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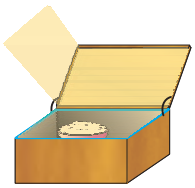
CHAPTER 14
Sources of Energy



In Class IX, we learnt that the total energy during a physical or chemical process is conserved. Why, then, do we hear so much about the energy crisis? If energy can neither be created nor destroyed, we should have no worries! We should be able to perform endless activities without thinking about energy resources!

This riddle can be solved if we recall what else we learnt about energy. Energy comes in different forms and one form can be converted to another. For example, if we drop a plate from a height, the potential energy of the plate is converted mostly to sound energy when it hits the ground. If we light a candle, the process is highly exothermic so that the chemical energy in the wax is converted to heat energy and light energy on burning. What other products are obtained when we burn a candle?

The total energy during a physical or chemical process remains the same but suppose we consider the burning candle again – can we somehow put together the heat and light generated along with the products of the reaction to get back the chemical energy in the form of wax?

Let us consider another example. Suppose we take 100 mL of water which has a temperature of 348 K (75°C) and leave it in a room where the temperature is 298 K (25°C). What will happen? Is there any way of collecting all the heat lost to the environment and making the water hot once it has cooled down?

In any example that we consider, we will see that energy, in the usable form, is dissipated to the surroundings in less usable forms. Hence, any source of energy we use, to do work, is consumed and cannot be used again.

14.1 WHAT IS A GOOD SOURCE OF ENERGY?

What can then be considered a good source of energy? We, in our daily lives, use energy from various sources for doing work. We use diesel to run our trains. We use electricity to light our street-lamps. Or we use energy in our muscles to cycle to school.

Activity 14.1

- List four forms of energy that you use from morning, when you wake up, till you reach the school.
- From where do we get these different forms of energy?
- Can we call these 'sources' of energy? Why or why not?

The muscular energy for carrying out physical work, electrical energy for running various appliances, chemical energy for cooking food or running a vehicle all come from some source. We need to know how do we select the source needed for obtaining the energy in its usable form.

Activity 14.2

- Consider the various options we have when we choose a fuel for cooking our food.
- What are the criteria you would consider when trying to categorise something as a good fuel?
- Would your choice be different if you lived
  (a) in a forest?
  (b) in a remote mountain village or small island?
  (c) in New Delhi?
  (d) lived five centuries ago?
- How are the factors different in each case?

After going through the two activities above, we can see that the particular source of energy, or fuel, we select for performing some work depends on many different factors. For example, while selecting a fuel, we would ask ourselves the following questions.

(i) How much heat does it release on burning?
(ii) Does it produce a lot of smoke?
(iii) Is it easily available?

Can you think of three more relevant questions to ask about a fuel?

Given the range of fuels we have today, what are the factors which would limit our choices when it comes to a particular task like cooking our food? Would the fuel selected also depend on the work to be done? For example, would we choose one fuel for cooking and another for heating the room in winter?

We could then say that a good source of energy would be one

- which would do a large amount of work per unit volume or mass,
- be easily accessible,
- be easy to store and transport, and
- perhaps most importantly, be economical.

QUESTIONS

1. What is a good source of energy?
2. What is a good fuel?
3. If you could use any source of energy for heating your food, which one would you use and why?

14.2 CONVENTIONAL SOURCES OF ENERGY

14.2.1 Fossil Fuels

In ancient times, wood was the most common source of heat energy. The energy of flowing water and wind was also used for limited activities. Can you think of some of these uses? The exploitation of coal as a source of energy made the industrial revolution possible. Increasing industrialisation has led to a better quality of life all over the world. It has also caused the global demand for energy to grow at a tremendous rate. The growing demand for energy was largely met by the fossil fuels – coal and petroleum. Our technologies were also developed for using these energy sources. But these fuels were formed over millions of years ago and there are only limited reserves. The fossil fuels are non-renewable sources of energy, so we need to conserve them. If we were to continue consuming these sources at such alarming rates, we would soon run out of energy! In order to avoid this, alternate sources of energy were explored. But we continue to be largely dependent on fossil fuels for most of our energy requirements (Fig. 14.1).

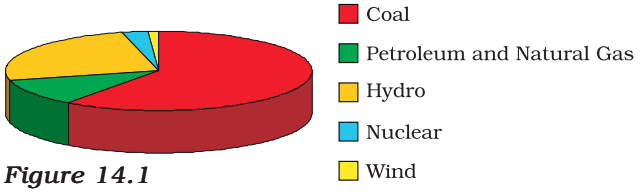


Figure 14.1
Pie-chart showing the major sources of energy for our requirements in India

Burning fossil fuels has other disadvantages too. We learnt in Class IX about the air pollution caused by burning of coal or petroleum products. The oxides of carbon, nitrogen and sulphur that are released on burning fossil fuels are acidic oxides. These lead to acid rain which affects our water and soil resources. In addition to the problem of air pollution, recall the green-house effect of gases like carbon dioxide.

Think it over

How would our lives change if we could no longer get electricity supply?
The availability of electrical energy to each individual in a country is one of the parameters to measure the growth of the country.

The pollution caused by burning fossil fuels can be somewhat reduced by increasing the efficiency of the combustion process and using various techniques to reduce the escape of harmful gases and ashes into the surroundings. Besides being used directly for various purposes – in gas stoves and vehicles, do you know fossil fuels are the major fuels used for generating electricity? Let us produce some electricity at our own small plant in the class and see what goes into producing our favourite form of energy.

Activity 14.3

- Take a table-tennis ball and make three slits into it.
- Put semicircular (⌓) fins cut out of a metal sheet into these slits.
- Pivot the tennis ball on an axle through its centre with a straight metal wire fixed to a rigid support. Ensure that the tennis ball rotates freely about the axle.

- Now connect a cycle dynamo to this.
- Connect a bulb in series.
- Direct a jet of water or steam produced in a pressure cooker at the fins (Fig. 14.2). What do you observe?

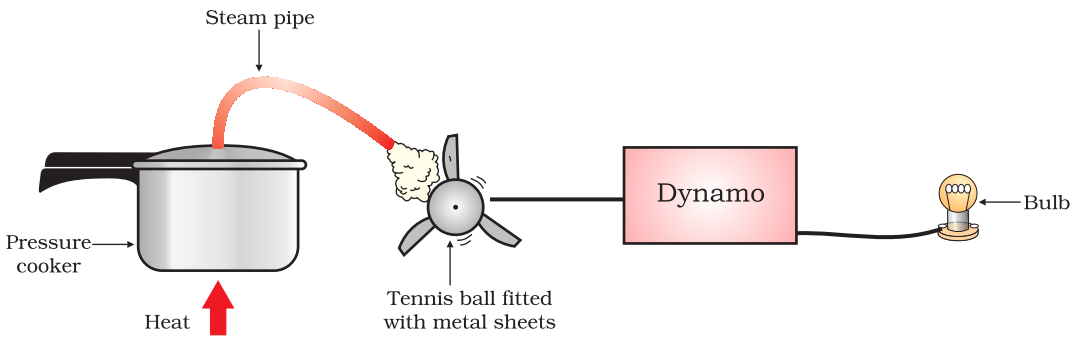


Figure 14.2 *A model to demonstrate the process of thermoelectric production*

This is our turbine for generating electricity. The simplest turbines have one moving part, a rotor-blade assembly. The moving fluid acts on the blades to spin them and impart energy to the rotor. Thus, we see that basically we need to move the fan, the rotor blade, with speed which would turn the shaft of the dynamo and convert the mechanical energy into electrical energy — the form of energy which has become a necessity in today's scenario. The various ways in which this can be done depends upon availability of the resources. We will see how various sources of energy can be harnessed to run the turbine and generate electricity in the following sections.

14.2.2 Thermal Power Plant

Large amount of fossil fuels are burnt every day in power stations to heat up water to produce steam which further runs the turbine to generate electricity. The transmission of electricity is more efficient than transporting coal or petroleum over the same distance. Therefore, many thermal power plants are set up near coal or oil fields. The term thermal power plant is used since fuel is burnt to produce heat energy which is converted into electrical energy.

14.2.3 Hydro Power Plants

Another traditional source of energy was the kinetic energy of flowing water or the potential energy of water at a height. Hydro power plants convert the potential energy of falling water into electricity. Since there are very few water-falls which could be used as a source of potential energy, hydro power plants are associated with dams. In the last century, a large number of dams were built all over the world. As we can see from Fig. 14.1, a quarter of our energy requirement in India is met by hydro power plants.

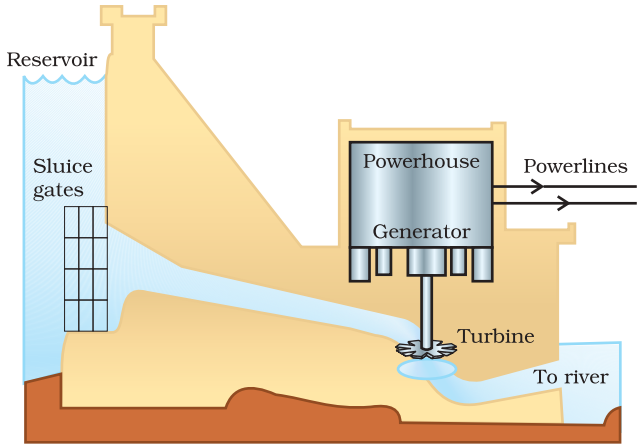


Figure 14.3
A schematic view of a hydro power plant

In order to produce hydel electricity, high-rise dams are constructed on the river to obstruct the flow of water and thereby collect water in larger reservoirs. The water level rises and in this process the kinetic energy of flowing water gets transformed into potential energy. The water from the high level in the dam is carried through pipes, to the turbine, at the bottom of the dam (Fig. 14.3). Since the water in the reservoir would be refilled each time it rains (hydro power is a renewable source of energy) we would not have to worry about hydro electricity sources getting used up the way fossil fuels would get finished one day.

But, constructions of big dams have certain problems associated with it. The dams can be constructed only in a limited number of places, preferably in hilly terrains. Large areas of agricultural land and human habitation are to be sacrificed as they get submerged. Large eco-systems are destroyed when submerged under the water in dams. The vegetation which is submerged rots under anaerobic conditions and gives rise to large amounts of methane which is also a green-house gas. It creates the problem of satisfactory rehabilitation of displaced people. Opposition to the construction of Tehri Dam on the river Ganga and Sardar Sarovar project on the river Narmada are due to such problems.

14.2.4 Improvements in the Technology for using Conventional Sources of Energy

Bio-Mass

We mentioned earlier that wood has been used as a fuel for a long time. If we can ensure that enough trees are planted, a continuous supply of fire-wood can be assured. You must also be familiar with the use of cow-dung cakes as a fuel. Given the large live-stock population in India, this can also assure us a steady source of fuel. Since these fuels are plant and animal products, the source of these fuels is said to be bio-mass. These fuels, however, do not produce much heat on burning and a lot of smoke is given out when they are burnt. Therefore, technological inputs to improve the efficiency of these fuels are necessary. When wood is burnt in a limited supply of oxygen, water and volatile materials present in it get removed and charcoal is left behind as the residue. Charcoal burns without flames, is comparatively smokeless and has a higher heat generation efficiency.

Similarly, cow-dung, various plant materials like the residue after harvesting the crops, vegetable waste and sewage are decomposed in the absence of oxygen to give bio-gas. Since the starting material is mainly cow-dung, it is popularly known as '*gobar-gas*'. Bio-gas is produced in a plant as shown in Fig. 14.4.

The plant has a dome-like structure built with bricks. A slurry of cow-dung and water is made in the mixing tank from where it is fed into the digester. The digester is a sealed chamber in which there is no oxygen. Anaerobic micro-organisms that do not require oxygen decompose or break down complex compounds of the cow-dung slurry. It takes a few days for the decomposition process to be complete and generate gases like methane, carbon dioxide, hydrogen and hydrogen sulphide. The bio-gas is stored in the gas tank above the digester from which they are drawn through pipes for use.

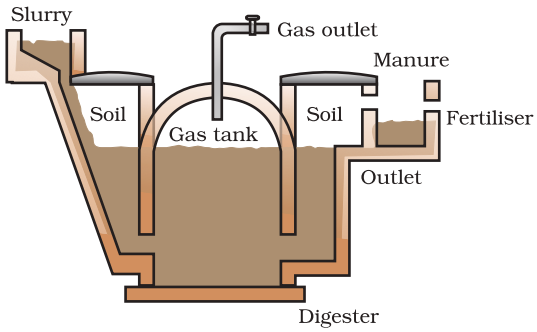


Figure 14.4
Schematic diagram of a bio-gas plant

Bio-gas is an excellent fuel as it contains up to 75% methane. It burns without smoke, leaves no residue like ash in wood, charcoal and coal burning. Its heating capacity is high. Bio-gas is also used for lighting. The slurry left behind is removed periodically and used as excellent manure, rich in nitrogen and phosphorous. The large-scale utilisation of bio-waste and sewage material provides a safe and efficient method of waste-disposal besides supplying energy and manure. Do you think that bio-mass is a renewable source of energy?

Wind Energy

We saw in Class IX how unequal heating of the landmass and water bodies by solar radiation generates air movement and causes winds to blow. This kinetic energy of the wind can be used to do work. This energy was harnessed by windmills in the past to do mechanical work. For example, in a water-lifting pump, the rotatory motion of windmill is utilised to lift water from a well. Today, wind energy is also used to generate electricity. A windmill essentially consists of a structure similar to a large electric fan that is erected at some height on a rigid support (Fig. 14.5).

To generate electricity, the rotatory motion of the windmill is used to turn the turbine of the electric generator. The output of a single windmill is quite small and cannot be used for commercial purposes. Therefore, a number of windmills are erected over a large area, which is known as wind energy farm. The energy output of each windmill in a farm is coupled together to get electricity on a commercial scale.

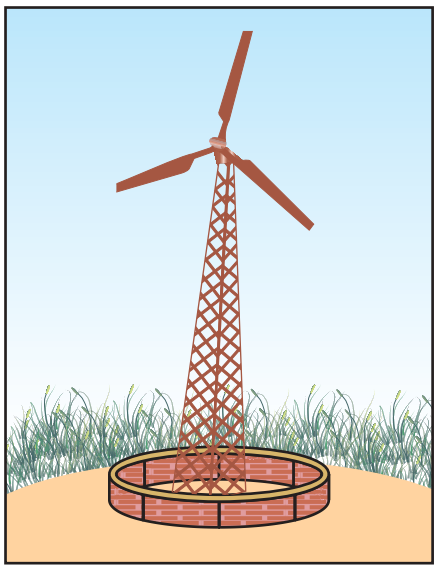


Figure 14.5 *A windmill*

Do You Know?

Denmark is called the country of 'winds'. More than 25% of their electricity needs are generated through a vast network of windmills. In terms of total output, Germany is the leader, while India is ranked fifth in harnessing wind energy for the production of electricity. It is estimated that nearly 45,000 MW of electrical power can be generated if India's wind potential is fully exploited. The largest wind energy farm has been established near Kanyakumari in Tamil Nadu and it generates 380 MW of electricity.

Wind energy is an environment-friendly and efficient source of renewable energy. It requires no recurring expenses for the production of electricity. But there are many limitations in harnessing wind energy. Firstly, wind energy farms can be established only at those places where wind blows for the greater part of a year. The wind speed should also be higher than 15 km/h to maintain the required speed of the turbine. Furthermore, there should be some back-up facilities (like storage cells) to take care of the energy needs during a period when there is no wind. Establishment of wind energy farms requires large area of land. For a 1 MW generator, the farm needs about 2 hectares of land. The initial cost of establishment of the farm is quite high. Moreover, since the tower and blades are exposed to the vagaries of nature like rain, Sun, storm and cyclone, they need a high level of maintenance.

QUESTIONS

1. What are the disadvantages of fossil fuels?
2. Why are we looking at alternate sources of energy?
3. How has the traditional use of wind and water energy been modified for our convenience?

14.3 ALTERNATIVE OR NON-CONVENTIONAL SOURCES OF ENERGY

With technological progress, our demand for energy increases day by day. Our life-styles are also changing, we use machines to do more and more of our tasks. Our basic requirements are also increasing as industrialisation improves our living standards.

Activity 14.4

- Find out from your grand-parents or other elders –
  (a) how did they go to school?
  (b) how did they get water for their daily needs when they were young?
  (c) what means of entertainment did they use?
- Compare the above answers with how you do these tasks now.
- Is there a difference? If yes, in which case more energy from external sources is consumed?

As our demand for energy increases, we need to look for more and more sources of energy. We could develop the technology to use the available or known sources of energy more efficiently and also look to new sources of energy. Any new source of energy we seek to exploit would need specific devices developed with that source in mind. We shall now look at some of the latest sources of energy that we seek to tap, and the technology designed to capture and store energy from that source.

Think it over!

Some people say that if we start living as our ancestors, this would conserve energy and our ecosystem. Do you think this idea is feasible?

14.3.1 Solar Energy

The Sun has been radiating an enormous amount of energy at the present rate for nearly 5 billion years and will continue radiating at that rate for about 5 billion years more. Only a small part of solar energy reaches the outer layer of the earth's atmosphere. Nearly half of it is absorbed while passing through the atmosphere and the rest reaches the earth's surface.

Do You Know?

India is lucky to receive solar energy for greater part of the year. It is estimated that during a year India receives the energy equivalent to more than 5,000 trillion kWh. Under clear (cloudless) sky conditions, the daily average varies from 4 to 7 kWh/m^2. The solar energy reaching unit area at outer edge of the earth's atmosphere exposed perpendicularly to the rays of the Sun at the average distance between the Sun and earth is known as the solar constant. It is estimated to be approximately 1.4 kJ per second per square metre or 1.4 kW/m^2.

Activity 14.5

- Take two conical flasks and paint one white and the other black. Fill both with water.
- Place the conical flasks in direct sunlight for half an hour to one hour.
- Touch the conical flasks. Which one is hotter? You could also measure the temperature of the water in the two conical flasks with a thermometer.
- Can you think of ways in which this finding could be used in your daily life?

A black surface absorbs more heat as compared to a white or a reflecting surface under identical conditions. Solar cookers (Fig. 14.6) and solar water heaters use this property in their working. Some solar cookers achieve a higher temperature by using mirrors to focus the rays of the Sun. Solar cookers are covered with a glass plate. Recall what we have learnt about the green-house effect. Does this explain why a glass plate is used?

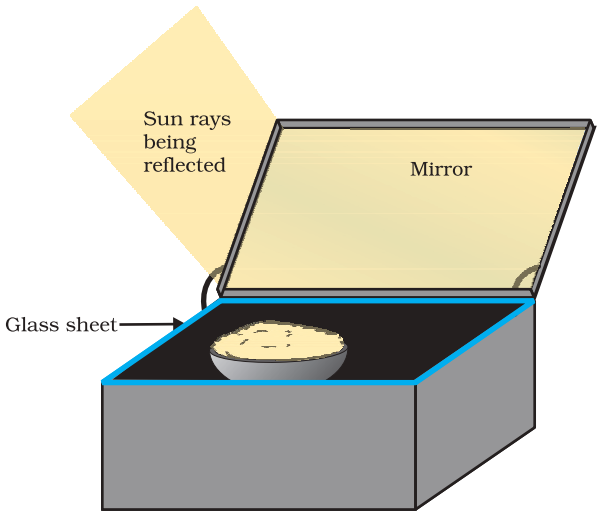


Figure 14.6 *A solar cooker*

Activity 14.6

- Study the structure and working of a solar cooker and/or a solar water-heater, particularly with regard to how it is insulated and maximum heat absorption is ensured.

- Design and build a solar cooker or water-heater using low-cost material available and check what temperatures are achieved in your system.
- Discuss what would be the advantages and limitations of using the solar cooker or water-heater.

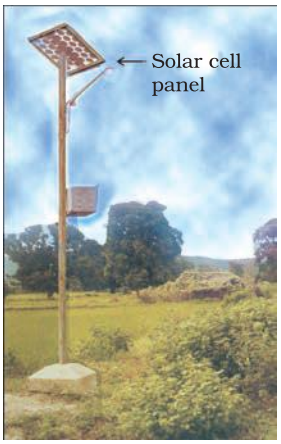


Figure 14.7
A solar cell panel

It is easy to see that these devices are useful only at certain times during the day. This limitation of using solar energy is overcome by using solar cells that convert solar energy into electricity. A typical cell develops a voltage of 0.5–1 V and can produce about 0.7 W of electricity when exposed to the Sun. A large number of solar cells are, combined in an arrangement called solar cell panel (Fig. 14.7) that can deliver enough electricity for practical use.

The principal advantages associated with solar cells are that they have no moving parts, require little maintenance and work quite satisfactorily without the use of any focussing device. Another advantage is that they can be set up in remote and inaccessible hamlets or very sparsely inhabited areas in which laying of a power transmission line may be expensive and not commercially viable.

Silicon, which is used for making solar cells, is abundant in nature but availability of the special grade silicon for making solar cells is limited. The entire process of manufacture is still very expensive, silver used for interconnection of the cells in the panel further adds to the cost. In spite of the high cost and low efficiency, solar cells are used for many scientific and technological applications. Artificial satellites and space probes like Mars orbiters use solar cells as the main source of energy. Radio or wireless transmission systems or TV relay stations in remote locations use solar cell panels. Traffic signals, calculators and many toys are fitted with solar cells. The solar cell panels are mounted on specially designed inclined roof tops so that more solar energy is incident over it. The domestic use of solar cells is, however, limited due to its high cost.

14.3.2 Energy from the Sea

Tidal Energy

Due to the gravitational pull of mainly the moon on the spinning earth, the level of water in the sea rises and falls. If you live near the sea or ever travel to some place near the sea, try and observe how the sea-level changes during the day. This phenomenon is called high and low tides and the difference in sea-levels gives us tidal energy. Tidal energy is harnessed by constructing a dam across a narrow opening to the sea. A turbine fixed at the opening of the dam converts tidal energy to electricity. As you can guess, the locations where such dams can be built are limited.

Wave Energy

Similarly, the kinetic energy possessed by huge waves near the sea-shore can be trapped in a similar manner to generate electricity. The waves are generated by strong winds blowing across the sea. Wave energy would be a viable proposition only where waves are very strong. A wide variety of devices have been developed to trap wave energy for rotation of turbine and production of electricity.

Ocean Thermal Energy

The water at the surface of the sea or ocean is heated by the Sun while the water in deeper sections is relatively cold. This difference in temperature is exploited to obtain energy in ocean-thermal-energy conversion plants. These plants can operate if the temperature difference between the water at the surface and water at depths up to 2 km is 20 K (20°C) or more. The warm surface-water is used to boil a volatile liquid like ammonia. The vapours of the liquid are then used to run the turbine of generator. The cold water from the depth of the ocean is pumped up and condense vapour again to liquid.

The energy potential from the sea (tidal energy, wave energy and ocean thermal energy) is quite large, but efficient commercial exploitation is difficult.

14.3.3 Geothermal Energy

Due to geological changes, molten rocks formed in the deeper hot regions of earth's crust are pushed upward and trapped in certain regions called 'hot spots'. When underground water comes in contact with the hot spot, steam is generated. Sometimes hot water from that region finds outlets at the surface. Such outlets are known as hot springs. The steam trapped in rocks is routed through a pipe to a turbine and used to generate electricity. The cost of production would not be much, but there are very few commercially viable sites where such energy can be exploited. There are number of power plants based on geothermal energy operational in New Zealand and United States of America.

14.3.4 Nuclear Energy

How is nuclear energy generated? In a process called nuclear fission, the nucleus of a heavy atom (such as uranium, plutonium or thorium), when bombarded with low-energy neutrons, can be split apart into lighter nuclei. When this is done, a tremendous amount of energy is released if the mass of the original nucleus is just a little more than the sum of the masses of the individual products. The fission of an atom of uranium, for example, produces 10 million times the energy produced by the combustion of an atom of carbon from coal. In a nuclear reactor designed for electric power generation, such nuclear 'fuel' can be part of a self-sustaining fission chain reaction that releases energy at a controlled rate. The released energy can be used to produce steam and further generate electricity.

Do You Know?

In a nuclear fission, the difference in mass, Δm, between the original nucleus and the product nuclei gets converted to energy E at a rate governed by the famous equation,

$$E = \Delta m\, c^2,$$

first derived by Albert Einstein in 1905, where c is the speed of light in vacuum. In nuclear science, energy is often expressed in units of electron volts (eV): 1 eV = 1.602 $\times 10^{-19}$ joules. It is easy to check from the above equation that 1 atomic mass unit (u) is equivalent to about 931 mega electron volts (MeV) of energy.

Nuclear power reactors located at Tarapur (Maharashtra), Rana Pratap Sagar (Rajasthan), Kalpakkam (Tamil Nadu), Narora (UP), Kakrapar (Gujarat) and Kaiga (Karnataka) have the installed capacity of less than 3% of the total electricity generation capacity of our country. However, many industrialised countries are meeting more than 30% of their electrical power needs from nuclear reactors.

The major hazard of nuclear power generation is the storage and disposal of spent or used fuels – the uranium still decaying into harmful subatomic particles (radiations). Improper nuclear-waste storage and disposal result in environmental contamination. Further, there is a risk of accidental leakage of nuclear radiation. The high cost of installation of a nuclear power plant, high risk of environmental contamination and limited availability of uranium makes large-scale use of nuclear energy prohibitive.

Nuclear energy was first used for destructive purposes before nuclear power stations were designed. The fundamental physics of the fission chain reaction in a nuclear weapon is similar to the physics of a controlled nuclear reactor, but the two types of device are engineered quite differently.

Do You Know?

Nuclear fusion

Currently all commercial nuclear reactors are based on nuclear fission. But there is another possibility of nuclear energy generation by a safer process called nuclear fusion. Fusion means joining lighter nuclei to make a heavier nucleus, most commonly hydrogen or hydrogen isotopes to create helium, such as

$$^{2}H + {}^{2}H \rightarrow {}^{3}He (+ n)$$

It releases a tremendous amount of energy, according to the Einstein equation, as the mass of the product is little less than the sum of the masses of the original individual nuclei.

Such nuclear fusion reactions are the source of energy in the Sun and other stars. It takes considerable energy to force the nuclei to fuse. The conditions needed for this process are extreme – millions of degrees of temperature and millions of pascals of pressure.

The hydrogen bomb is based on thermonuclear fusion reaction. A nuclear bomb based on the fission of uranium or plutonium is placed at the core of the hydrogen bomb. This nuclear bomb is embedded in a substance which contains deuterium and lithium. When the nuclear bomb (based on fission) is detonated, the temperature of this substance is raised to 10^{7} K in a few microseconds. The high temperature generates sufficient energy for the light nuclei to fuse and a devastating amount of energy is released.

Activity 14.7

- Discuss in class the question of what is the ultimate source of energy for bio-mass, wind and ocean thermal energy.
- Is geothermal energy and nuclear energy different in this respect? Why?
- Where would you place hydro electricity and wave energy?

QUESTIONS

1. What kind of mirror – concave, convex or plain – would be best suited for use in a solar cooker? Why?
2. What are the limitations of the energy that can be obtained from the oceans?
3. What is geothermal energy?
4. What are the advantages of nuclear energy?

14.4 ENVIRONMENTAL CONSEQUENCES

We have studied various sources of energy in the previous sections. Exploiting any source of energy disturbs the environment in some way or the other. In any given situation, the source we would choose depends on factors such as the ease of extracting energy from that source, the economics of extracting energy from the source, the efficiency of the technology available and the environmental damage that will be caused by using that source. Though we talk of 'clean' fuels like CNG, it would be more exact to say that a particular source is cleaner than the other. We have already seen that burning fossil fuels causes air pollution. In some cases, the actual operation of a device like the solar cell may be pollution-free, but the assembly of the device would have caused some environmental damage. Research continues in these areas to produce longer lasting devices that will cause less damage throughout their life.

Activity 14.8

- Gather information about various energy sources and how each one affects the environment.
- Debate the merits and demerits of each source and select the best source of energy on this basis.

QUESTIONS

1. Can any source of energy be pollution-free? Why or why not?
2. Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?

14.5 HOW LONG WILL AN ENERGY SOURCE LAST US?

We saw earlier that we cannot depend on the fossil fuels for much longer. Such sources that will get depleted some day are said to be exhaustible sources or non-renewable sources of energy. On the other hand, if we manage bio-mass by replacing the trees we cut down for fire-wood, we can be assured of a constant supply of energy at a particular rate. Such energy sources that can be regenerated are called renewable sources of energy.

Renewable energy is available in our natural environment, in the form of some continuing or repetitive currents of energy, or is stored in such large underground reservoirs that the rate of depletion of the reservoir because of extraction of usable energy is practically negligible.

Activity 14.9

- Debate the following two issues in class.
  (a) The estimated coal reserves are said to be enough to last us for another two hundred years. Do you think we need to worry about coal getting depleted in this case? Why or why not?
  (b) It is estimated that the Sun will last for another five billion years. Do we have to worry about solar energy getting exhausted? Why or why not?
- On the basis of the debate, decide which energy sources can be considered (i) exhaustible, (ii) inexhaustible, (iii) renewable and (iv) non-renewable. Give your reasons for each choice.

QUESTIONS

1. Name two energy sources that you would consider to be renewable. Give reasons for your choices.
2. Give the names of two energy sources that you would consider to be exhaustible. Give reasons for your choices.

What you have learnt

- Our energy requirements increase with our standard of living.
- In order to fulfil our energy requirements, we try to improve the efficiency of energy usage and also try and exploit new sources of energy.
- We also need to look for new sources of energy because the conventional sources of energy like fossil fuels are in danger of getting exhausted soon.
- The energy source we select would depend on factors like the ease and cost of extracting energy from the source, the efficiency of the technology available for using that source of energy and the environmental impact of using that source.
- Many of the sources ultimately derive their energy from the Sun.

EXERCISES

1. A solar water heater cannot be used to get hot water on
   (a) a sunny day. (b) a cloudy day.
   (c) a hot day. (d) a windy day.

2. Which of the following is not an example of a bio-mass energy source?
   (a) wood (b) *gobar-gas*
   (c) nuclear energy (d) coal
3. Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the Sun's energy?
   (a) geothermal energy (b) wind energy
   (c) nuclear energy (d) bio-mass.
4. Compare and contrast fossil fuels and the Sun as direct sources of energy.
5. Compare and contrast bio-mass and hydro electricity as sources of energy.
6. What are the limitations of extracting energy from—
   (a) the wind? (b) waves? (c) tides?
7. On what basis would you classify energy sources as
   (a) renewable and non-renewable?
   (b) exhaustible and inexhaustible?
   Are the options given in (a) and (b) the same?
8. What are the qualities of an ideal source of energy?
9. What are the advantages and disadvantages of using a solar cooker? Are there places where solar cookers would have limited utility?
10. What are the environmental consequences of the increasing demand for energy? What steps would you suggest to reduce energy consumption?

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CHAPTER 15
Our Environment

We have heard the word 'environment' often being used on the television, in newspapers and by people around us. Our elders tell us that the 'environment' is not what it used to be earlier; others say that we should work in a healthy 'environment'; and global summits involving the developed and developing countries are regularly held to discuss 'environmental' issues. In this chapter, we shall be studying how various components in the environment interact with each other and how we impact the environment.

15.1 ECO-SYSTEM — WHAT ARE ITS COMPONENTS?

All organisms such as plants, animals, microorganisms and human beings as well as the physical surroundings interact with each other and maintain a balance in nature. All the interacting organisms in an area together with the non-living constituents of the environment form an ecosystem. Thus, an ecosystem consists of biotic components comprising living organisms and abiotic components comprising physical factors like temperature, rainfall, wind, soil and minerals.

For example, if you visit a garden you will find different plants, such as grasses, trees; flower bearing plants like rose, jasmine, sunflower; and animals like frogs, insects and birds. All these living organisms interact with each other and their growth, reproduction and other activities are affected by the abiotic components of ecosystem. So a garden is an ecosystem. Other types of ecosystems are forests, ponds and lakes. These are natural ecosystems while gardens and crop-fields are human-made (artificial) ecosystems.

Activity 15.1

- You might have seen an aquarium. Let us try to design one.
- What are the things that we need to keep in mind when we create an aquarium? The fish would need a free space for swimming (it could be a large jar), water, oxygen and food.
- We can provide oxygen through an oxygen pump (aerator) and fish food which is available in the market.

- If we add a few aquatic plants and animals it can become a self-sustaining system. Can you think how this happens? An aquarium is an example of a human-made ecosystem.
- Can we leave the aquarium as such after we set it up? Why does it have to be cleaned once in a while? Do we have to clean ponds or lakes in the same manner? Why or why not?

We have seen in earlier classes that organisms can be grouped as producers, consumers and decomposers according to the manner in which they obtain their sustenance from the environment. Let us recall what we have learnt through the self sustaining ecosystem created by us above. Which organisms can make organic compounds like sugar and starch from inorganic substances using the radiant energy of the Sun in the presence of chlorophyll? All green plants and certain bacteria which can produce food by photosynthesis come under this category and are called the producers.

Organisms depend on the producers either directly or indirectly for their sustenance? These organisms which consume the food produced, either directly from producers or indirectly by feeding on other consumers are the consumers. Consumers can be classed variously as herbivores, carnivores, omnivores and parasites. Can you give examples for each of these categories of consumers?

- Imagine the situation where you do not clean the aquarium and some fish and plants have died. Have you ever thought what happens when an organism dies? The microorganisms, comprising bacteria and fungi, break-down the dead remains and waste products of organisms. These microorganisms are the decomposers as they break-down the complex organic substances into simple inorganic substances that go into the soil and are used up once more by the plants. What will happen to the garbage, and dead animals and plants in their absence? Will the natural replenishment of the soil take place, even if decomposers are not there?

Activity 15.2

- While creating an aquarium did you take care not to put an aquatic animal which would eat others? What would have happened otherwise?
- Make groups and discuss how each of the above groups of organisms are dependent on each other.
- Write the aquatic organisms in order of who eats whom and form a chain of at least three steps. [ ] → [ ] → [ ]
- Would you consider any one group of organisms to be of primary importance? Why or why not?

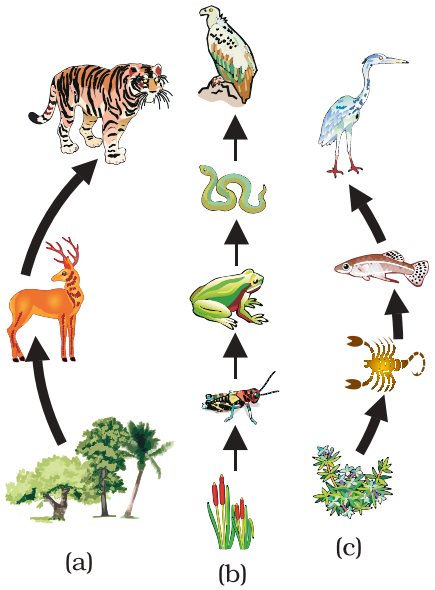

Figure 15.1
Food chain in nature (a) in forest, (b) in grassland and (c) in a pond

15.1.1 Food Chains and Webs

In Activity 15.4 we have formed a series of organisms feeding on one another. This series or organisms taking part at various biotic levels form a food chain (Fig. 15.1).

Each step or level of the food chain forms a trophic level. The autotrophs or the producers are at the first trophic level. They fix up the solar energy and make it available for heterotrophs or the consumers. The herbivores or the primary consumers come at the second, small carnivores or the secondary consumers at the third and larger carnivores or the tertiary consumers form the fourth trophic level (Fig. 15.2).

We know that the food we eat acts as a fuel to provide us energy to do work. Thus the interactions among various components of the environment involves flow of energy from one component of the system to another. As we have studied, the autotrophs capture the energy present in sunlight and convert it into chemical energy. This energy supports all the activities of the living world. From autotrophs, the energy goes to the heterotrophs and decomposers. However, as we saw in the previous Chapter on 'Sources of Energy', when one form of energy is changed to another, some energy is lost to the environment in forms which cannot be used again. The flow of energy between various components of the environment has been extensively studied and it has been found that –

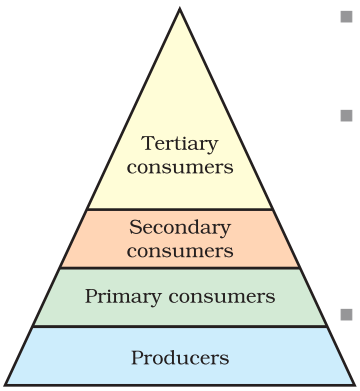

Figure 15.2
Trophic levels

- The green plants in a terrestrial ecosystem capture about 1% of the energy of sunlight that falls on their leaves and convert it into food energy.
- When green plants are eaten by primary consumers, a great deal of energy is lost as heat to the environment, some amount goes into digestion and in doing work and the rest goes towards growth and reproduction. An average of 10% of the food eaten is turned into its own body and made available for the next level of consumers.
- Therefore, 10% can be taken as the average value for the amount of organic matter that is present at each step and reaches the next level of consumers.
- Since so little energy is available for the next level of consumers, food chains generally consist of only three or four steps. The loss of energy at each step is so great that very little usable energy remains after four trophic levels.
- There are generally a greater number of individuals at the lower trophic levels of an ecosystem, the greatest number is of the producers.
- The length and complexity of food chains vary greatly. Each organism is generally eaten by two or more other kinds of organisms which in turn are eaten by several other organisms. So instead of a straight line food chain, the relationship can be shown as a series of branching lines called a food web (Fig. 15.3).

From the energy flow diagram (Fig. 15.4), two things become clear. Firstly, the flow of energy is unidirectional. The energy that is captured by the autotrophs does not revert back to the solar input and the energy which passes to the herbivores does not come back to autotrophs. As it moves progressively through the various trophic levels it is no longer available to the previous level. Secondly, the energy available at each trophic level gets diminished progressively due to loss of energy at each level.

Another interesting aspect of food chain is how unknowingly some harmful chemicals enter our bodies through the food chain. You have read in Class IX how water gets polluted. One of the reasons is the use of several pesticides and other chemicals to protect our crops from diseases and pests. These chemicals are either washed down into the soil or into the water bodies. From the soil, these are absorbed by the plants along with water and minerals, and from the water bodies these are taken up by aquatic plants

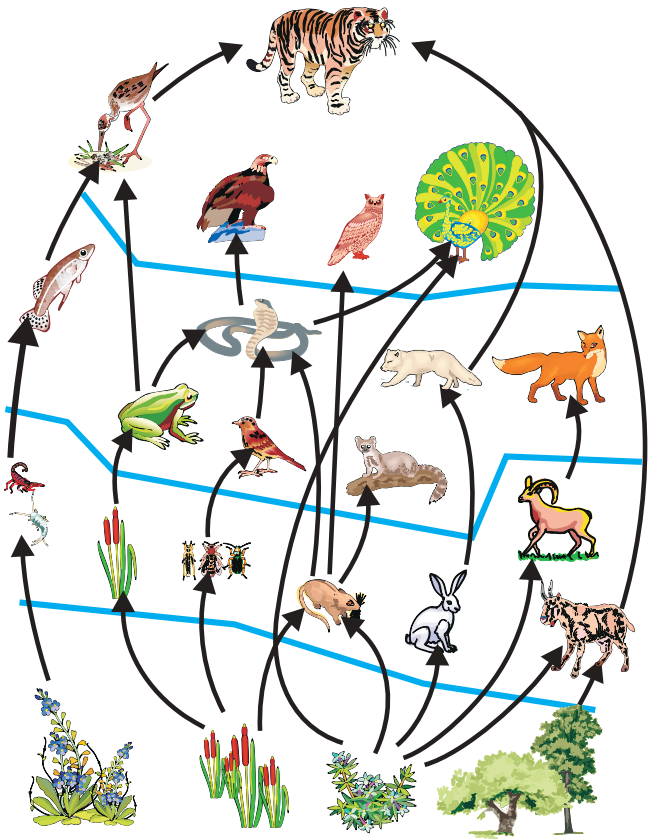

Figure 15.3 *Food web, consisting of many food chains*

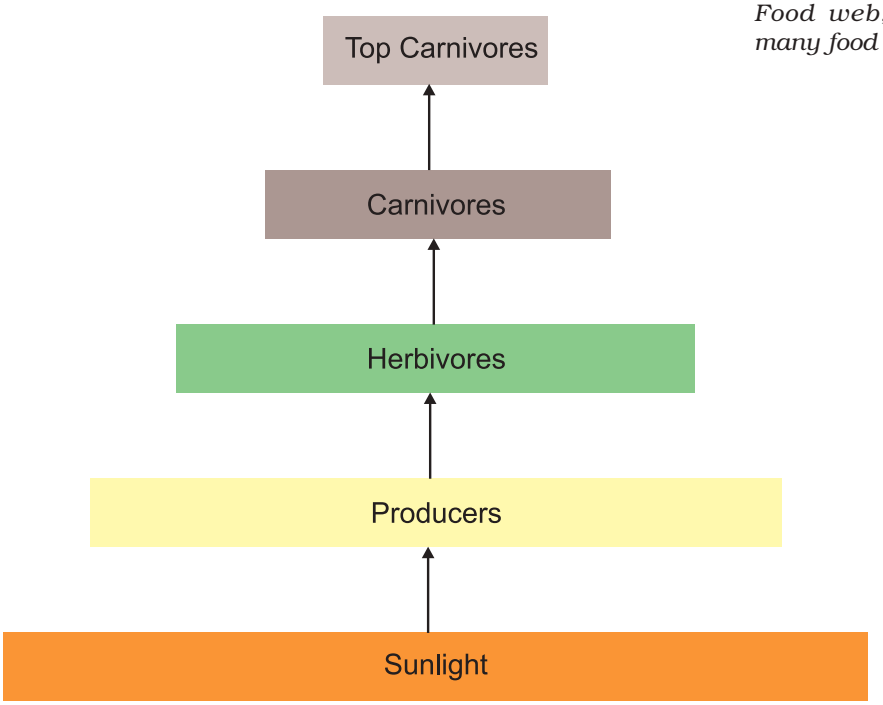

Figure 15.4 *Diagram showing flow of energy in an ecosystem*

and animals. This is one of the ways in which they enter the food chain. As these chemicals are not degradable, these get accumulated progressively at each trophic level. As human beings occupy the top level in any food chain, the maximum concentration of these chemicals get accumulated in our bodies. This phenomenon is known as biological magnification. This is the reason why our food grains such as wheat and rice, vegetables and fruits, and even meat, contain varying amounts of pesticide residues. They cannot always be removed by washing or other means.

Activity 15.3

- Newspaper reports about pesticide levels in ready-made food items are often seen these days and some states have banned these products. Debate in groups the need for such bans.
- What do you think would be the source of pesticides in these food items? Could pesticides get into our bodies from this source through other food products too?
- Discuss what methods could be applied to reduce our intake of pesticides.

QUESTIONS

1. What are trophic levels? Give an example of a food chain and state the different trophic levels in it.
2. What is the role of decomposers in the ecosystem?

15.2 HOW DO OUR ACTIVITIES AFFECT THE ENVIRONMENT?

We are an integral part of the environment. Changes in the environment affect us and our activities change the environment around us. We have already seen in Class IX how our activities pollute the environment. In this chapter, we shall be looking at two of the environmental problems in detail, that is, depletion of the ozone layer and waste disposal.

15.2.1 Ozone Layer and How it is Getting Depleted

Ozone (O_3) is a molecule formed by three atoms of oxygen. While O_2, which we normally refer to as oxygen, is essential for all aerobic forms of life. Ozone, is a deadly poison. However, at the higher levels of the atmosphere, ozone performs an essential function. It shields the surface of the earth from ultraviolet (UV) radiation from the Sun. This radiation

is highly damaging to organisms, for example, it is known to cause skin cancer in human beings.

Ozone at the higher levels of the atmosphere is a product of UV radiation acting on oxygen (O_2) molecule. The higher energy UV radiations split apart some moleculer oxygen (O_2) into free oxygen (O) atoms. These atoms then combine with the molecular oxygen to form ozone as shown—

$$O_2 \xrightarrow{UV} O + O$$

$$O + O_2 \rightarrow \underset{\text{(Ozone)}}{O_3}$$

The amount of ozone in the atmosphere began to drop sharply in the 1980s. This decrease has been linked to synthetic chemicals like chlorofluorocarbons (CFCs) which are used as refrigerants and in fire extinguishers. In 1987, the United Nations Environment Programme (UNEP) succeeded in forging an agreement to freeze CFC production at 1986 levels. It is now mandatory for all the manufacturing companies to make CFC-free refrigerators throughout the world.

Activity 15.4

- Find out from the library, internet or newspaper reports, which chemicals are responsible for the depletion of the ozone layer.
- Find out if the regulations put in place to control the emission of these chemicals have succeeded in reducing the damage to the ozone layer. Has the size of the hole in the ozone layer changed in recent years?

15.2.2 Managing the Garbage we Produce

In our daily activities, we generate a lot of material that are thrown away. What are some of these waste materials? What happens after we throw them away? Let us perform an activity to find answers to these questions.

Activity 15.5

- Collect waste material from your homes. This could include all the waste generated during a day, like kitchen waste (spoilt food, vegetable peels, used tea leaves, milk packets and empty cartons), waste paper, empty medicine bottles/strips/bubble packs, old and torn clothes and broken footwear.
- Bury this material in a pit in the school garden or if there is no space available, you can collect the material in an old bucket/ flower pot and cover with at least 15 cm of soil.
- Keep this material moist and observe at 15-day intervals.
- What are the materials that remain unchanged over long periods of time?
- What are the materials which change their form and structure over time?
- Of these materials that are changed, which ones change the fastest?

We have seen in the chapter on 'Life Processes' that the food we eat is digested by various enzymes in our body. Have you ever wondered why the same enzyme does not break-down everything we eat? Enzymes are specific in their action, specific enzymes are needed for the break-down of a particular substance. That is why we will not get any energy if we try to eat coal! Because of this, many human-made materials like plastics will not be broken down by the action of bacteria or other saprophytes. These materials will be acted upon by physical processes like heat and pressure, but under the ambient conditions found in our environment, these persist for a long time.

Substances that are broken down by biological processes are said to be biodegradable. How many of the substances you buried were biodegradable? Substances that are not broken down in this manner are said to be non-biodegradable. These substances may be inert and simply persist in the environment for a long time or may harm the various members of the eco-system.

Activity 15.6

- Use the library or internet to find out more about biodegradable and non-biodegradable substances.
- How long are various non-biodegradable substances expected to last in our environment?
- These days, new types of plastics which are said to be biodegradable are available. Find out more about such materials and whether they do or do not harm the environment.

QUESTIONS

1. Why are some substances biodegradable and some non-biodegradable?
2. Give any two ways in which biodegradable substances would affect the environment.
3. Give any two ways in which non-biodegradable substances would affect the environment.

Visit any town or city, and we are sure to find heaps of garbage all over the place. Visit any place of tourist interest and we are sure to find the place littered with empty food wrappers. In the earlier classes we have talked about this problem of dealing with the garbage that we generate. Let us now look at the problem a bit more deeply.

Activity 15.7

- Find out what happens to the waste generated at home. Is there a system in place to collect this waste?
- Find out how the local body (*panchayat*, municipal corporation, resident welfare association) deals with the waste. Are there mechanisms in place to treat the biodegradable and non-biodegradable wastes separately?
- Calculate how much waste is generated at home in a day.
- How much of this waste is biodegradable?
- Calculate how much waste is generated in the classroom in a day.
- How much of this waste is biodegradable?
- Suggest ways of dealing with this waste.

Activity 15.8

- Find out how the sewage in your locality is treated. Are there mechanisms in place to ensure that local water bodies are not polluted by untreated sewage.
- Find out how the local industries in your locality treat their wastes. Are there mechanisms in place to ensure that the soil and water are not polluted by this waste?

Improvements in our life-style have resulted in greater amounts of waste material generation. Changes in attitude also have a role to play, with more and more things we use becoming disposable. Changes in packaging have resulted in much of our waste becoming non-biodegradable. What do you think will be the impact of these on our environment?

Think it over

Disposable cups in trains

If you ask your parents, they will probably remember a time when tea in trains was served in plastic glasses which had to be returned to the vendor. The introduction of disposable cups was hailed as a step forward for reasons of hygiene. No one at that time perhaps thought about the impact caused by the disposal of millions of these cups on a daily basis. Some time back, *kulhads*, that is, disposable cups made of clay, were suggested as an alternative. But a little thought showed that making these *kulhads* on a large scale would result in the loss of the fertile top-soil. Now disposable paper-cups are being used. What do you think are the advantages of disposable paper-cups over disposable plastic cups?

Activity 15.9

- Search the internet or library to find out what hazardous materials have to be dealt with while disposing of electronic items. How would these materials affect the environment?
- Find out how plastics are recycled. Does the recycling process have any impact on the environment?

QUESTIONS

1. What is ozone and how does it affect any ecosystem?
2. How can you help in reducing the problem of waste disposal? Give any two methods.

What you have learnt

- The various components of an ecosystem are interdependent.
- The producers make the energy from sunlight available to the rest of the ecosystem.
- There is a loss of energy as we go from one trophic level to the next, this limits the number of trophic levels in a food-chain.
- Human activities have an impact on the environment.
- The use of chemicals like CFCs has endangered the ozone layer. Since the ozone layer protects against the ultraviolet radiation from the Sun, this could damage the environment.
- The waste we generate may be biodegradable or non-biodegradable.
- The disposal of the waste we generate is causing serious environmental problems.

EXERCISES

1. Which of the following groups contain only biodegradable items?
   (a) Grass, flowers and leather
   (b) Grass, wood and plastic
   (c) Fruit-peels, cake and lime-juice
   (d) Cake, wood and grass
2. Which of the following constitute a food-chain?
   (a) Grass, wheat and mango
   (b) Grass, goat and human

(c) Goat, cow and elephant

(d) Grass, fish and goat

3. Which of the following are environment-friendly practices?

(a) Carrying cloth-bags to put purchases in while shopping

(b) Switching off unnecessary lights and fans

(c) Walking to school instead of getting your mother to drop you on her scooter

(d) All of the above

4. What will happen if we kill all the organisms in one trophic level?

5. Will the impact of removing all the organisms in a trophic level be different for different trophic levels? Can the organisms of any trophic level be removed without causing any damage to the ecosystem?

6. What is biological magnification? Will the levels of this magnification be different at different levels of the ecosystem?

7. What are the problems caused by the non-biodegradable wastes that we generate?

8. If all the waste we generate is biodegradable, will this have no impact on the environment?

9. Why is damage to the ozone layer a cause for concern? What steps are being taken to limit this damage?