATER SCARCITY

### 31.3.1 Examples of individual and community efforts to overcome water scarcity

There are many examples of individual and community efforts on water conservation in our country. Some important examples are given below:

Year after year, every summer, both the rural and urban areas of Saurastra and Kutch reel under water shortages. In the coastal areas the problem is further compounded by salinity ingress into ground water aquifers. The government machinery responds to the situation by providing water trucks and trains. While a large number of people continue to depend on the rain Gods or the government water tankers, in some areas people have begun to take the matter in their own hands.

**Case Studies**

(i) In Gandhigram, a coastal village in Kutch distrirct, the villagers had been facing a drinking water crisis for the past 10 to 12 years. The groundwater table had fallen below the sea level due to over extraction and the seawater had seeped into the ground water aquifers. The villagers formed a village development group, Gram Vikas Mandal. The Mandal took a loan from the bank and the villagers contributed voluntary labor (Shramdan). A check dam was built on a nearby seasonal river, which flowed past the village. Apart from the dam, the villagers also undertook a micro-watershed project, due to these water retention structures, the villagers now have sufficient drinking water, and 400 ha of land, which earlier lay barren, has come under irrigation.Similar examples of people's initiative in organizing rainwater harvesting can also be seen in the two villages of Khopala and Jhunka in Bhavnagar district of Saurastra.

(ii) A noteworthy example of students's participation in such an endeavor took place in 1955-98 at Bhavnagar University under the guidance of the, then Vice Chancellor of the university Prof. Vidyut Joshi. The coastal city of Bhavnagar was facing a severe drinking water shortage. Prof. Joshi initiated the digging of a percolation tank in the university premises. About 650 students, 245 teachers and other employees of the university worked as voluntary labour. During the following monsoon, all the bore wells in university as well as those in the adjoining areas were recharged.

The success stories have proved that management of water resources by the end users themselves can lead to sustainable benefits. Such community based systems of resource management are not new to society. They have been practiced by many traditional communities all over the world, but are gradually being replaced by 'modern' centralized systems of resource management.

### 31.3.2 Artificial recharge to groundwater

Artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding normal rate of seepage and replenishment. Any man-made scheme or facility that enhances seepage water to an aquifer may be called to be an artificial recharge system.

Ground water exploitation is inevitable is urban areas. But the groundwater potential is getting reduced due to certain adverse effects of urbanization. These are:

- increase in water demand.
- more dependence on ground water use.
- over exploitation of groundwater.
- increase in run-off, decline in well yields and fall in water levels.
- reduction in open soil surface area.
- reduction in infiltration and deterioration in water quality.

Hence, a strategy to implement the ground water recharge, in a major way needs to be launched with concerted efforts by various governmental and non-governmental agencies and public at large to build up the water table and make the ground water resource, a reliable and sustainable source for supplementing water supply needs of the urban dwellers.

Recharge of groundwater through storm run off and rooftop water collection, diversion and collection of runoff into dry tanks, play grounds, parks and other vacant places are to be implemented by town panchayats/municipaliites/ municipal corporations and other government establishments.

The town panchayats/ municipalities/ municipal corporations offer help to the citizens and builders for adopting suitable recharge method in one's own house or building through demonstration and offering subsidies for materials and incentives.

**Methods of artificial recharge in urban areas:**

- Water spreading.
- Recharge through pits, trenches, wells, shafts.
- Rooftop collection of rainwater.
- Roadtop collection of rainwater.
- Induced recharge from surface water bodies.

Computation of artificial recharge from rooftop rainwater collection:

Factors taken computation

- Roof top are 100 sq.m. for individual house and 500 sq.m. for multistoried building.
- Average annual monsoon rainfall = 780 mm.
- Effective annual rainfall contributing to recharge 70% = 550 mm.

| | **Individual houses** | **Multistoried building** |
|---|---|---|
| Roof top area (sqm) | 100sq.m. | 500 sq.m. |
| Total quantity available for recharge per annum (Cum) | 55 cu. m. | 275 cu. m |
| Available water (in day) for 5 member family | 100 days | 500 days |

**Benefits of artificial recharge in urban areas**

- Improvement in filtration and reduction in run-off.
- Improvement in groundwater levels and yields.
- Reduces strain on town panchayats/municipal/ municipal corporation water supply.
- Improvement in groundwater quality.
- Estimated quantity of additional recharge from 100 sq. m. roof top area is 55.000 litres.

### 31.3.3 Government's efforts on water conservation

On water conservation following main efforts can be noted.

- National Water Policy 2002 strongly emphasize conservation of water.
- Efforts to retain rain water on land through various schemes.
- Construction of large number of dams on various river systems.
- Interlinking of rivers (proposed).
- Promotion of bunds at village level.
- Promotion of rain water harvesting.
- Promotion of reuse and recycling of wastewater.
- Steps to protect water quality.
- Drought-proofing the future.

Temporary cutbacks or permanent operating adjustments can help conserve water. Permanent conservation measures may include:

- Subsidizing use of water-efficient faucets, toilets and showerheads
- Public education and voluntary use reduction.
- Billing practices that impose higher rates for higher amounts of water use
- Building codes that require water-efficient fixtures or appliances
- Leak detection surveys and meter testing, repair and replacement
- Reduction in use and increase in recycling of industrial water

Temporary cutbacks may include:

- Reduction of system-wide operating pressure
- Water use bans, restrictions, and rationing

Strengthening of local or municipal bodies could help addressing the issue of water shortage and its management in cities. India's national water policy give overriding priority to drinking water. Urban development projects are required to make provisions for drinking water. India is developing both ground and surface water resources. Current policies prioritize the utilization of static reserves to prevent ground water mining but development of ground water mining is very intensive in many parts of our country.

Success stories like the revival of the Aravari river basin by the waterman of Rajasthan-Rajender Singh –are already well known. The drought prone rain fed areas in Karnataka are being drought proofed. Farm ponds and re-adoption of tree agriculture ensures water consuming tree produce in the drought years.

There was also a discussion on the role that central and state ground water boards can play in improving prospects of success of water harvesting initiatives across the country. These bodies should act as libraries and resource centres for those planning to work on ground water. The government needs to support initiatives for water conservation across the country and to assess earlier large projects before any new ones are announced. On the whole, smaller local efforts found much more support than grandiose schemes; revival of a large number of ponds and tanks in the country would provide for water storage for dry months and also prevent floods by storing excess river water in depressions. Small structures, be it tanks or check-dams or lakes, have higher ecological efficiency in ground water recharge.

It is also recognized that rural and urban water crises are very closely related. Urban areas enjoy political and economic clout to divert rural resources to urban centres. Hence techniques like rooftop rainwater harvesting should be promoted in urban centres to avert water crises in cities without impacting rural areas. The use of commercial media and regular airtime on national channels to discuss issues of water management is an effective way to promote water conservation. Publicity and government support to success stories will motivate the public to think about water conservation. There is a strong need to create awareness about water conservation among the urban youth.

The urban water economy is seen as wasteful and highly polluting. The importance of applying a polluter pays principle to domestic users in urban areas must be recognized.

In many parts of our country the water is polluted by discharges of domestic or industrial effluents. There is an urgent need to implement the anti-pollution law. Quality of groundwater is a very important concern as it supports more than 50% of agriculture even today.

### 31.3.4 Traditional solutions revisited

Indian communities have long been aware of the dependence of their lives on the natural resources around them, when unscrupulous traders were felling trees, local people, under the leadership of environmentalist Sunderlal Bahuguna, spearheaded the Chipko movement which involved local people physically embracing trees to prevent loggers from cutting them.

India has a rich legacy of water harvesting technologies and these methods, combined with modern science, could lead to permanent solution to this problem. Rainwater harvesting, simply put, is putting water back into soil where it is stored in underground rivers and reservoirs so that it can be drawn when needed. In cities, rain water harvesting is merely collecting rainwater in large tanks constructed on roof tops to be used when required.

Revival of traditional rain harvesting systems, have transformed some of the areas from places of economic backwardness to areas of abundance. They are also highly sustainable.

Economic growth and urbanization will go hand-in-hand with environmental crises. We must rejuvenate our traditional knowledge and tap the traditional systems of resource management to suit our present day needs. The basic simple wisdom is underlined by the continued success of traditional methods of managing earth's resources in India as well as in other parts of the world. Modern communities the world over should, therefore, be encouraged to look at time tested traditional methods of resource management.

There are many ways to conserve water that result in significant reduction wastage of water. For example, residential water consumption can be reduced by using water efficient fixtures (faucets, toilets and showerheads) and appliances and through better managed lawn watering.

### 30.3.5 Some simple water saving methods are as follows:

#### (i) What can an individual do to conserve water?

The most important step in the direction of finding solutions to issues of water and environmental conservation is to change people's attitudes and habits this includes each one of us. Conserve water because it is right thing to do. we can follow some of the simple things listed below for water conservation:

- Use only the amount you actually need.
- See that there are no leaks in the toilet tank. You can check this by adding colour to the tank. If there is a leak, colour will appear in the toilet bowl within 30 minutes. (Flush as soon as the test is done, since food colouring may stain the tank).
- Do not leave the tap running while you are brushing your teeth or soaping you is your face.
- Avoid flushing the toilet unnecessarily.
- Put a brick or any other device that occupies space to cut down on the amount of water needed for each flush.
- When washing the car, use water from a bucket and not a hosepipe.
- Do not throw away water that has been used for washing vegetables, rice or dals use it to water plants or to clean the floors, etc.
- Make sure that your home is leak –free. Many homes have leaking pipes that go unnoticed.
- Encourage your family to keep looking for new ways to conserve water in and around your home.
- Try to do one thing each day that will result in saving water. Don't worry if the savings are minimal every drop counts'! You can make a difference.
- Form a group of water conscious people and encourage your friends and neighbours to be part of this group. Promote water conservation in community newsletters and on bulletin boards. Encourage yours friends, neighbours and co-workers to also contribute.
- You can store water in a variety of ways. a simple method is to place a drum on a raised platform directly under the rainwater collection source.

Keep a water bottle filled with water in a cistern tank for reducing the amount of flushing water by one litre. Only 1.5 litres of water 7 litres flushing required for water is solid waste, however, the existing cistern tank size is 12 litres. Simple strainer in the wash basin tap will reduce the outflow of water by 50% just as practiced by air crafts. Using a mug instead of running water for shaving saves 17.5 litres per shave.

| Activity | Method adopted | Qty. used Ltr. | Methods to be adopted | Qty. required Ltr. | Qty. saved Ltr. |
|---|---|---|---|---|---|
| Brushing teeth | Running tap for 5 minutes | 45 | Tumbler or glass | 0.5 | 44.5 |
| Washing hands | Running tap for 2 minutes | 18 | Half filled wash basin | 2.0 | 16.0 |
| Shaving | Running tap for 2 minutes | 18 | Shaving mug | 0.25 | 17.75 |
| Shower | Letting shower run while soaping staying under shower too long | 90 | Wet down, tap off, soap up, rinse off | 20.00 | 70.00 |
| Flushing toilet | Using old fashioned large capacity cistern | 13.5 or more | Dual system short flush liquid waste full flush solid waste | 4.5 9.0 | 4.5 or more |
| Watering plants | Running hose for 5 minutes | 120 | Water can | 5.0 | 115.00 |
| Washing floor | Running hose for 5 minutes | 200 | Mop and bucket | 18.0 | 182.00 |
| Washing car | Running hose for 10 minutes | 400 | Buckets (two) | 18.0 | 382.00 |

### Case study

### Tarun Bharat Sangh

The work of **Tarun Bharat Sangh** (TBS), and its founder Shri Rajendra Singh in then districts of Rajasthan can easily be over-simplified as water-shed management whereas, it is in fact a revolution in regenerating life and society in denuded and deserted lands.

It is seemingly simple two-step programme. First, revive vegetation on barren hill slopes and second, build small water catchments in the valleys and the plains.

The efforts resulted in:

- dead rivers begin to flow.
- agriculture becomes possible round the year.
- impoverished villagers, labouring in cities return, and families are re-united.
- wearying labour like fetching water, gives way to positive developmental work.
- with enough water and fodder, income from animal husbandry begins to flow.
- nutrition levels rise and public health improves.
- wooded hills welcome back wildlife, that round off forests whole-ness.

- people rid of insecurities, come together to address other issues of life, like education and local governance.
- awareness and confidence enable micro-credit schemes that lower the cost of households and starts small enterprises.
- people with leisure, turn to crafts, reviving folk practices like herbal medicine and community welfare.
- when small communities like these succeed, the government itself wakes up and development becomes what it should be: ground-up, instead of top-down.

**How did it happen?**

Well, it has happened in the space of 15 years in Rajasthan. Beginning from the small village of Bhikampura in Alwar district, the people-centred development model is spreading all over Rajasthan. Today you can see the river Aravari, dead for 40 years flow again. So too the rivers Ruparel, Jahjajwali and numerous other rivulets. You can drive through Alwar district and observe without effort, stark barren hills contrasting with those beginning to turn green. You begin to believe more hill slopes will be green too. You see a land where peace reigns. The contentment in the air is palpable.

**Johad rediscovered**

It all began with a young man called Rajendra Singh in 1985. A self-effacing man with nerves of steel. As he himself would want it, let us talk of his Tarun Bharat Sangh's (TBS) work first and then look at his personal story.

Tarun Bharat Sangh's (TBS), discovered that only people's fullest cooperation can achieve these ends. No amount of money, government action or legislation can deliver results. Therefore the design, location and construction of each water harvesting structure is discussed endlessly by Gram sabha's until a true consensus is reached. True consensus is measured as attained, when every member of the community agrees to contribute either money or labour towards the construction of a johad, a check dam or a weir. In one village the consensus took 5 years to arrive at. To the modern mind, that may seem too long for a piece of civil works that then took 6 months to build. But once such consensus-work are built, they become everyone's are guarded and maintained. Issues of use and sharing have been settled before construction began rather than later. Such works are forever and the 5 years of deliberation recedes into significance.

Regeneration of vegetation on hills ensures dependable water supply to streams. Hills can be revived when left alone by preventing humans cutting off mature trees, and nibbling of sprouting stumps by cattle. TBS discuss these issues with villagers in the chosen hill areas through hundreds of hours of meetings over several months until they all agree to suspend browsing by cows for 3 years, goats for 5 years and camels for 7 years.

This agreements leads to what TBS calls ‘social fencing’ which, in contrast with physical fences, is virtual; only in mind. With great fanfare, elders lead villagers on a walk through the entire line of the agreed ‘social fence’, sanctify it by sprinkling a mixture of scared waters and milk. Once thus notified, TBS has found that villagers respect it and police it! Can government funds and fiats ever achieve this?

TBS’s ‘people centred’ approach to development is:

- endless discussions on every conceivable issue.
- arrival at a consensus, however long it takes.
- involvement of villagers with, service, money or material.
- keeping the government at bay, with defiance if needs be.
- and finally, low down the list, balance fund raising and actual execution of the works.

This was not a received wisdom that Rajendra Singh has handed down. he put the rules together as he worked over the years, close to the people. In 1985, as a newly married 28 years old he was well settled, with a government job in Jaipur. But the ghosts of Mahatma Gandhi and Jaiprakash Narayan haunted him goading him into doing something. Not unlike the Buddha he walked out on his wife and home and was inaccessible for two years. Along with four of his friends, he arrived at the village of Kishori and said to the bewildered villagers that he wanted to do something. They were puzzled, intrigued or wary.

Accident had chosen the place well for him. In the thirties, the district of Alwar in the green valleys of the Aravalli hills was a prosperous land. But a greedy prince, with an eye cocked on a free India that would take away his primacy, sold off the rights to the timber on the hills. In ten swift years, contractors laid the land low. Rains brought down loads of earth from naked hills that filled catchment works. Water sped off without stopping to feed the wells and fields. Often they hurtled into deep marble mines and lay uselessly there. Land owners joined landless labourers on a trek to Delhi and Agra to toil for small sums to send home. Families broke up.

For forty years, a whole new generation did not know that there had been hope and fertility once around them.

**A water conservation model**

A few like Mangu Ram remembered the old days. He led Rajendra Singh and his friends to a place where they begin to dig. It was the first johad in forty years. A johad is a dug out pond, created at a place chosen with native wisdom, informed by remembered patterns of water flow during the rains. After the rains, water stays in for months and recharges the wells nearby. The success of the first johad switched on the collective memory of the people. And enthusiastic construction began all around, guided by elders. When the 650th johad was dug out, close to the forgotten river bed of the Aravari, the river woke up at the next rains and began to run! and providing water and life to the people of the area. At Hamirpur, it is broad river supporting year round agriculture on it's bank. Today all over Rajasthan the TBS model pioneered by Rajendra Singh, is spreading. There are 3500 people-made water conservation structures. Villagers contribute one third the cost of all construction. TBS organizes the rest. Government at last, has stopped being a hindrance and begun to be a facilitator. President Narayanan, flew down to Hamirpur to pay tribute to the villagers.

It is nothing but humbling to see the transformation brought about by unlettered man who rallied around an unsophisticated young man, who preaches that mountains are nature's breasts and rivers water, the milk.

## INTEXT QUESTIONS 31.3

1. How can you save water at your personal level? List at least 6 ways.

   ______________________________________________

2. There are many examples in Gujarat of individual and community action on rain water harvesting. List two such activities.

   ______________________________________________

3. Government is promoting conservation of water. List any two reasons of such promotions.

   ______________________________________________

4. List the achievement of Tarun Bharat Sangh in context of water conservation.

   ______________________________________________

## WHAT YOU HAVE LEARNT

- Water is a scarce resource. It needs to be conserved.
- Conservation can be accomplished through many methods.
- Efficient use of water at domestic and agricultural level may save water significantly.
- Better irrigation techniques are very important in water conservation.
- Recycling of waste water is very important in water conservation.It has many benefits.
- Watershed is an area through which a water body gets its water.
- Protection of forests and vegetation helps conservation of water in a watershed.
- Forests-soil-litter is a good filter media for water.

- It removes most of the impurities of water.
- The water passing through a forested watershed is generally clean.
- There are many examples of individual, community and government on conservation of water.
- The efforts of Tarun Bharat Sangh led by Sh. Rajendra Singh to revive Aravari river in Rajasthan is a world famous example of water conservation.
- Efforts at individual and community level in Gujarat on water conservation are also quite famous.
- A large number of dams and reservoirs created in the country are good example of government's efforts of water conservation.
- There are number of policy and regulatory initiatives taken by the government to promote rainwater harvesting and water conservation.

## TERMINAL EXERCISE

1. Why water conservation is important in India
2. Name few important methods of water conservation.
3. What an individual can do for water conservation at house hold level.
4. How watershed management helps promoting water conservation?
5. What is rainwater harvesting? How it helps conserving water?
6. Explain in brief the example from Gujarat on rainwater harvesting
7. What are the benefits of rain water harvesting?
8. What are the main attributes of ground water?
9. Name few initiatives of the Government on water conservation.
10. How Tarun Bharat Sangh has changed the face to few villages in Rajasthan?

## ANSWER TO INTEXT QUESTIONS

**31.1**

1. Refer to text
2. Sprinklers, drip irrigation
3. Saves water and minerals
4. Antitranspirants, $K^+$ use

Notes

5. Two benefits: 1. Conserve water by holding it for longer time in the field 2. Since it prevents run off water too fast, prevents soil erosion.

**31.2**

1. An area through which a water body gets water either run off or underground path.
2. Forests prevent rains and excellent filler and excess water absorbs through the roots of the forest trees.
3. Water moves through soil and little layers are excellent filters and relatively pure.
4. Only one tree is felled at any one point and the small gap so created is soon sealed by the outward growth of its neighbour.

**31.3**

1. Refer to section 31.3
2. Refer to section 31.3
3. Refer to section 31.3
4. Refer to section 31.3

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# 31

# ENERGY CONSERVATION

In the 1970s energy issues were dominated by the oil crisis and the threats to energy security. At that time environmental issues associated with the production and consumption of energy were yet to gain widespread attention. Nowadays, environmental issues are among top priority in private, public and government circle. Excessive energy use and growing exploitation of natural resources have adversely affected our environment. To reduce the adverse impacts of growing use of energy on the environment, it is important to improve energy use efficiency and switch to environment friendly energy sources. Improved energy efficiency and better energy management will help in preventing environmental damage and help in financial saving.

## OBJECTIVES

After completing this lesson, you will be able to:

- *discuss the impact of energy use on environment;*
- *explain the importance of energy in daily life;*
- *explain the relation between energy and economic development;*
- *explain energy conservation with examples;*
- *explain how we can improve energy efficiency in industry;*
- *describe how we can conserve energy at various levels;*
- *describe the concept of energy efficient buildings and towns;*
- *describe the limitations of alternative sources of energy;*
- *define the concept of energy auditing.*

## 31.1 IMPACT OF ENERGY USE ON ENVIRONMENT

Energy use and supply is of fundamental importance to society which has made the greatest impact on the environment of any human activity Although energy and environment concerns were originally local in character – for example, problems associated with extraction, transport or noxious emissions – they have now widened to cover regional and global issues such as acid rain and the "greenhouse effect". Such problems have now become major political issues and the subject of international debate and regulation.

Apart from **depletion of energy resources,** use of energy especially burning of fossil fuels cause environmental pollution. Burning of fossil fuels emit green house gases that cause global warming. The changing weather patterns due to global warming are now a reality. The impact of global warming has already created an alarming situation and will soon become distratous for the entire earth including the living creatures that have made this earth their home. We should better be cautious and aware to this to save our planet earth. To sum up, therefore, the impact of energy use on the environment has been two fold.

- Depletion of energy resources.
- Pollution of environment from emission of green house gases from burning of fossil fuels.

## 31.2 IMPORTANCE OF ENERGY IN DAILY LIFE

In an average home for almost all types of activities like lighting, cooling and heating the house, for cooking, for running televisions, computers and other electrical gadgets energy is used.

From the time you wake up to the time you go to sleep at night, energy has affected your life. Energy is important in everyone's life, whether you notice it or not. Without it people would have a hard time waking up and an even harder time getting anywhere. Energy is important whether its solar energy, mechanical energy, nuclear power, or the energy your body makes that allows you to talk, move, and walk. These are the tasks that we normally do that involve energy, and that we couldn't do without it.

You will probably pass a traffic light on your way to school or work place and that is powered by electricity. Without the traffic light, cars would be going all over the place and crashing all the time. Traffic lights help to manage the chaos. If you walked to school you used the energy your body made from converting calories from food to energy. You might turn on lights in your house, when it gets dark. Electricity allows you to light up the room and makes it bright.

In the transport sector, buses, trucks, trains, aeroplanes, ships, automobiles are powered by coal, gasoline, diesel and gas. These are fossil fuels and their over exploitation is causing scarcity.

In the agricultural sectors, pumps for irrigation run on diesel (a fossil fuel) or electricity. Tractors, threshers, combined harvesters are all fuel-intensive.

In the industrial sectors, energy is required in huge amount at various stages in the manufacturing of goods.

Energy has been universally recognized as one of the most important inputs for economic growth and human development. The energy sector in India has been receiving high priority in the planning process.

## 31.3 ENERGY AND ECONOMIC DEVELOPMENT

Energy development is an integral part of economic development. Economically developed countries use more energy per unit of economic output and have much more per capita energy consumption as compared to developing countries. Energy has been universally recognized as one of the most important inputs for economic growth and human development. Growth of economy will stand global competitiveness withstand only when it will depend on cost effective or cheaper and environment friendly energy sources.

Energy intensity is an indicator to show how efficiently energy is used in the economy. India's energy intensity is much higher than the emerging economies of other Asian countries.

Energy sector in India has been receiving high priority in the planning process. Government of India has recognized the fact that the energy sector can become a major constraint or hurdle in the achievement of a high growth rate or Gross Domestic Product (GDP). It has therefore called for an increase in the reform process and adoption of an integrated energy policy.

## INTEXT QUESTIONS 31.1

1. Mention two most important impacts of energy use on environment.

   ______________________________

2. Mention four important activities which you require energy in your daily life.

   ______________________________

3. Which is the most important input or factor required for economic growth in today's world?

   ______________________________

Notes

## 31.4 ENERGY CONSERVATION

As you have already learnt, that industrial development and modern means of transport and various types of gadgets require increasing amounts of energy. Fossil fuels are universally the main source of energy which are finite and non renewable. It is therefore necessary to prevent wastage of energy and make all our efforts for energy conservation. The use of fluorescent light bulbs, energy efficient appliances and low emissive glass could reduce energy consumption significantly. We shall fail in our duty, if energy sources are exhausted. We owe our responsibility towards the next generation.. Energy conservation must become an everyday duty of every human being. Sincere efforts are needed at individual, community and at government level for energy conservation.

### 31.4.1 Conservation of energy at various levels

**(A) Energy conservation at household level**

In every country residential demands constitute major part of total energy used. When comparing an average house to our energy efficient house, it is possible to reduce annual energy bills up to 40%. We should develop an energy conservation plan for our house. This is both an environment friendly and economically sound action.

The steps in developing an energy conservation plan for our home are (1) identify the problem areas where energy is being lost or inefficiently used. (2) to prioritize the problem areas according to how much energy is being lost or inefficiently used and (3) systematically correct the prioritized problems according to the limits of our household energy improvement budget.

Apart from lights and fans, several other household appliances have flooded the market. A cautious operation and use of good quality electrical appliances (with five star rating) not only enhance their life but also save energy. Some energy conservation activities are mentioned below:

**(i) Major appliances for domestic use**

Large appliances are the major consumers of energy and improving the operating efficiency of such household appliances will significantly reduce the overall consumption of electricity.

(a) **Refrigerator**

Do you know that refrigerators account for the consumption of a huge amount of energy? Condenser is found either behind the fridge or underneath the fridge and helps in maintaining its lower temperature. We can conserve energy while using refrigerator in the following ways:

- It should be maintained at 37ºF- 400 $^0$ F and freezer section at 50$^0$F and should have automatic moisture control.

- We should keep the fridge as full as possible and it should be kept in that position that its outside surface is not exposed to direct sunlight.
- If the door of the fridge is not closed properly it will consume much more energy. Uncovered liquids should not be put in the refrigerators as it will give extra workload to the compressor.
- Before putting food in the refrigerator it should be cooled up to room temperature.
- Door of the fridge should not be opened several times.

(b) **Ovens/Microwave oven**

To conserve energy while using ovens we should keep in mind the following:

- We should use microwaves as they consume 50% less energy than conventional ovens.
- The oven door should not have any cracks or tears in it.
- We should use “lids-on” cooking to permit temperature over heating.
- Keep reflector pans beneath stove top heating elements bright and clear.
- Carefully measure water used for cooking to avoid having to heat needed.
- Begin cooking on highest heat until liquid begins to boil. Then lower the settings and allow food to simmer until fully cooked.
- One should cook as much of the meal in the oven at one time as possible.
- Rearrange oven shelves before turning your oven on and do not peep in oven. Every time the oven is opened temperature is lowered by 4° - 5°C.
- When preheating an oven for baking, time the preheat period carefully, minutes should be sufficient.
- For large items, stove-top cooking is most efficient, especially with gas.

(c) **Ironing**

Everyday we iron our clothes. It consumes approximately 1000-watt energy, which is a huge amount. But we can save energy by ironing clothing in bulk and not just one or two at a time. Ensure that the thermostat on the iron is working and set the right temperature for the clothing being ironed.

(d) **Cooking**

Major part of energy is consumed during cooking. It can be saved during cooking by using all these measures. Use a cooking pan that is slightly bigger than your cooker plate, coil or burner. Keep saucepan lids on. Turn down the heat once food starts boiling.

(e) **Washing machines**

Washing machines consume 20% of the electricity. Energy can be conserved during the use of working machine in the following ways:

- We should try to use cold water while working and rinsing as almost 90% of the energy consumed by washing machine is used to heat the water.
- Follow detergent instructions carefully. Adding too much detergent for effective working action may require more energy.
- Wash only full loads of clothing but do not overload machine.
- Soak or prewash the clothes for effective cleaning as well as to reduce energy consumption.

(ii) **Lighting**

Increasing energy demand the world over and the ever-increasing prices of energy have provided a justifiable reason for improving energy efficiencies of all energy intensive technologies. Some methods of saving energy during lighting are as follows:

- Light should be turned off when not in use.
- Maximum sunlight should be used during the day. Bulbs and tubelights should not be used during day.
- Use task lighting whenever possible instead of brightly lighting an entire area or room.
- Use compact fluorescent lamps (CFL) in place of incandescent bulbs. A 23-watt compact fluorescent bulb can replace a 90 or 100 watt.
- Use dim light in galleries, lobbies; balconies etc.
- Do not keep computer, TV, tape recorder, music system in stand by mode. Do you know how much electricity you can conserve by turning off the TV instead of keeping it on stand-by? You can save 70-kilowatt hour per year.
- Geysers consume the maximum amount of electricity. Thermostat can be set to a lower temperature 45°C to 50°C.
- Lamps should be put in those corners of the rooms where they can reflect many light surfaces instead of one.
- Use dimmable bulbs wherever possible.

(iii) **Electricity conservation**

With the growing awareness about the depletion of global energy reserves and adverse environmental impacts of energy use, now efforts are underway to develop energy efficient machines and technologies to reduce energy expenditure and to minimize environmental hazards. Some such steps are as follows:

- Use ISI marked appliances and equipments.
- Substitute bulbs with tungsten filaments lamps (TLP) tubes.
- CFL (compact fluorescent lamps) should be used as they use comparatively less electricity and last longer.
- Electric geyser can be replaced by gas geyser to save electricity.

**(iv) Others**

Some other methods by which energy can be saved are as follows:

- Adjust the flame of gas cooking appliances, so that the flame remains blue not red or yellow.
- Shut down computers when not in use.
- Select appliances (i.e. curling irons, coffee pots, irons) with time limited shut off switches.
- Replace aging old appliances, TVs and VCRs when needed, with energy efficient models.

(v) **Cooling**

A huge amount of energy is wasted in cooling. Following cooling measures can be taken to conserve energy:

- We should open windows at night, to bring cool air inside.
- Windows should be closed during daytime.
- West facing windows should be shaded. A whole house fan can be used to draw cool night air into the house.
- An evaporative cooler should be installed.
- Use room air conditioning only where needed and install energy efficient models.
- Cooling in air conditioned houses should be maintained at 25°F.
- Regular cleaning of filter in air conditioning systems and cleaning of condenser conserve energy.

**(B) Energy conservation at community level**

Energy conservation is a very sensitive issue throughout the world. In a society where money and especially saving of financially advantageous options are available to us, we should follow the following measures to reduce energy consumption-

Notes

- All unnecessary lights should be turned off especially when conference rooms etc. are not in use.
- Energy uses should be minimized during peak demand hours.
- Set computers, monitors, photocopiers and other business equipments to their energy saving mode. Turn them off during long idle hours such as lunch breaks.
- Skylights should be used for warehouses.
- Ensure that offices having air conditions have proper windows and all doors are closed when the air conditioner is in use.

(i) **Use of renewable energy resources**

Alternative resources i.e. renewable energy sources should be used in place of non-renewable energy sources e.g. solar energy, biogas, wind energy etc. Energy audits of homes, buildings, hotels and factories should be done at regular interval.

Demonstration of projects involving the introduction of appropriate, renewable solar technologies at the community level like solar pumps for water purification and irrigation of lawns, play grounds, gardens, community centres, as well as solar energy for cooking and heating should promoted. Projects involving wind-generated energy for community and municipal needs should be demonstrated to the whole community. Demonstration of biogas programmes (see lesson 30) is also required to tell people for the efficient used of it. Collaborative community/ academic research and development in order to produce low-cost, sustainable energy options should be given priority.

Environment friendly public transport system should be promoted to reduce the use of individual motorized transport. For a single purpose minimum number of vehicles should be used. It will be also helpful in reducing $CO_2$ emission.

**(ii) Energy conservation at community level for housing complexes**

We require energy for all kinds of work. Cooking, lighting, cooling, transportation etc. But often the amount of energy which we use is comparatively much less than the amount of energy which is wasted. As the energy sources are fast depleting, it is necessary for us to save energy. At the community level following measures can be used:

- Installation of photoelectric controls or timers should be used to make sure that outdoor lighting is sufficient during the day. Open area or yard area lightings should be switched off after sunrise and again switched on only after sun sets. Tube lights in common area and staircase landings should be reduced and twin tubelight should be replaced by one tube light. Number of electrical lighting points could be reduced to one point per room. All additional fittings may be removed permanently or switched off.
- Water pumps should be switched off during non-peak utility hours.

- Elevators/lifts should be used for going up beyond three floors and for coming down the usage of lifts may be reduced. Whenever two elevators/lifts are provided in a building only single should be operated during "non-peak" hours. Do not allow children to play with elevators.
- Environmentally sustainable transport will promote more mileage less pollution by GHC gases.
- Conservation and sustainable use of water bodies, including watersheds, rivers barriers and coastal zones will be helpful in the energy conservation at community level.
- Training programme about energy efficient repairs should be organized to conserve energy at community level. Advocacy to remove subsidies to inefficient and polluting sources of energy should become essential. Locally manufactured, improved cook stoves should be introduced to reduce charcoal/fuel consumption.

### (C) Energy conservation in industry and other places

Energy conservation is the practice of decreasing the quantity of energy used. It may be achieved through efficient energy use, in which case energy use is decreased while achieving a similar outcome, or by reduced consumption of energy services. At different places such as factories, business centres, transportation sector and construction activities, it can be saved in the following ways:

(i) **At factories and business centres including shops**

(a) **Auditing**

Regular monitoring and audit of energy consumption results in energy conservation.

(b) **Process modification**

Process modification means replacement of old and more energy consuming processes by the new energy efficient processes. Old factories should now employ process modification.

(c) **Improved measuring instruments**

We can use new technologies and energy efficient instruments and processes to conserve energy.

(d) **Energy loss reduction**

A lot of energy is wasted everyday. We can reduce energy loss by using following measures, for example: thermal insulation of fuel tanks can be done, Ceramic fiber sealing of furnaces, electrical tracing of liquid fuel lines instead of conventional steam heating.

(e) **Light load reduction**

A significant amount of energy can be saved by reducing light load. Bulbs have been replaced by tube lights. Nowadays CFLs have proved very helpful in reducing energy needs for lighting purposes.

Notes

**(D) Energy conservation in transportation sector**

Transportation includes all vehicles used for personal or freight transportation. Do you know of the energy used in this sector, approximately 65% is consumed by gasoline powered vehicles, primarily personally owned. Diesel powered transport (trains, merchant ship, heavy trucks etc.) consume about 20% and air traffic consumes most of the remaining 15%. Energy can be conserved in transportation by the following ways:

(i) **Reduction of fuel consumption**

Fuel consumption can be reduced in the following ways:

- Use public transportation as much as possible instead of using own vehicles.
- Car speed should be maintained as far as possible 50 to 60 km/hr.
- Do not use choke unless necessary, when choke is used, put it off as soon as engine is warmed up, if there is a starting trouble, press clutch to start the engine.)
- Avoid free frequent starts and stops to reduce fuel consumption. Release clutch pedal gradually and simultaneously press accelerator to racing and or jerking.
- Never race engine when declutched. Declutch fully when changing gears on clutch pedal because this increases clutch wear and fuel consumption.
- Do not run on hand brake and preferably install a warming light device. Apply brakes gradually as far as possible. Anticipate need for braking. Switch to lower gears on gradients (up/down) at the right time. All these will be helpful in reducing fuel consumption
- If possible it is always better to live near workplace.

(ii) **Fuel economy- maximizing behaviour**

Fuel economy maximizing behaviour describes techniques that drivers can use to optimize their automobile fuel economy. The energy in fuel consumed in driving is lost in many ways including engine inefficiency, aerodynamic drag, rolling friction and kinetic energy lost due to braking. They include following measures-

- moderate driving
- driving at lower speeds
- using cruise control (speed control or auto cruise controls speed and maintains steady speed by the driver).
- turning off a vehicles engine at stops rather than idling;
- a vehicles gas mileage decreases rapidly at highway speeds, normally above 55 miles per hour (though the exact number varies by vehicle).

Notes

## INTEXT QUESTIONS 31.2

1. Name any one purpose for which the community may install a solar pump.

2. Why should we replace the ordinary bulbs in our house by CFL bulbs?

3. Why should there be regular monitoring and energy audit at work place?

4. What is car pool and how can car pool help in conserving petrol?

## 31.5 CONCEPT OF ENERGY EFFICIENT BUILDINGS

### 31.5.1 Energy efficient devices

Day by day we see that the demand of energy is increasing all over the world and as the demand is increasing energy prices are also increasing. Therefore, it is very necessary to develop energy efficient devices to save energy.

Compact Fluorescent Lamps (CFL) replaced incandescent bulbs. Open utensils cooking have been replaced with pressurized steam cooking and of course solar cooking. Many energy efficient devices can be manufactured and many technologies can be used for energy conservation. In many industries older and inefficient equipment has been replaced by new and efficient ones.

Other energy efficient devices which can be used for energy conservation are diamond hot plate, PRP bullock cart, tubelight with electronic ballast device which helps in reducing energy consumption by limiting amount of electric current in an electric circuit. Diamond mono-block lathe, natural water cooler, improved crematoria etc. (Fig. 31.1 a, b, c)

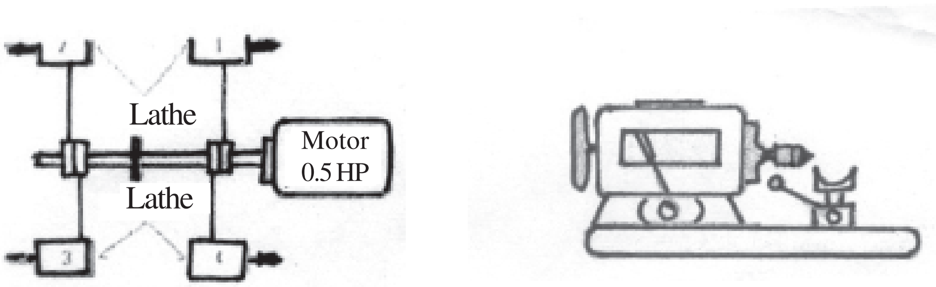



***Fig 31.1 (a):*** *Monoblock lathe (Q) consumes 80% less energy than conventional lathe (P)*

Natural water cooler is a safe drinking water device which works on the principle of "cooling by evaporation". No external source of energy such as electricity or ice is required.

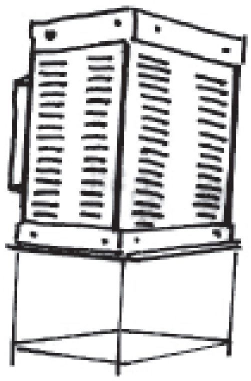
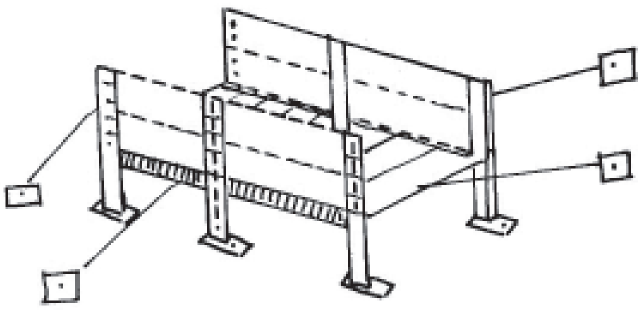


*Fig. 31.1 (b): Natural water cooler*

Promoted by government of Gujarat, India, improved crematoria are prefabricated cradle like iron structures desiged for proper acration for proper combustion. Consumption of wood for cremation is much reduced and consequently trees prevented from being axed.



| | | |
|---|---|---|
| 1. Side bars/plates | CI | 12 nos. |
| 2. Fire bar/plates | CI | 8 nos. |
| 3. Vertical Supports | MS | 6 nos. |
| 4. Horizon Suppports | MS | 2 nos. |
| 5. Nut/bolt sets | MS | 88 nos. |

*Fig. 31.1(c) Improved crematoria*

### 31.5.2 Energy efficient buildings

Many energy efficient houses were made to save energy. Different types of new technologies were used to make them energy efficient. Some examples of such energy efficient buildings are as follows-

(i) **Eco house**

It is a residential building and was constructed in mid seventies. It was equipped with solar cooker and a multifeed biogas plant. Rain water harvesting is also used in this house. A roof mounted wind generator was also contemplated but not installed. Following technologies were used in this house-

- Rainwater harvesting with underground cistern.
- Roof integrated solar water heater.

- Window mounted retractable solar cooker.
- Multifeed biogas plant, usable as septic tank, if required.
- Three different types of experimental roofs (hollow concrete tiles, Prefab brick jack arches, Madras terrace roof).
- Design for ventura (ventilation via inner courtyard). (Fig. 31.2)

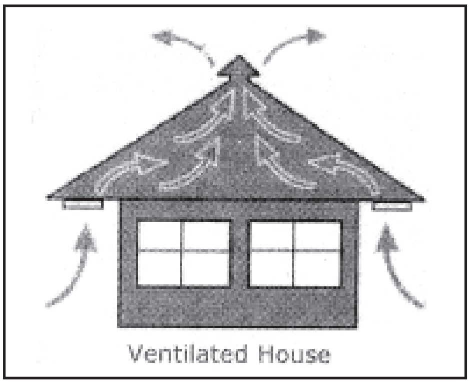



***Fig. 31.2:** Ventura system of using high and low pressure for sucking in cool air and pushing out hot air through roof ventilator*

(ii) **The Auroville visitors centre**

It is a public building constructed in Pondicherry 1989. Several cost effective and alternative technologies had matured by mid eighties. Attempts to integrate everything in a functional and pleasing environment was quite successful and won the Hassan Fathy International award in 1992. The following technologies and equipment were used during its construction.

- Compressed earth blocks
- Ferro-cement roof channels and building elements
- Solar chimneys
- Wind pump
- Water solar PV pump
- Wind generators
- Decentralized waste water system.

(iii) **Solar kitchen**

It is a community kitchen and constructed for preparing 2000 meals a day. This concept began to be implemented in 1994. Since solar energy is abundant in southern India, using steam as the heat transfer medium for preparing the meals was the obvious choice. Solar kitchen possesses the following features (Fig. 31.3)

- Compressed earth blocks

Notes

- 10m long ferro-cement roof channels
- Decentralized waste water system consisting of Imhoff tank (Fig. 31.4), baffled reactor and polishing pond (Fig. 31.5).
- Solar bowl concentrator of 15m diameter.
- Scheffler community cooker concentrator (Fig. 31.6).

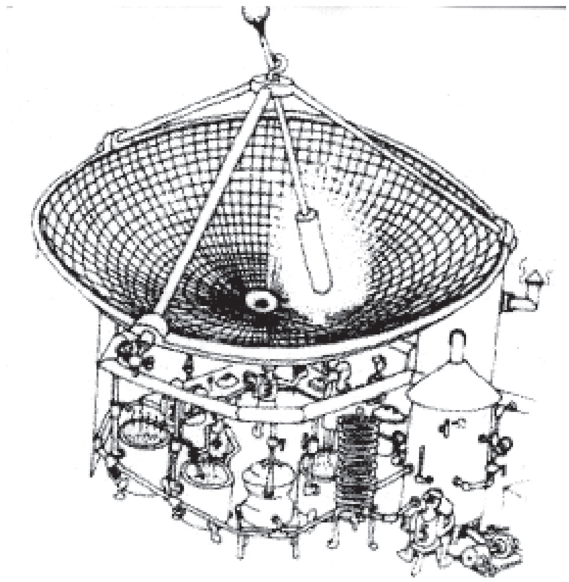


***Fig. 31.3:** Solar kitchen*

A collective kitchen for Auroville community, the solar kitchen has a big "solar-bowl" on its roof.

**Imhoff Tank** is a septic tank with improved technology for waste water treatment.

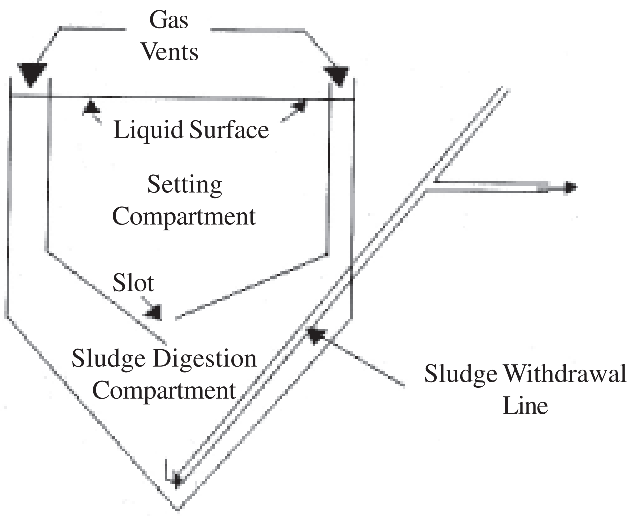



***Fig. 31.4:** Components of Imhoff tank*

Oscillatory baffled reactors are in demand in chemical and pharmaceutical industries for efficient use of reagents, solvents and energy. The waste produced is minimized.

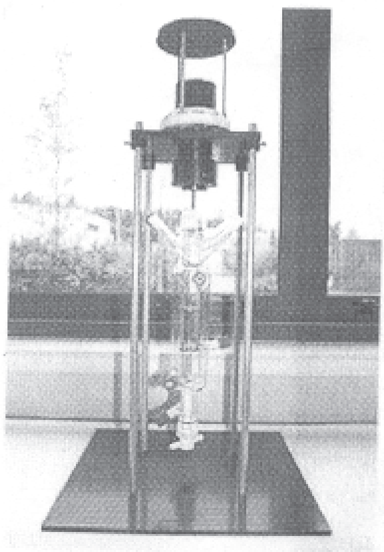


***Fig. 31.5:*** *Lab-scale batch OBR*

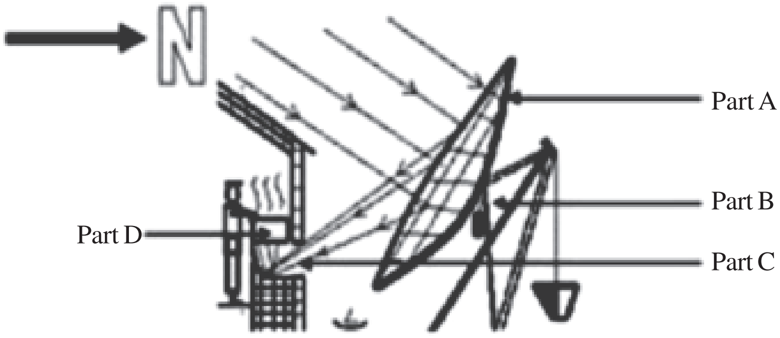



***Fig. 31.6:*** *Scheffler community cooker concentrator*

## INTEXT QUESTIONS 31.3

1. Expand CFL.

___

2. Name the equipment which uses wind as a source of energy at Auroville in Pondicherry.

___

3. What is the concept of an energy-efficient town?

___

## 31.6 CONCEPT OF ENERGY EFFICIENT NEW TOWNS

Energy conservation should be considered in any comprehensive land use planning process. A variety of heating sources like fuel oil, gas, wood, electricity, the sun and coal etc. are used in homes and business houses. This energy consumption and conservation of energy resources is the hot topic these days. Substantial economic savings can be realized through energy conservation.

Effective use of land could prove to be a good way of energy conservation. The design of the town should be such that developmental densities should be highest towards the centre of the town, which is served by municipal water and sewer. Outlying areas should have much less constructions.

A township can be oriented towards becoming eco-friendly only with the cooperation of the inhabitants. A township may have structures of echo-friendly architecture but unless the inhabitants resolve and practice energy conservation and eco-friendly way of life, the purpose of energy efficient town would be defeated. Education, eco-friendly behaviour and ecologically sound infrastructure can truly create energy efficient green towns.

(i) **Education**

Education is the best way of creating awareness for energy conservation. A branded programme can be created with a title and logo to imprint the conservation message on all township communities and documents. Energy conservation information should be present on the websites, local cable access station.

(ii) **Changing behaviour**

For right attitude towards energy conservation residents should be encouraged to drive less, walk and bike more by installing bike racks at public buildings.

A best way to conserve energy is to switch off the lights while leaving the room, shut down the computers when not in use. When appliances are not in use they should be unplugged. Lower the thermostats in the winter and raise them in the summer.

Household and business wastes should be recycled. It will positively result in energy conservation.

(iii) **Greening our infrastructures**

Light bulb should be replaced with the energy efficient compact fluorescent bulbs as they use 75% less energy and last up to ten times longer than standard incandescent bulbs.

Appliances and office equipments should be replaced with energy star rated units. It will lower energy usage and costs.

**Green buildings**

Currently this method is expensive. But energy conservation elements that are not higher in cost than that of traditional products can be used.

Besides, the setting, design and construction of buildings strongly influence the amount of energy needed for heating, cooling as well as for lighting. Proper design, building orientation, construction, and landscaping provide opportunities for energy conservation measures such as passive solar space, domestic hot water heating mechanism, natural lighting and photovoltaic electricity production. Besides, renewable energy sources should be used more instead of non-renewable energy sources. Other measures which will be helpful in energy conservation are as follows-

(i) Building designs and construction practices should promote energy conservation.

(ii) Use of renewable energy sources should be encouraged.

(iii) Facilitate energy conservation as related to local transportation needs.

(iv) Awareness should be raised among people for conservation of energy sources.

(v) Promote community self-sufficiency and independence with respect to energy levels and encourage the use of the least environmentally damaging sources of energy.

(vi) Town should minimize its energy consumption.

## 31.7 LIMITATIONS OF ALTERNATE SOURCE OF ENERGY

Once humans became aware about the limited stocks of fossil fuels, use of renewable sources of energy began. Currently the sources of energy in global use are:

(1) fossil fuels (coal, oil and natural gas) – 88%

(2) nuclear energy (Fission and fusion of atoms) – 05%

(3) other sources (hydel, tidal, wind, geothermal, solar, fuel wood, solid waste and biomass conversion energy) – 07%

You are well aware now about the limitations and impacts of use of fossil fuels. You have already learnt that the other sources mentioned above are renewable but they have their limitations as tabulated below:

***Table 31.1:*** *Limitations of alternate sources of energy*

| Source of energy/Fuel | Production | Advantages | Limitations |
|---|---|---|---|
| Nuclear energy | Nuclear fission (splitting of atom) and Nuclear fusion | No air pollution<br>Fuel efficient | • High cost of construction of nuclear plant.<br>• Fear of security and nuclear accidents.<br>• Problem of safe disposal of nuclear waste. |
| Hydel power or Hydropower | Dams built on river for electricity generation | World's hydro electricity capacity high | • Ecosystems behind dams disturbed.<br>• Human settlements up rooted for building dam.<br>• Habitat loss and consequent biodiversity loss.<br>• Developmental cost high.<br>• Fertile farmland lost and amount of nutrient rich silt on down river agricultural fields reduced. |
| Solar energy | From natural sunlight | Environment friendly<br>Ample or unlimited availability. | • Limited capacity for storage of sunlight.<br>• Cloud cover may man usefulness.<br>• Collecting equipment expensive. |
| Wind energy | Fans for directing winds in use from long for irrigation crops | • No pollution<br>• Available for free | • Not available everywhere or intermittently available.<br>• Fans of wind mills visual hazards for flying birds and aeroplanes (visual pollution). |
| Tidal energy | Harnessing tidal power by suitable structures | Free and clean | • Structures (plant) used for harnessing energy expensive.<br>• Plant disrupts natural flow of estuary and concentrate pollutants in the area. |
| Geothermal energy | Wells drilled to trap steam which powers electrical generators. Steam naturally produced from underground water which gets heated due to very high temperature that region. | Environment friendly | • Steam contains Hydrogen Sulphide ($H_2S$) having odour of rotten eggs.<br>• Minerals in the steam corrosive to pipe lines and equipment causing maintenance problems.<br>• Minerals in the water toxic to fish. |
| **Biomass**<br>(1) Fuel wood | Cutting trees for fuel wood and burning them straight away | Cheap so popular in under developed and developing countries | • Comparatively low level of energy.<br>• Bulky so difficult to transport.<br>• Burning wood causes air pollution.<br>• Destruction of forests to obtain fuel wood and so desertification.<br>• Release lot of fly ash. |
| (2) Biomass conversion | Obtaining energy from chemical energy. Stored in biomass (or live material). Burned directly for cooking or to produce electricity converted to ethanol or methane (biogas) | Renew able energy | • May lead to food shortage because nutrients not returned to soil from biomass.<br>• Growing maize for ethanol requires more energy expenditure than the amount of energy in the form of alcohol retrieved.<br>• Land for growing food used for growing biomass for conversion into fuel. |
| Solid waste | Waste sorted and burnable material separated | • Decreases cost of fresh disposal<br>• Reduces need for land fill sites | • Causes air pollution for burning releases $CO_2$ and other gases.<br>• Waste such as bleached paper and plastics have chlorine containing compounds which form. **dioxins** which are highly toxic and suspected to be carcinogenic. |

## 31.8 CONCEPT OF ENERGY AUDITING

Energy auditing is a systematic approach to monitor industrial energy consumption and to find out the sources of energy wastage. It consists of activities that seek to identify conservation opportunities before conducting or developing any energy saving program.

These audit programs are helpful in understanding and analyzing the energy utilization of any organization. The audit programmes help to identify and reduce energy wastage.

**The role of an energy audit**

The first and most important role of energy auditing is to identify the areas of energy consumption and to find the overuse for accessing the opportunity of saving energy. In this way, money can be saved for example during the audit of a factory; the employees of the factory can be trained for the use of energy saving equipment. Also they would be made aware of the need for energy conservation. So there is an attitudinal change for reducing energy use and energy wastage.

It is amply clear that energy auditing plays an important role in energy conservation.

**Analysis of energy use**

Analysis of energy use is done for identifying the areas of energy consumption. This analysis can be used in the review of management structures and procedures for controlling energy use. Sub meters can be installed in different plant locations to pinpoint the actual energy consumption per area. This data could be helpful in allocating energy use. With the help of this plant manager can list all the equipment used and the corresponding operating hours. This information can play an important part in creating spreadsheet information and the charts resulted by can prove useful for analysis.

## INTEXT QUESTIONS 31.4

1. What is the role of energy auditing?

   ______________________________________________

2. Give one limitation for each of following renewable source of energy (i) hydel power (ii) geothermal energy (iii) nuclear energy

   ______________________________________________

3. Give one advantage for each of the following renewable source of energy (i) solar (ii) biomass (iii) wind.

   ______________________________________________

## WHAT YOU HAVE LEARNT

- Impact of energy use on environment.Impact of energy use in daily life.
- The relationship between energy and economic development.

- The concept of energy conservation and how it could be saved at various levels.
- Different new energy efficient devices and technologies should be used to conserve energy.
- Methods of conservation of energy at individual and community levels and at industries.
- Awareness among people about the concept of energy conservation could prove very helpful.
- Some new technologies can be used while building construction to save the energy limitations of alternate sources of energy.
- By the help of auditing, we can come to know the areas where energy consumption is higher and accordingly we can plan to reduce the usage of energy to save it.

## TERMINAL EXERCISE

1. What is energy conservation and how can it be conserved at household level?
2. How is energy conservation possible while constructing buildings? Explain with the example of some energy efficient buildings.
3. What are energy efficient devices? Give some examples of such devices.
4. How can energy efficient towns be designed?
5. Define the concept of energy auditing. How can it be helpful in energy conservation?
6. Mention the advantages and limitations of using solar energy.
7. Write short note on importance of energy in your daily life.
8. Justify the statement that 'the energy is most important input for economic growth and human development.
9. How can we conserved energy at community level for housing complexes

## ANSWER TO INTEXT QUESTIONS

**31.1**

1. Depletion of energy; emission of green house gases due to burning of fossil fuel.
2. Cooking, heating and cooling of houses, TVs and computers and electrical gadgets. (Any other)
3. Population

**31.2**

1. Water purification/irrigation
2. They use much less electricity and last longer.
3. To reduce energy consumption/ to conserve energy.
4. Car pool is sharing of cars for going to work place. Much petrol is wasted when each person takes his own car to travel to same place.

**31.3**

1. Compact Fluorescent Lamp
2. Wind pump
3. A township whose constructions are eco-friendly and inhabitants are eager to conserve energy resources.

**31.4**

1. Systematic approach for monitoring industrial energy consumption and identifying sources of wastage.
2. (i) Ecosystems/human settlements disturbed/ habitat loss/ biodiversity loss/ high developmental cost (any one)

   (ii) Smelly $H_2S$ released/ pipelines corroded/ toxic minerals released. (any one)

   iii) High cost of construction of nuclear plant/ fear of security and nuclear accidents/ problem of safe disposal of nuclear waste. (any one)
3. (i) Environment friendly, cheap so popular in underdeveloped and developing countries

   (iii) No pollution, available for free.