

Environmental Issues and Waste Management

# Water Pollution

# INTRODUCTION

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Water is a very important resource for all the living things as well as the environment. It sustains the lives of everything on the Earth's surface. In its purest form, water is tasteless, odourless and colourless (Freeman, 2007). Water molecules simply made up of one hydrogen atom and 2 oxygen atoms bonded by covalent bond. It exists in the form of solid, liquid and gas (vapour). However, this relatively simple molecule is very essential to every life and its importance even causes political disputes among nations. It is treasured yet it is taken for granted, and pollution of water is one of the sign of water being taken for granted by people.

Water pollution is defined as the addition of something to water which changes its natural qualities with substances which make it unfavourable for life (Wisdom, 1956 cited in Gopal and Agarwal, 2003). Water which constitutes 70 percent of Earth's surface is mainly oceans and sea (97%). The total volume of water on Earth is about 1.4 billion km<sup>3</sup>. The volume of freshwater resources is around 35 million km<sup>3</sup>, or about 2.5 percent of the total volume. Of these freshwater resources, about 24 million km<sup>3</sup> or 70 percent is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions while another about 30% exist as groundwater and only 0.03% are lakes and rivers (UN Water, 2014). This report will specifically cover only on freshwater pollution especially on rivers and lakes.

In sustaining development, fresh water ecosystem plays an important role and often becoming the limiting factor. Water which is readily available for exploitation by human is the center of so called development. Great civilization developed along river banks as these rivers provide water for industry, agricultures, aquaculture, method of transportation and etc. Yet, it is also the site for dumping sewage, industrial waste, and domestic waste as well as serving as catchment area for flood and run-off. Most of the rivers in the industrialized nations of the world are already polluted to a greater or lesser degree (Gopal and Agarwal, 2003).

Statistics by the United Nations Inter-Agency mechanisms on all freshwater related issues, including sanitations, UN Water stated that in developing countries, 70 percent of industrial waste is dumped untreated into waters where they pollute the usable water supply. The food sector contributes respectively 40 and 54 percent to

the production of organic water pollutants in high-income and low-income countries. Up to 90 % of wastewater in developing countries flow untreated into rivers, lakes and highly productive coastal zones, threatening health, food security and access to safe drinking and bathing water (UN Water, 2014).

While the development spiked, the issues of water pollution became more severe and even in rapidly developing countries, for example in China, the challenge of clean water is yet to be conquered. Factories and small-scaled industries along the banks of China's rivers simply dump their waste into the water. More than a quarter of the water that flows through China's seven major river systems and their tributaries is unfit even for industry or agriculture, much less human consumption (Economy and Starr, 2008). The Yellow River, one of the world's longest rivers, supplies water to more than 150 million people and 15 percent of China's agricultural land. Yet two-third of its water is considered unsafe to drink, and 10 percent is classified as sewage. In India, the whole 20 km stretch of Yamuna River between Wazirabad and Okhla is heavily polluted by sewage sludge and industrial waste. This 20 km stretch has water totally black with lot of Total Solids, both inorganic and organic, very high in Biological Oxygen Demand (BOD), has almost no dissolved oxygen (D.O) without flora and fauna, and therefore, acting as septic tank (Khan, Parveen and Untoo, 2003). The condition is no lesser in the western countries. River Thames, the pride of London was once called the Great Stink. During the mid-nineteenth century, London was plagued by cholera and tens of thousands of people died. It was agreed that the polluted River Thames, where the people of London drew their drinking water from, was the cause of the epidemic (Hansen, 2015). The pollution in River Thames worsened as the development along its river banks continued. In 1878 the pleasure steamship Princess Alice sunk in a river collision. Most of the 600 or so passengers who died did so because they were overpowered by a noxious cocktail of human and industrial filth before they could reach safety (Owen, 2005). Until 1950s, salmon become extinct from River Thames and the river is considered biologically dead.

In evaluating pollution, indicator is needed to ascertain the severity of the pollution. One of the indicators is the biological indicator of pollution. Certain species significant to the environment is used to evaluate the condition of the environment. The absence or presence of these species provides some guide to environmental

condition in the river (Khan, Parveen and Untoo, 2003). For example, salmon which disappeared from River Thames indicate the severity of the condition in the River Thames and triggers concerns that something has to be done to fix the situation. Another techniques developed is the Environment Impact Assessment (EIA) which have become the essential tools for the planning and management of riverine environment ( Vaas, 1999 cited in Khan, Parveen and Untoo, 2003). Biological Assessment of River Pollution is another tool used to assess the pollution of water. Serious study of the biological aspects of pollution were first began in Germany at an early date, and the result were first codified by Kolkwitz and Marsson (1908) who developed their well-known *Saprobien system* for the assessment of organic pollution (Liebmann,1951 cited in Khan, Parveen and Untoo, 2003). Later, Liebmann (1951) and Sramek-Hursack (1958) revised the system (Khan, Parveen and Untoo, 2003).

Pollution of water is a worldwide concern and the society is not only to reduce current pollution inputs, but also to restore the natural ecology of rivers and make them safe for people (Gopal and Agarwal, 2003). The story of Great Stink should never be repeated again especially as technologies had been so much better. Extensive effort and law enforcement are some of the action taken to improve the condition in River Thames. Nowadays, the once Great Stink is once again London's pride. More than 130 seals have been spotted in the Thames, according to the Zoological Society of London. Bottlenose dolphins have been seen upstream of London Bridge. And in summer 2005, the first sea horse was recorded in the Thames estuary in 30 years (Owen, 2005). It is the cleanest river flowing through major cities.

# CAUSES

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Most water pollution doesn't begin in the water itself. Virtually any human activity can have an effect on the quality of our water environment. When farmers fertilize the fields, the chemicals they use are gradually washed by rain into the ground water or surface waters nearby. Sometimes the causes of water pollution are quite surprising. Chemicals released by smokestacks (chimneys) can enter the atmosphere and then fall back to earth as rain, entering rivers and lakes and causing water pollution. That's called atmospheric deposition. Water pollution has many different causes and this is one of the reasons why it is such a difficult problem to solve.

## Sewage

One of the major causes of water pollution is sewage. Domestic households, industrial and agricultural practices produces wastewater that can cause pollution of many lakes and rivers. Sewage is the term used for wastewater that often contains faeces, urine and laundry waste. Since there are billions of people on Earth, so treating sewage is a big priority. Untreated sewage water in such areas can contaminate the environment and cause diseases.

**Table 1: Some of the Primary Constituents of Sewage from a City Sewage System**

Constituent	Potential Sources	Effects in Water
Oxygen-demanding substances	Mostly organic materials, particularly human feces	Consume dissolved oxygen
Refractory organics	Industrial wastes, household products	Toxic to aquatic life
Viruses	Human wastes	Cause diseases (possibly cancer)
Detergents	Household detergents	Toxic to aquatic life, prevent oil and grease removal
Phosphates	Detergents	Algal nutrients
Heavy Metals	Industrial wastes, chemical laboratories	Toxicity
Grease and Oil	Cooking, food processing, industrial wastes	Harmful to some aquatic life

As shown in Table 1, sewage from domestic, commercial, food processing, and industrial sources contains a wide variety of pollutants. Some of these pollutants are particularly oxygen-demanding substances. Sewage pollution is caused by several factors including failing and outdated infrastructure that is compounded by rapid development that paves over the farms, forests and wetlands that naturally soak up storm water. As a result, rain and snow that would have naturally drained into the ground or slowly run off the land into streams now gets diverted through culverts, often discharging directly into public sewage systems where it combines with sewage and domestic wastewater.

### **Industrial Waste**

Besides that, industrial wastes also can cause water pollution. Industries produce huge amount of waste which contains toxic chemicals and pollutants which can cause damage to us and environment. They contain pollutants, such as lead, mercury, sulphur, asbestos, nitrates and many other harmful chemicals. Many industries do not have proper waste management system and drain the waste in the fresh water which goes into rivers. The toxic chemicals have the capability to change the colour of water, increase the amount of minerals, also known as Eutrophication, change the temperature of water and pose serious hazard to water organisms.

### **Mining Activities**

In addition, mining activities also have high contribution in water pollution. Mining is the process of crushing the rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contains harmful chemicals and can increase the amount of toxic elements when mixed up with water which may result in health problems. Mining activities emit several metal waste and sulphides from the rocks and is harmful for the water.

### **Chemical fertilizers and Pesticides**

However, water pollution also can occur in the excessive using of chemical fertilizers and pesticides. Chemical fertilizers and pesticides are used by farmers to protect crops from insects and bacteria. They are useful for the plant growth. However when these chemicals are mixed up with water, it is harmful for plants and animals. When it rains, the chemicals mix up with rainwater and flow down into rivers and canals which pose serious damages for aquatic animals.

### **Urban development**

Urban development nowadays also can cause to water pollution. As population has grown, so has the demand for housing, food and cloth. As more cities and towns are developed, they have resulted in increased use of fertilizers to produce more food, soil erosion due to deforestation, increase in construction activities, inadequate sewer collection and treatment, landfills as more garbage is produced, increase in chemicals from industries to produce more materials.

### **Animal Waste**

Last factor of water pollution is animal wastes. The waste produce by animals is washed away into the rivers when it rains. It gets mixed up with other harmful chemicals and causes various water borne diseases like cholera, diarrhea, jaundice, dysentery and typhoid.

# EFFECTS

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## Environment

### Flooding

Water pollution can also result in flooding. Solid wastes piling up in waterways cause congestion in the flow of water from rivers, lakes, and oceans. Water then spills out of these waterways and onto areas where it is not meant to flow in quantity, and this often causes flooding. In turn people may lose their homes, or worse their lives.

### Water crisis

Water pollution has spread on the global scale uncontrollably. Many parts of the world are experiencing water crisis due to the polluted water resources especially the developing countries. The industrial growth has affected the water quality in many countries causing irreparable damage. It will need billions of dollars to repair the damage done on the environment especially the rivers. Many of the world's rivers are in the state of permanent damage especially those in the developing countries where industrial effluents are discharged into streams and eventually rivers without any proper treatment. Thermal pollution also occurs exclusively due to human activity, the dramatic changes in water temperature from the operations of industrial facilities. Physical pollution occurs when rivers, lakes and streams are used as dump.





**Figure 1:** The coast of the Philippines depicts water pollution, a problem affecting most of the world in one form or another.

## **Ecosystem**

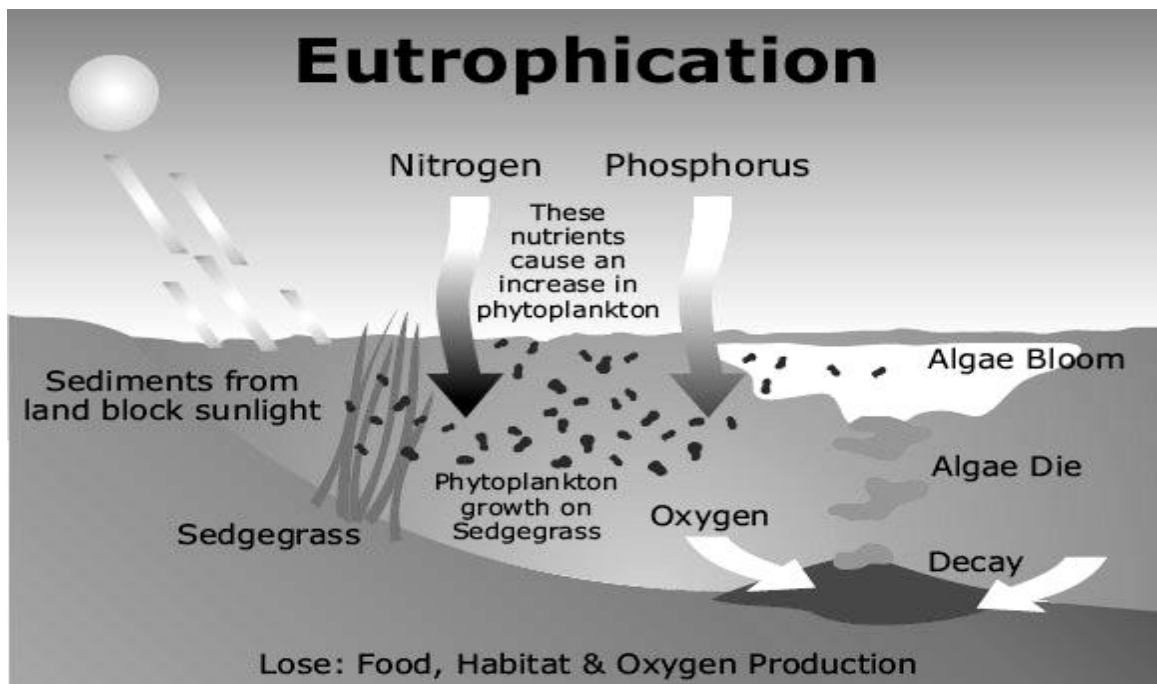
### **Death of animals**

Animal, including water animals die when water is poisoned for various reasons. Other animals are stressed and their populations are endangered. In a classic case of marine pollution in recent time, 16000 miles of a US coastline was affected by an oil spill. That water pollution caused a lot of damage and deaths of many animals. Over 8,000 animals (birds, turtles, mammals) were reported dead just 6 months after the spill, including many that are already on the endangered species list. Immediate impact on the wildlife includes oil-coated birds and sea turtles, mammal ingestion of oil, and dead or dying deep sea coral. Animals are also affected by solid waste thrown into water bodies, as they harm them in many ways.

## Eutrophication

Eutrophication is a process by which a body of water is depleted of its oxygen supply by decaying plant and algae. Other than decaying plant and algae, the discharge of various types of chemicals as nutrients such as phosphate and nitrates into the water body will enhance the process of eutrophication. The nutrients originate from municipal sewage, plant fertilizers, animal waste, storm water runoffs and others. The nutrients will result in excessive growth in the water due to supply of abundant nutrient in the form of nitrogen and phosphorus. Lack of oxygen will cause the death of other organisms, such as fish. The Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process.

For instance, at dead zones like the one found at the Gulf of Mexico occur when sewage discharge and fertilizer run off from farms, golf courses and lawns that enter surface waters (Walls and Thumma, n. d.). Intended to promote the growth of plants and fertilizers but also encourage the growth of algae.



**Figure 2:** Eutrophication process



**Figure 3:** Excessive growth of filamentous algae on the surface of water

## Human Health

We all drink water that comes from a source. This may be a lake or local river. In countries that have poor screening and purification practices, people often get water-borne disease outbreaks such as cholera and tuberculosis. Every year, there are an estimated 3–5 million cholera cases and 100,000–120,000 deaths due to cholera (“Effects of water pollution,” 2014). In developed countries, even where there are better purification methods, people still suffer from the health effects of water pollution. Toxins emitted by algae growth for instance, can cause stomach aches and rashes. Excess nitrogen in drinking water also poses serious risks to infants.

Other common water-borne diseases include typhoid, intestinal parasites, and diarrhea. Although these diseases are preventable by vaccination and curable by existing medicines, people continue to become sick largely due to the ongoing problem of water pollution caused by disease-carrying microorganisms. Diseases and other ailments may also be caused by non-organic matter like harmful

chemicals. Ingestion of water laced with such chemicals could result in physical deformities, organ failure, and even death.

For example, on Sept 1998, there was a contamination of ground water in Medak district of Andhra in India from different chemical industries which released poisonous chemicals. The ground water become greenish in colour and emitted foul smell. It caused dysentery, vomiting, jaundice and diarrhea and a number of deaths were reported (Ahluwalia and Sunita, 2006).

# SOLUTIONS AND CHALLENGES

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Solutions to the water pollution problems involved all level of the society, from the governments, both federal and state, local authorities, law enforcement, industrial community, domestic community and also individual member of the society. There is no simple solution to the problem but continuous effort from all parties will ensure better condition for the water ecosystem which been abused for as long as the history had been recorded.

## **Law Enforcement**

When the salmon disappeared from River Thames and the Mersey, series of Acts of Parliament were passed. Gas Works Clause Act of 1847 prohibited discharge of gas-work into rivers. The Salmon Fishing Act of 1861 and 1865 made it an offence to pollute salmon waters so as to kill the fish. In 1857, a Royal Commission on prevention of river pollution was set up and a few other Royal Commissions was also set up the following years (Whitton, 1975 cited in Khan, Parveen and Untoo, 2003). A few Acts of Parliaments were passed such as Drainage of Tide Premises Act, which gave industries the right, under certain conditions, to discharge effluents into sewers. Various other similar Acts of Parliament and government body was established around the world to protect and reduce water pollution. In United States of America, Environment Protection Agency (EPA) responsible for implementing environmental laws written by the Congress. The agency writes regulations and enforces them as well as setting standards which the states and tribes enforce to their own regulations (EPA, 2015).

## **Technology**

Pollution in river can be controlled by adopting various well-tried pollution abatement technologies (Khan, Parveen and Untoo, 2003). Methods of treating water or wastewater contaminated by heavy metals and various contaminants had been developed across the world. as such technology is the technique to remove arsenic from water. The As (III) ions are oxidized by using some chemical agents like chlorine, potassium permanganate and ozone. Next, the physico-chemical methods of coagulation-precipitation, adsorption, ion exchange, reverse osmosis, electrodialysis, membrane filtration, and so on are used to obtain arsenic-free water

(De and Maiti,2012). Back in those days when the River Thames was heavily polluted, Joseph Bazalgette developed sewerage system which improves the quality of the river significantly and reduce the cholera epidemic. Embankments were also created which narrows the river and thus increasing the flow, producing the 'scouring' effect which aided in the cleansing of the river (Hansen, 2015). Nowadays, sewage is treated before released into the river. London has five major sewage treatment plants with the size of a small town each which reduce the amount of untreated sewage into the river. Upgrades are planned for these plants which will further reduce the amount of untreated sewage into the river by 90 percent, allowing the river to flourish biologically (Hansen, 2015).

### **Awareness**

Water pollution issue like any other pollution issues is everyone's responsibilities. Awareness to preserve and conserve the water ecosystem should be raised in each individual. Various campaigns and incentives can be done to give the information related to water pollution to the community and encourage people to participate in any programmes or campaigns to improve water quality. For example, World Water Day is held annually on 22 March as a means of focusing attention on the importance of freshwater and advocating for the sustainable management of freshwater resources. An international day to celebrate freshwater was recommended at the 1992 United Nations Conference on Environment and Development (UNCED). The United Nations General Assembly responded by designating 22 March 1993 as the first World Water Day. Each year, World Water Day highlights a specific aspect of freshwater and is coordinated by one or more Member(s) on behalf of UN-Water (UN-Water, 2014). Every individuals can contributes to the improvement of water quality and reduce water pollution. Several steps can be taken to minimize water pollution.

1. Use water wisely. Do not keep the tap running when not in use. Also, we can reduce the amount of water we use in washing and bathing. If we all do this, we can significantly prevent water shortages and reduce the amount of dirty water that needs treatment.
2. Do not throw chemicals, oils, paints and medicines down the sink drain, or the toilet. In many cities, our local environment office can help with the disposal of

medicines and chemicals. Check with the local authorities if there is a chemical disposal plan for local residents.

3. Buy more environmentally safe cleaning liquids for use at home and other public places. They are less dangerous to the environment and we can also install water filters to help clean the water in our home.
4. Run the dishwasher or clothes washer only when we have a full load. This conserves electricity and water. Besides, we can minimize the use of pesticides, herbicides, fertilizers.
5. Do not dispose of these chemicals, motor oil, or other automotive fluids into the sanitary sewer or storm sewer systems. Both of them end at the river.
6. Help clean up litter in water-filled areas if living near a local body of water, there's a lot that can be done to help reduce pollution there. See if there's a group working to clean up local beaches, lakes, rivers or oceans. Many cities host clean-up days during which volunteers can come help clean up trash to purify local waterways.

### **Continuous monitoring**

Any effort of fixing the polluted water ecosystem is not a short-termed effort since development also never ceased to exist. A revived water ecosystem may become greater environmental disaster if it is not monitored and continuously protected. River Thames had been revived from its dark days and blooms with flora and fauna in its estuary. Yet, nowadays the condition is not better than the moment it is revived. Local agencies have warned people not to row, canoe or sail after heavy rainfall downstream of Teddington Lock, where the tidal river starts, because of health hazards. The Environment Agency said surveys of Thames water quality between 1999 and 2002 had shown that levels of micro-organisms with the potential to cause disease in humans increased around the times there were storm discharges into the river (Meikle, 2004). As a consequence of the increasing environmental pressures on water resources the Thames Region of the EA has developed a network of fixed, transportable and fully mobile Automatic Water Quality Monitoring Stations (AWQMS) (). The water quality is measured and monitored along the river for every 15 minutes. Continuous monitoring enables detection of pollution at any time, 24 hours per day, 365 days per year.

## Challenges

If there are solutions for the water pollution, it also has its challenges. Lack of awareness among the community is one of the challenges faced by any effort made to fight pollution. The **community does not realize the important of water in life and thus keep taking it for granted**. Lack of awareness in higher level of the community is very critical to the future of our natural resources such as water. Government with less interest to the water pollution problems will not only do nothing to fixed the problem, the situation may get worse as any exploitation effort on the water resources is permitted. In lower level of the community, **people do not realize what damage they are doing because they throw any chemicals in the sink drain** that can infect the water supply for everyone. Most water filtration systems aren't designed to remove medications, cosmetics, or the chemicals from many cleaning supplies and thus, wastewater released to the river is still polluted to some degree even after treatment.

However, a bigger challenge is there to be overcome. Continuous development, the initial cause of pollution never ceased and will continue to pollute the environment. Worse, when there is no rule of law implemented regarding the issues. Despite continuous effort to clear River Thames of its structure along its bank as well as on the river itself, new structures also emerges somewhere along the stretch. In some places, river is continued to be abused in the name of 'environmental protection'. The quest for renewable energy brings engineers to the hydraulic power station. Yet, dams and blockades disrupts the natural flow of the river, destroying its natural balances and ecosystem, it also cause flooding and destroy other ecosystem around the river.

Lastly, **effort to remedies the water pollution is costly** and also **requires energy/time** because a lot of time needed to clean the place if the place is more polluted as well as more energy is from the machine or the people involved.



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# Appendices

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Figure 1: 1<sup>st</sup> most Polluted River/Lakes in the world, Lake Karachay



Figure 2: 2<sup>nd</sup> most Polluted River/Lakes in the world, Matanza-Riachuelo River, New Mexico.



Figure 3: 3<sup>rd</sup> most Polluted River/Lakes in the world, Citarum River, west Java, Indonesia.