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BEVAE-181
ABILITY ENHANCEMENT COMPULSORY COURSE (AECC) ON ENVIRONMENTAL STUDIES

Block

3

ENVIRONMENTAL ISSUES AND CONCERNS

BLOCK 3 ENVIRONMENTAL ISSUES AND CONCERNS

In Block 2, we discussed in detail about the importance of various natural resources, their uses in socio-economic development and the effect of developmental activities on the environment. More importantly, the need to properly manage the natural resources and environmental conservation have led to the concept of environmental quality management and use of eco-friendly technologies. This Block, discusses the threats to biodiversity and its conservation in Unit 8. Unit 9, describe about the pollution of the environment and how human health is being affected by it . This is followed by Unit 10 on 'Waste Management' where we focus our discussion on solid waste management. With a wide exposure to various aspects of the environment in the previous units, it is quite appropriate now to know about various environmental issues which are a matter of concern for people across the national boundaries. Hence, Unit 11 discusses about global environmental issues.

Unit 8 Biodiversity: Threats and Conservation: This unit discusses the threats to biodiversity and its conservation and list various causes for biodiversity losses and their major impact on earth. This unit will also explain the need for biodiversity conservation for *in-situ* and *ex-situ* conservation of species.

Unit 9 Environmental Pollution and Hazards: This unit describes the pollution of environment and how human health is being affected by the environmental pollution. This unit will enable you to identify and list major types of pollutants that contaminate our air, water and soil. In this unit we will also understand and trace the pathways of major pollutants in the ecosystem, explains the reasons for high noise levels in the urban areas, and discusses the hazardous effects of radiations and the need for safeguards to prevent accidental release of radioactivity.

Unit 10 Waste Management: This Unit focuses the discussion on solid waste management. It defines and classifies the hazardous waste chemical and distinguishes them from toxic chemicals. This unit will also explain the pre-requisites of hazardous waste and management, compares and contrasts various methods for disposal of hazardous wastes, describe how hazardous waste is being disposed off presently in our country.

Unit 11 Global Environmental Issues: These issues have become topics of hot discussions at various forums in last few decades. Global issues are so named because their impacts and damages affect not only the countries that caused the problems but they go beyond their national boundaries and extend to the global scale. Also, the solutions to these issues require efforts at the international level. In this unit, we would discuss some global issues namely global warming and climate change, ozone layer depletion and acid rain. We have discussed the causes as well as the effects of these phenomena and some of the measures taken to deal with these issues at international level in the form of conventions and treaties. Broad features of such conventions and treaties have been briefly enumerated in the unit at appropriate places. In addition, some useful websites have also been listed for further relevant information.

UNIT 8

BIODIVERSITY : THREATS AND CONSERVATION

Structure

8.1 INTRODUCTION

Since 3.5 billion years ago when life began, about 500 million kinds of plants, animals and microorganisms have made earth their home. UN Convention on Biological Diversity says there are some 13 million species still living on earth of which 1.7 million species have been identified and described. We, however, do not have an exact number because there are many areas of the earth that are biologically unexplored, such as the tropical rain forests where majority of the living organisms live but are yet to be identified.

A few species naturally become extinct over time and it is believed that during certain periods of geological time, great numbers of species have been lost relatively quickly – on the scale of thousands of years. Scientists have documented five periods of mass extinctions since the emergence of life on this planet. It is thought that each of these episodes, during which a large fraction of all species were lost, was caused by a catastrophic natural event on earth. Growing human population, leading to over exploitation of biotic resources and habitat destruction, is responsible for today's exceptionally high extinction rates. Many scientists consider this as the sixth extinction episode.

Biotic diversity -the richness of life on earth -is like a common property or resource belonging to the whole human race. Therefore biodiversity conservation is a major concern worldwide. Conservationists are involved in global efforts to protect biodiversity. We should conserve the rich biodiversity of the earth for the posterity so that in future people can enjoy the richness of earth.

In this unit the two mechanisms for protection of biological diversity have been given special emphasis. Conservation of natural communities and populations in the wild is known as *in situ* or on site conservation. Nature reserves are also very important site of flora and fauna as they are conserved there in pristine state. The other strategy, where species are maintained in artificial conditions under human supervision, is known as *ex situ* or off-site conservation. Examples of *ex situ* conservation are the botanical gardens and zoological parks.

Expected Learning Outcomes

After completing the study of this unit you should be able to:

- list various causes of biodiversity losses and discuss its major impact on whole world;
- explain the need and concept of biodiversity conservation;
- enumerate the needs for *in-situ* conservation of species and the various measures and mechanisms;
- appreciate the need for *ex-situ* conservation of species and the various mechanisms that are involved in this process of conservation; and
- appreciate the importance of nature reserve in biodiversity conservation.

8.2 CAUSES OF BIODIVERSITY LOSS

The main causes of biodiversity loss include land-use changes, changing levels of atmospheric carbon dioxide, changing climate, biological invasion and nitrogen deposition (air pollution). The causes of biodiversity loss are many and varied, and often interrelated. You will study about these factors in detail in the following subsections.

8.2.1 Habitat Loss

Habitat refers to the area where species seek food, get shelter and reproduce. The greatest threat to wild plant and animal species is due to destruction or alteration of their habitat. If an animal's habitat is destroyed or disrupted, it must adapt to the new changes, move elsewhere or die. When it is forced out of its territory, and if it finds a suitable habitat there is a possibility that the habitat is already in use. Consequently, it must compete with the local population of the same species as well as other animals. The other option is that it must migrate into a marginal habitat where it may succumb to predation, starvation or disease. Some organisms such as pigeon, house sparrows, rodents (like rat and mice) and deer flourish in the modified habitats provided by human activities but many others do not.

Some habitats are more vulnerable to species extinction, these are called fragile habitats. **Coral reefs, oceanic islands and mountain tops are important fragile habitats.**

Box. 8.1: Case study 1: Fragile habitats

Coral Reefs

Coral reefs have been found to be particularly fragile as they are susceptible to a rise in water temperature, sea levels and the introduction of pollutants and sediments that change its water quality. Coral reef development is greatest in warm, shallow sun-drenched areas and it needs clean and clear water. Productivity is decreased, or even eliminated, in areas subject to dirty sediment-laden water. Coral growth is naturally very slow.

In 1992, about 10% of the earth's existing coral reefs were found to be irreparably damaged, while 30% were expected to suffer damage within the next 20 years. It is also expected that there may be a further 30% loss within the next 20-40 years if remedial action is not implemented. It is estimated that Tsunami, 2004 had caused considerable damage to the coral reefs of coastal areas of India, Sri Lanka and Thailand.

Oceanic Islands

Existing data shows that 75% of the recorded animal extinctions since 1600 have been on islands rather than in continental areas .Terrestrial species in isolated oceanic islands are more vulnerable to being wiped out than continental species. The reasons for species extinction on oceanic island are restricted ranges, threat from alien species and characteristics of island species.

Habitat Islands

Species in ecological islands or "habitat islands" (areas of habitat separated from other such areas by inhospitable environments that act as effective barriers to dispersal) are at greater risk of extinction. For instance, freshwater lakes – bodies of water surrounded by land – like real islands, suffer high rates of extinction due to habitat modification or the introduction of exotic invasive species. Among continental extinctions, at least 66% of species loss has been in aquatic habitats.

Biodiversity loss in lakes is further increased by the fact that isolated inland water bodies can also have a high species endemism, resulting in global extinctions when these species are lost.

Habitat destruction is recognised today as the most significant threat to global biodiversity and bears responsibility for much of the species loss worldwide. This includes:

- felling of forests for land use (e.g. clear felling for development, agriculture), large scale logging and small scale patchwork agriculture. Shifting cultivation alone is believed to be responsible for 70% of deforestation in Africa, 50% of deforestation in Asia, and 35% of forest loss in the America.

- destruction of mangrove sites for aquaculture
- mining and destruction of corals
- conversion of wetlands for land uses
- over-extraction of timber and fuel wood
- human-induced burning of habitats (e.g. forest firing for shifting cultivation and firing grasslands to improve fodder for cattle)
- damming of rivers
- siltation and sedimentation of freshwater bodies
- pollution also disturbs the natural habitat considerably. Industrial wastes cause severe impact, particularly on the aquatic habitats. For example, during the 1950s and 1960s, insecticides particularly chlorinated hydrocarbons (such as DDT), reduced the population levels of several birds such as the bald eagle and brown pelican.

In many countries there are very few pristine areas left that have not been modified in some way by humans. When habitats are not completely destroyed, they are fragmented into smaller patches, creating islands of habitats in a sea of development. Fragmentation exposes species to more light, wind and temperature effects than are natural, thus affecting the species survival as food and water sources are lost and few mates remain. In fragmented landscapes many species soon become isolated from others of their own kind resulting in inbreeding, loss of genetic diversity and local extinction.

More than three quarters of the species that are in danger of extinction today are due to the destruction of their forest habitats. A large number of these species are from the tropics, where human population growth has been most explosive and habitats have been destroyed most rapidly. Tropical rain forests cover a mere 7 per cent of the earth's surface, yet they house about three quarters of the total species. Today these forests are being destroyed at an alarming rate.

8.3 HUMAN–WILD LIFE CONFLICT

People use some plant and animal species at a greater rate than the species can replace themselves. Nine of the world's major ocean fisheries are declining because of too much fishing as well as water pollution and habitat destruction, e.g. southern bluefin tuna, the Atlantic halibut and the Pacific and Atlantic salmon. Current logging rates threaten to eliminate mahogany and many other tree species that take many years to grow and mature.

The $10 billion-a-year global market in wildlife – for pets, folk medicines, gourmet foods, decorative objects and other uses – threatens elephants and rhinos, sea horses and colourful corals, tropical plants and birds, and bears, pandas and tigers.

8.3.1 Selective Destruction of Species

The selective destruction of one species of an existing fauna can produce equally unfortunate results. The perfect demonstration of unexpected consequences of such selective destruction can be explained to you by the example of Passenger pigeon (Fig. 8.1). The Passenger pigeon (*Ectopistes migratorius*) was probably most abundant bird on earth as recently as the middle of the nineteenth century. Their flocks darkened the sky during migration, and one such flock alone was 400 km long and had no less than two billion birds. So huge was their numbers that the branches of trees would break under the weight of the perching birds. It took hours for the flocks to pass through a place. There used to be as many as 90 nests per tree throughout a stretch of forest of about 5 km width and 67 km length. In 1871, an estimated 136 million passenger pigeons nested in a 2,200 sq. km area of central Wisconsin, USA. An immense tonnage of droppings fertilised the forests where passenger pigeons roosted. Today there is not even a single passenger pigeon on the earth. You must be wondering why this extinction occurred. This happened because millions of passenger pigeons were killed for food every year.

Fig.8.1: Passenger pigeon a lesson learnt but too late.

8.3.2 Domestication of Selective Species

Humans have taken care of the living beings which are useful to them through extensive breeding programmes, to derive maximum benefit of their products. During the process, the species have lost certain useful characteristics so much so that these forms cannot survive on their own in nature. A very good example is corn, which is pampered so much by human that if it is left on its own, it cannot survive.

Today human has large herds of domestic animals. These animals can also play a significant part in the reduction of animal populations by overgrazing the land, thus destroying the vegetation on which both they and the wild animals depend. The native wildlife of a particular area is capable of utilising the native plant life much more efficiently than introduced domestic cattle, and is thus much less likely to convert fertile areas into deserts.

The other important parameter is that the domestic cattle are carriers of several diseases which they can transmit to wild animals. For example, the steady rehabilitation of the Great Indian Rhinoceros was seriously hampered by the rinderpest disease which they contracted from the local domestic cattle.

Several years ago, a hillside in Mexico was being ploughed when a few alert scientists discovered a previously unknown species of wild corn – *Zea diploperennis* that only grew on that hill and was found nowhere else. These corn plants are perennial whereas the domestic varieties of corn are annuals. Moreover, the wild corn is resistant to many diseases that infest domestic varieties. The species was thus saved and it is now being used to breed and improve new domestic varieties.

8.3.3 Use of Pesticides

Pesticides harm insect pollinators, including managed honeybee populations, which can in turn reduce crop yields. Runoff seeping into rivers, lakes and coastal environments can produce negative impacts on entire aquatic ecosystems.

Several pesticides banned in the United States are still exported to developing countries such as DDT, DDE and PCBs. These substances mimic or interface with normal hormones in living organisms. Reproductive

abnormalities have been found in alligators, terns, salmon and gulls exposed to high levels of chemicals from pesticides and animal hormones in their environment.

8.3.4 Global Climate Change

Substantial evidence demonstrates that people are contributing to measurable changes in the global climate, threatening life. By burning fossil fuels such as oil, natural gas and coal and by burning trees, we have dramatically increased the amount of CO_2 in the atmosphere. While scientists do not know the exact effects of increased CO_2, they predict that it will lead to higher overall global temperatures, increasing sea levels, and changes in climate patterns.

The changed atmospheric conditions that result from global warming could create greater numbers of intense storms and prolonged droughts. On the other hand, the expected speed of climate changes coupled with direct loss of natural habitat may prevent some species from adapting quickly enough. They are likely to become extinct, locally or more broadly, and their roles in natural systems will be lost forever.

SAQ 1

a) What are the demerits of domestication of selective animals? How can it destroy biodiversity?

b) The perfect example of selective destruction is
   i) Great Indian Rhinoceros
   ii) Alligators
   iii) Passenger pigeon
   iv) Sea gulls

c) The main reasons for animal species extinction at the current high rates are
   i) Habitat destruction
   ii) Hunting
   iii) Over harvesting from the wild
   iv) Domestication of selective species of animals

d) Habitat modification may occur due to
   i) Fragmentation of original habitat
   ii) Pollution
   iii) Changes in species composition due to humans
   iv) All of the above

8.4 POACHING OF WILD LIFE

The hunting and export of excessive numbers of certain animal species is another important factor leading to dangerous reductions in numbers. There are three main types of hunting:

i) **Commercial hunting** – in which the animals are killed for profit from sale of their furs, bones or other parts;

ii) **Subsistence hunting** – the killing of animals to provide food for survival; and

iii) **Sport hunting** – the killing of animals for recreation. Although subsistence hunting was once a major cause of extinction of some species, it has now declined sharply in most areas. Sport hunting is now closely regulated in most countries; species are endangered only when protective regulation does not exist or are not enforced.

On a worldwide basis, commercial hunting threatens a number of large animal species. The jaguar, tiger, snow leopard, and cheetah are hunted for their skins, elephants for their ivory tusks (accounting for the slaughter of about 90,000 elephants a year) and rhinoceros for their horns. Single rhino horn – which is a mass of compact hair – is worth as much as $24,000 in the black market. It is used to make handles for ornamental knives in North Yemen, and ground into a powder and used in parts of Asia for medicinal purposes, especially reducing fever. It is also thought to be an aphrodisiac or sexual stimulant even though it consists of a substance (keratin) that can be obtained by eating hair trimmings and finger nails. Although 60 countries have agreed not to import or export rhino horns, illegal trafficking goes on because of its high market value.

Another highly publicised commercial hunt is that of the whale. The whaling industry has generally concentrated its efforts on the large, profitable baleen whales, which were slaughtered for their blubber and baleen, the bony sieves they filter sea water with. From the blubber, high grade oil was made for lamps and for lubricating machines. The baleen or "whalebone" was used to make corset stays, combs and similar products. The history of whaling is one of over-exploitation followed by abandonment.

Carolina parakeet-their brightly coloured feathers caused their downfall. These feathers were prized for decorating women's hats and made the birds popular as pets. Their extinction came in 1914.

The heath hen was used as food. In the early 1900s people realised that the bird was becoming scarce and a bird sanctuary was set up. The flock soon grew, but a fire swept across the sanctuary, and only a few males survived. The last bird died in 1932.

The Labrador duck became extinct before anyone realised it was gone. Most of the birds were killed for their feathers, which were used to stuff pillows.

Among all the countries, India has the greatest number of mammalian species on the threatened species (endangered, rare etc.) list, and in the Red Data Book, ranks first of the world.

8.5 BIOLOGICAL INVASION

Purposely or accidentally, people often bring non-native species into new areas where the species have few or no natural predators to keep their populations in check. These invasive species – also called **alien**, **introduced** or **exotic species** – are considered the most important cause of native biodiversity loss. Invasive or alien species are those species which when introduced into new areas cause **biological invasions**. They range from microbes to mammals. Invasive species also cause economic and environmental havoc. Invasive species can also alter fire cycles, nutrient cycling and the hydrology and energy budgets in native ecosystems. The problem of invasive species will rise severely through climate change.

Some examples of invasive species are given below which you can see and experience yourself how these destroy the local flora.

- Water hyacinth, a water plant with a showy purple flower, is a native of the Brazil and is now seen as the most important nuisance aquatic plant

The blue whale, the largest animal that has ever lived, once numbered around 2,00,000 but by the mid 1950s it has been reduced to about 10,000. Many scientists believe that the blue whale population, although now protected, may not recover

worldwide. It affects water flow, electricity generation, transport, water quality and indigenous biodiversity. In India it was introduced in 1886 in Bengal as an ornamental, pond plant. Since then it has spread throughout India as an obnoxious aquatic weed covering large area. Fish and rice crops worth millions of rupees are damaged each year at the hands of this weed.

- *Parthenium hysterophorus,* also known as congress weed was introduced in India with food grains imported from USA. It reproduces freely from seeds and has spread in neglected areas throughout the country. Its pollen also causes skin allergies.
- Golden apple snail is one of the most devastating invasive alien species. It was imported from Latin America to South East Asia in the 1980s.
- *Prosopis juliflora* (Mesquite) in the semi-arid parts of India has displaced other flora of the area. It has become as invasive seriously threatening the biodiversity.

SAQ 2

a) Invasive species which causes skin allergies

i) water hyacinth

ii) congress weed

iii) mesquite

iv) sweet pea

b) Discuss with example how is poaching responsible for extinction of big animals

c) Discuss the harmful effects of invasive species with example

8.6 NEED FOR CONSERVING BIODIVERSITY

Why is biodiversity so important? Why should we care about it? What is the, value- biodiversity? May be the lay people don't understand the various roles it plays in our life, but certainly they know the importance of biodiversity.

There are many factors that underlie the need to conserve biodiversity, such as,

"The more biodiversity we destroy and the more irrevocably we change the biosphere, the more we limit our choices for the future."

- present and potential uses of the components of biological diversity - especially as we have no way of knowing or predicting what will be of use in the future.
- biodiversity is essential to maintain the earth's life support systems that enable the biosphere to support human life.
- It is ethically important to maintain all of the earth's biological diversity, including all the other extant (currently existing) life forms.

Biological diversity has to be conserved at all levels - comprising genes, species and ecosystems. The greater the number of individuals of a species

and the number of different populations of the species conserved, the greater will be the biological diversity conserved. Maintaining a high genetic diversity ensures that individual species are more adapted to their environment and changing conditions, and are thus less vulnerable to extinction. Wide ecosystem diversity will ensure that more species have living conditions vital for their survival; while a wide species diversity will ensure that ecosystems are more stable in the long term.

8.7 CONSERVATION OF BIODIVERSITY

Conservation needs different strategies, they can be species based or habitat based or ecosystem based. Some species are given importance at national level while some need treatment at international levels. Most of the conservation is done at *in situ* and *ex situ* conditions. In this unit we will discuss what these conditions mean, what is the difference between them and what are the methods and techniques used. We have also described some important projects such as project tiger and how this project had helped in increasing tiger populations. Some techniques such as seed bank and tissue culture are also proving very helpful in conservation of plants which fulfill several of our needs.

In-situ conservation means "on-site conservation". It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators. The benefit to *in-situ* conservation is that it maintains recovering populations in the surroundings where they have developed their distinctive properties.

Wildlife conservation is mostly based on *in-situ* conservation. This involves the protection of wildlife habitats. Also, sufficiently large reserves are maintained to enable the target species to exist in large numbers. The population size must be sufficient to enable the necessary genetic diversity to survive within the population.

***Ex-situ* conservation** means, literally "off-site conservation". It is the process of protecting population of an endangered species of plant or animal by removing it from an unsafe or threatened habitat and placing it, or part of it, under the care of humans. While *ex-situ* conservation is comprised of some of the oldest and best known conservation methods known to human, it also involves newer, sometimes controversial laboratory methods.

Ex-situ conservation, while helpful in human's efforts to sustain and protect our environment, is rarely enough to save a species from extinction. It is to be used as a last resort or as a supplement to *in-situ* conservation because it cannot recreate the habitat as a whole: the entire genetic variation of a species, its symbiotic counterparts, or those elements which, over time, might help a species adapt to its changing surroundings. Further more, *ex-situ* conservation techniques are often costly. Plants and animals living in *ex-situ* breeding grounds have no natural defense to the diseases and pests new to the species.

8.7.1 *In-situ* Conservation

This approach deals with maintaining species in their natural habitats, which is believed to be the best way to maintain the earth's biological diversity. It also allows natural evolutionary processes to continue and for species to keep on adapting to their surroundings. However, this needs good management practices and controlled land use to ensure the successes of conservation objectives. Thus **Protected Areas** play a very important role in *in-situ* conservation of species, particularly threatened species, by ensuring conservation of their habitat.

When a location is selected, the design of the preserved area plays an important role and is characterised by three important characteristics: size, shape and connectivity. If the size of the preserved area is big it increases the number of species contained in preserved area. The rounder shape minimizes edge effects because the perimeter (edge) is smaller relative to the area inside than with other shapes. Connectivity between potential fragments allows members of the same species to immigrate and interbreed. The connections are also called corridors. Buffer zones are another important preserve characteristic (Fig.8.2)

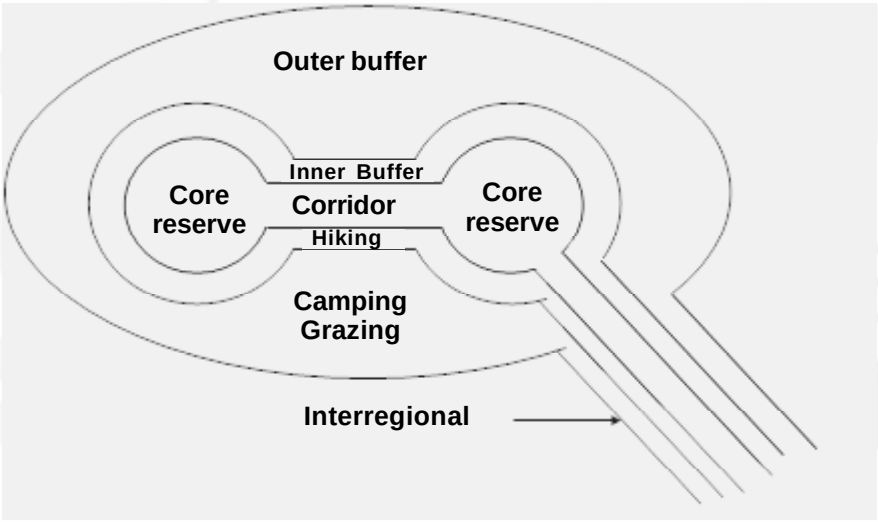

Fig.8.2: Structure of preserved areas

A buffer zone is moderately utilised land that provides a transition into the unmodified natural habitat in the core preserve where no human disturbance is allowed.

Buffer zones are very important for both psychological and practical reasons and from this zone inhabitants of the area can derive some benefits from the preserve. By permitting moderate recreational forestry, farming and other activities, buffer zone provides jobs, and income with no ill effects on species in the core preserve. Other types of areas that are important for *in-situ* conservation of species are:

- **National parks and sanctuaries**

  Most national parks are areas of land that have great natural beauty, which are set aside and protected for the conservation of habitat of many

plants and animals. In national parks peoples are allowed to enjoy the scenery and wildlife, but visitor management is often required to reduce conflicts between recreation and conservation.

National parks are largely natural and unchanged by human activities, but many of them already had existing human impacts before they were designated for protection and human activities have often been allowed to continue. People have no rights in a National Park.

The first wildlife sanctuary was the Vedanthangal Bird Sanctuary near Madras, set up in 1878, which merely formalised the traditional protection afforded by villagers for pelicans, herons and other birds breeding at Vedanthangal. Another such sanctuary was set up at Ranganathittu near Mysore, in 1942. As in 2018, India has 103 National Parks, 536 Wildlife Sanctuaries and 18 Biosphere Reserves.

Box. 8.2: Tigers Reserves

Project tiger was launched on 1 April, 1973 as centrally sponsored scheme of Government of India to maintain viable population of the tiger and its natural habitat. The main objective of the scheme is to ensure a viable population of tiger in India for scientific, economic, aesthetic, cultural and ecological values and to preserve areas of biological importance as natural heritage for the benefit, education and enjoyment of the people. Main objectives under the scheme include wildlife management and protection. Initially, the Project started with nine tiger reserves, covering an area of 16,339 sq.km with a population of 268 tigers. At present there are 27 tiger reserves covering an area of 37, 761 sq.km. with a population of 2967 tigers. This amounts of almost 1.14% of the total geographical area of the country. The selection of reserves was guided by representation of ecotypical wilderness areas across the biogeographic range of tiger distribution in the country. Project Tiger is undisputedly a custodian of major gene pool in the country. It is also a repository of some of the most valuable ecosystem and habitats for wildlife.

Fig. 8.3: Indian Tiger.

The Tiger Reserves are constituted on a 'core-buffer strategy'. The core area is kept free of biotic disturbances and forestry operations, collection of minor forest produce, grazing and human disturbances are not allowed within. However, the buffer zone is managed as a 'multiple use area' with twin objectives of providing habitat supplement to the spillover population of wild animals from the core conservation unit, and to

"A Tiger is a large-hearted gentleman (Fig.8.3) with boundless courage and that when he is exterminated – as exterminated he will be unless public opinion rallies to his support – India will be the poorer by having lost the finest of her fauna" **-Jim Corbett**

provide site specific ecodevelopmental inputs to surrounding villages for relieving the impact on the core. No relocation is visualized in the buffer area, and forestry operations, Non-Timber Forest Produce (NTFP) collection and other rights and concessions to the indigenous communities are permitted in a regulated manner to complement the initiatives in the core unit. The effective protection and intensive conservation measures inside the reserves have brought about considerable indescribable achievements. The project has been instrumental in mustering local support for conservation programme in general.

Captive Breeding Programmes

Captive breeding does play an important role in elephant conservation. Some of the most successful captive breeding programmes are those where elephants are kept under semi-natural conditions like in forest camps. In the forest camps in southern India, elephants have been seen to regularly breed in captivity and it has also been observed that the elephant population has sustained itself without the addition of any elephant from the wild.

In most forest camps, bulls and cows of all ages are kept together and are allowed to mingle with each other. They are also left in the forests at night, so that they can feed. Sometimes, the cows have been known to mate with wild bulls.

Crocodile Conservation

In situ conservation of selected species of birds and reptiles has been fortified through captive breeding programmes. The Government of India started a Crocodile Breeding and Management Project in 1976 to save the three endangered crocodilian species, the fresh water crocodile, salt water crocodile and the *gharial*. Thousands of crocodiles of these three species have been reared at 16 centres and several of these have been released into the wild. Eleven sanctuaries have been declared specially for crocodile protection including the National Chambal Sanctuary in Madhya Pradesh. The endangered white-winged wood duck was also bred in captivity and released into Protected Areas of the Northeast, in an Indo-British collaborative programme.

SAQ 3

a) Total number of Biosphere Reserves in India are

   i) 12

   ii) 14

   iii) 16

   iv) 18

b) Describe the importance of buffer zone in protected areas.

8.7.2 *Ex-situ* Conservation

Ex-situ conservation is comprised of some of the oldest and best known conservation methods known to human, it also involves newer, sometimes controversial laboratory methods.

Ex situ conservation has certain limitations for conservation of animals. These include adaptation problems, loss of genetic variability due to inbreeding, and concentration in small place, surplus animals, and continuity in funds. Research on captive population can provide insight into the basic biology of the species and suggest new conservation strategies.

However, much more needs to be done to protect global resource (flora and fauna) needed for healthy and productive animals and plants that are used for food, material, economic and aesthetic needs of the society.

- **Botanical Gardens**

  Together, the world's 1500 botanic gardens (Fig. 8.4), arboreta, and national plant collections maintain the largest array of plant diversity outside of nature, and they have major, if often overlooked, potential as resource centers for conservation, education, and development. If the infrastructure and technical facilities of most of these institutions can be strengthened, they can conserve *ex situ* stocks of most of the world's endangered plant species. Already, individuals of an estimated 12,000 to 15,000 threatened species are being cultivated in botanic gardens and arboreta

Fig. 8.4: The Great Banyan Tree in Indian Botanical Garden, Kolkata.

- **Zoological Parks**

  The basic philosophy behind the creation of zoological parks in modern times is to create an understanding of the environment and ecological balance of life, meaning strengthening the bond between people and the living earth. These zoological parks are no mere picnic spots. They are now centres for *ex-situ* wild life conservation and environmental education.

  The history of modern zoos has started some 200 years ago with the creation of the first public zoo. Since then every part of world has

Collectively the zoos of the network are visited annually by at least 600,000,000 people (approximately 10% of the current world population).

developed their own zoological parks with great diversity such as aquaria, bird-parks, private zoos and safari parks. The World Zoo Conservation Strategy concludes that the evolution of zoo should continue to help the conservation of wildlife. There are several species of wildlife which would have been extinct today except for efforts by zoos and animal reserves.

Ex-Situ conservation of wild animals in zoo

Some important techniques used in *ex-situ* conservation are dealt here.

i) **Captive breeding**

Captive breeding is one of the important strategies used by both government and non-government organizations. Captive-breeding programmes of endangered and threatened species have become familiar programmes that strive to preserve biodiversity and species-survival plans such as cheetah.

ii) **Embryo Storage and transfer technology**

Techniques for embryo transfer and artificial insemination, which have been developed for laboratory animals and farm animals, are potentially very useful for improving the reproductive potential of captive populations of endangered species. These kinds of techniques have been worked out mainly for mammals.

iii) **Artificial insemination**

Artificial insemination is another technology that may be useful. Sperm can be frozen and used later, or transferred to another breeding facility to increase genetic diversity. Sometimes, the sperm can be added to the eggs in a dish and fertilization will occur. In other cases (for example, horses) the sperm has to be injected into the egg. A few years ago, the black-footed ferret was down to six individuals, but artificial insemination has now been used to produce 16 kittens. Elephants and cheetahs have conceived, and a cheetah cub has been born following artificial insemination. Elephants have not bred naturally in captivity, so this method may be useful simply to make captive breeding possible.

In New Zealand scientists are hoping to use trans-species cloning to bring back the recently extinct Huia bird.

iv) **Somatic cell cloning**

Somatic cell cloning holds some promise for propagating from one or a few survivors of an almost extinct species. This was first done with domestic sheep at the Roslin Institute in Edinburgh (from University of Virginia) but has since been done with other mammals. It has already been used to rescue a rare breed of cattle that had been reduced to a single old female (“Lady”) and some frozen sperm. Granulosa cells (somatic cells in the ovary) from Lady were fused with enucleated eggs (lacking DNA) from a different breed, and the resulting eggs were implanted into an Angus cow (a common breed). The first calf born from these cells is genetically identical to Lady, as expected, although her markings were slightly different.

v) **Fostering**

Many egg-laying animals (i.e. birds and reptiles) are capable of producing many more eggs than they can rear. This raises the possibility of collecting the extra eggs and hatching and rearing the animals in captivity with a foster parent, then using them to supplement wild populations. It has worked extremely well with some birds, particularly the peregrine falcon, which is now doing so well that the fostering programme is being phased out. Rearing of whooping cranes has also been successful, and the species recovered from a population of 21 birds in 1941 to over 300 in 1996.

vi) **Translocations**

Sometimes conservation of faunal species involves or necessitates translocation of animals. This means the movement of individuals from its natural habitat, or from captivity, to another habitat. Translocations are carried out in connection with introductions or reintroductions, and should be handled with extreme caution.

vii) **Introduction**

This involves the translocation of a species (from its natural habitat or from captivity) into an area outside its historical distribution. Such species would then become an "exotic" to the area. This should be handled with extreme care and needs. Extensive study of the habitat and the behaviour and social organization of the species to be introduced has to be done, to ensure that the species has a good chance of adapting to the habitat.

viii) **Reintroduction**

This involves the translocation of a species (from its natural habitat or from captivity) into an area within its historical distribution, either to boost existing populations, or to establish new populations when the original population had died out. This too should be handled with extreme care and needs extensive study of the habitat and the behaviour and social organization of the species to be reintroduced.

In at least seven cases (Pere David's deer, Arabian Oryx, American bison, Red wolf, Guam kingfisher, Guam rail, and the California condor) the species were extinct in the wild at the time of reintroduction.

Seed Bank

The preservation of plant germplasm in seedbanks, (or genebanks), is one of the techniques of *ex-situ* conservation of plant species.Seeds have a natural dormancy feature, which allows for their suspended preservation for long periods of time with little damage, provided the conditions are favourable. Banking dormant seeds enables to keep genetically representative samples of rare and endangered plant species as a kind of "genetic insurance".

Seeds Storing

Storing germplasm in seedbanks is both inexpensive and space efficient. It allows preservation of large populations with little genetic erosion. Seedbanks also offer good sources of plant material for biological research, and avoid disturbance or damage of natural populations.

Tissue Culture

Plant tissue culture is an essential component of plant biotechnology. The possibility to regenerate whole plant from protoplasts, single cells, tissues and organs, *in vitro*, has opened out entirely new approaches to plant improvement, and has considerably enhanced the efficiency of the conventional methods of plant breeding and plant propagation.

SAQ 4

a) Which of the following provides genetic insurance

   i) tissue culture

   ii) somatic cell cloning

   iii) introduction

   iv) seed bank

b) Artifical insemination can be beneficial in

   i) Dogs

   ii) Cats

   iii) Elephants

   iv) Snakes

8.8 NATURE RESERVES

The nature reserves are the important area for the conservation of biodiversity. The growing destruction of biodiversity reemphasises the valuable contribution of nature reserves. These areas are resourceful and useful means to deal with biodiversity losses and help in buffering society from climatic effects and maintains the critical ecosystem services to the society.

Biosphere Reserves

Bisphere reserves are internationally recognised areas established to promote and demonstrate a balanced relationship between humans and the biosphere (Fig. 8.5). They highlight the value of nature conservation within a particular natural region and reconcile the conservation of biological diversity with sustainable use. Consequently they are ideally suited to meet today's conservation needs when human populations are increasing and the practicality of leaving aside large areas to protect pristine natural wild lands is decreasing, despite the fact that more people than ever before are dependent on wild species and natural ecosystems for their well-being.

The programme of Biosphere Reserve was initiated under the Man and Biosphere (MAB) programme by UNESCO in 1971. Biosphere Reserves programme is intended to conserve representative ecosystems as opposed to only species or habitat conservation. It provides *in-situ* conservation under natural conditions, long-term conservation of plants, animals and micro organisms. The purpose of the formation of the Biosphere Reserve is to conserve *in-situ* all forms of life, along with its support system, in its totality, so

Fig. 8.5: Sundarban Biosphere Reserve.

that it could serve as a referral system for monitoring and evaluating changes in natural ecosystems. The first biosphere reserve of the world was established in 1979, since then the network of biosphere reserves has increased to 425 in 95 countries in the world (MAB - 2003). Presently, there are 18 designated biosphere reserves in India. India's first Biosphere Reserve was the Nilgiri Biosphere Reserve.

Wetlands

India's wetlands (Fig.8.6) are distributed in different geographical regions ranging from the cold arid zone of Ladakh to the wet humid climate of Imphal; the warm arid zone of Rajasthan to tropical monsoonal Central India, and the wet humid zone of the Southern peninsula.

Fig. 8.6: Wetlands.

In the world over, a wetland is considered important if it:

- is particularly a good representative example of a natural or near natural wetland, characteristic of the appropriate biogeographic region;
- plays a substantial hydrological, biological, or ecological role in the natural functioning of a major river basin or coastal system;
- is a specific type of wetland, rare or unusual; or
- supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plants or animals.

Importantly, wetlands are habitats for a wide variety of plant and animal life. Most important of these is the waterfowl. Since wetlands are shallow water

areas, they provide an ideal habitat for water birds. Examples of such kinds of wetlands can be found all over the world.

Apart from harbouring birds, wetlands are also a nursery ground for several species of fish and shell fish and a wide variety of aquatic organisms. Chilka in Odisha, for example, has dolphins that move around in the area where the lake meets the sea. Coastal wetlands especially being an ecotone between the sea and freshwater, and/or freshwater and terrestrial habitats have high species diversity.

Ecologically, too, wetlands perform important functions. They regulate the water regime, act as natural filters and, display a marvelous nutrient dynamics. As an ecosystem, wetlands are useful for nutrient recovery and cycling, releasing excess nitrogen, deactivating phosphates, removing toxins, chemicals and heavy metals through absorption by plants and also in the treatment of waste water.

Bulwark a defensive wall, especially of earth

Furthermore, coastal wetlands with their unique mangroves (Fig. 8.7) are a natural bulwark against erosion by sea. The possible threat of rise in sea level is universally dreaded. One immediate preventive of this possible threat, as has been suggested by experts, would be the plan of a network of mangroves. In fact, mangrove wetlands of India and Bangladesh act as buffers against the devastating storms of the Bay of Bengal. Wetlands, thus, help in mitigating floods, recharging aquifers and reducing surface run-off and the consequent erosion.

Some of the most important Indian wetlands are: Kolleru (Andhra Pradesh), Wullar (Jammu and Kashmir), Chilka (Odisha), Loktak (Manipur), Bhoj (Madhya Pradesh), Sambar (Rajasthan), Pichola (Rajasthan), Ashtamudi (Kerala), Sasthamkotta (Kerala), Harike (Punjab), Kanjli (Punjab), Ujni (Maharashtra), Sukhna (Chandigarh), Renuka (Himachal Pradesh), Kabar (Bihar), Nalsarovar (Gujrat) and Dal (Jammu and Kashmir).

Fig. 8.7: Mangroves acting as bulwark for environment.

In the context of the environment, too, wetlands play a very important role. They protect and improve the quality of water and keep the local weather moderate. Using wetlands for water quality improvement has been tried in cold climates. Wetlands in urban periphery are natural receptacles for waste water and can harness effectively the nutrients available in the waste through fisheries and agriculture.

Box 8.3: Natural Wetlands of India

Most of the natural wetlands of India are connected with the river systems of the North and South. On the other hand, the various multi-purpose projects launched to harness river systems have provided a number of wetlands, e.g., Harike Barrage at the confluence of the Beas and Sutlej in Punjab, Bhakra Nangal Dam in Punjab and the Kosi Barrage on the Bihar-Nepal border. Besides these, we also have a network of lakes – natural as well as manmade, for example, Kabar lake, Chilka lake, Pichola Complex and Sukhna lake etc. In addition of these, there are 6,740 square kilometres of mangroves. The major concentrations of mangroves in the country are the Sunderbans and the Andaman and Nicobar Islands, which hold 80% of the mangroves in India. Rests of them are in Odisha, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Gujrat, and Goa.

The two wetlands from India which found place in first International Convention on Wetlands held at Ramsar in Iran in February 1971were Chilka and Bharatpur. Currently there are 26 Ramsar sites in India, covering most of the important wetlands.

In a remarkable sense, wetlands have become central points for bird observations, the lead example being set by Bharatpur Sanctuary. It is, therefore, proposed at various forums to develop other wetlands as tourist attraction centres.

8.9 SUMMARY

- Biodiversity is threatened by the sum of all human activities. It is useful to group threats into the categories of habitat destruction, invasion by non-native species, over-hunting, pollution and climate charge.
- Habitat loss presents the single greatest threat to world biodiversity, and the magnitude of this threat can be approximated from species-area curves and rates of habitat loss. The spread of non-native species threatens many local species with extinction, and pushes the world's biota towards a more homogeneous and widely distributed sub-set of survivors.
- Climate change threatens to force species and ecosystems to migrate toward higher latitudes, with no guarantee of suitable habitat or access routes.
- Many species have gone extinct, some naturally and others because of human activities i.e. deforestation, desertification and destruction of wetlands and coral reefs.
- Habitats that are vulnerable to greater species extinction are referred to as fragile habitats. Coral reefs, oceanic islands, mountain tops and habitat islands are considered as fragile habitats.
- Major impacts of biodiversity loss are steady increase in atmospheric CO_2 level, adverse effects on local climate and water flow, reduction of genetic diversity, extinction of species and loss of livelihoods.

- *In-situ* conservation meaning on-site conservation and *Ex-situ* conservation meaning off-site conservation are two important ways of conservation of species. Wildlife conservation is mostly based on *in-situ* conservation. *Ex-situ* conservation is man's efforts to sustain and protect the environment and *ex-situ* conservation is used when species extinction is imminent.
- *In-situ* conservation of species is generally operated in places like, National Parks and Wildlife Sanctuaries, Wetlands, Biosphere Reserves. Tiger Reserves and Elephant Reserves.
- *Ex-situ* conservation sites are Botanical Gardens and Zoologica Parks.
- Seed banks and tissue culture are important methods for plant conservation.
- Nature reserves are hubs of biodiversity and they should be left as such so ecosystem can function properly.

8.10 TERMINAL QUESTIONS

1. Why is biodiversity important for human beings? Make a list of advantages from biodiversity .
2. Describe how is global climate change harming biodiversity on the earth.
3. Why is biodiversity important? Discuss some of its values, and indicate the ones you favour the most.
4. Describe each of the five major threats to biodiversity. Give an example of a species affected by each of these threats.
5. Differentiate between *in-situ* and *ex-situ* conservation. What is the ultimate goal of captive breeding? Why is it best used only as a last resort?
6. Visit a local zoo or botanical garden. What activities are conducted there to promote biological conservation? List them.
7. What are the advantages of tissue culture ?
8. Write a note on Biosphere Reserves.

8.11 ANSWERS

Self-Assessment Questions

1. a) please refer to sub-section 8.3.2
   b) (iii);
   c) (iv);
   d) (iv)
2. a) (ii);
   b) please refer to section 8.4
   c) please refer to section 8.5

3. a) (iv);
   b) See sub-section 8.7.1
4. a) (iv);
   b) (iii)

Terminal Questions

1. Refer to sub-section 8.6
2. Refer to sub-section 8.3.4.
3. Refer to introduction of the unit and section 8.6.
4. Refer to section 8.2 causes of biodiversity loss.
5. Refer to section 8.7 conservation of biodiversity.
6. This is open ended question, visit a local zoo or botanical garden make a list of various activities that are taking place there for biological conservation.
7. Refer to sub-section 8.7.2.
8. Refer to section 8.8 Nature reserves.

8.12 FURTHER READING

1. WCMC (1992) Global Biodiversity. Status of the earth's Living Resources. Chapman & Hall.
2. National Biodiversity Action Plan and Strategy of India, (Draft of 2002).
3. IUCN (1999) *Resource Material on Biodiversity for General Certificate of Education*.
4. Glowka, L. et. al., (1994) A Guide to the Convention on Biological Diversity. IUCN. Gland and Cambridge.

Internet Sites

http://www.unep.ch/conventions/geclist.htm

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http://www.cites.org/eng/disc/what.shtml

Acknowledgement for Figures

1. Fig. 8.3 Indian Tiger

   https://www.indiatoday.in/education-today/gk-current-affairs/story/international-tiger-day-india-1298968-2018-07-28

2. Fig. 8.4 The Great Banyan Tree (photograph by Biswarup Ganguly)https://www.atlasobscura.com/articles/curious-fact-of-the-week-great-banyan-tree

3. Fig. 8.5 sundarban reserves

   http://www.moef.nic.in/report/0203/

UNIT 9

ENVIRONMENTAL POLLUTION AND HAZARDS

Structure

9.1 INTRODUCTION

In the previous unit you have studied about biodiversity, the threats it focus and the need for conservation. In this unit we will discuss pollution, which is causing a serious problem to human health as well as agriculture. Pollution is caused by any undesirable physical, biological or chemical change in the components of the environment i.e., air, water and soil. In our daily usage pollution implies the adverse state of environment in which we live. In the preceding units you have studied about the concept of environment and earth's resources available for meeting the basic requirements and developmental needs of ever-growing human population. Unmindful use of resources and energy intensive technologies that generate lot of wastes have resulted in degradation of environment. The adverse effects are on living systems including humans, buildings and other materials.

In this Unit you will learn about the phenomenon of pollution in air, water and soil, their sources and their effects. Apart from gaseous emissions and liquid effluents, noise, radiations and thermal pollution also have adverse effects on living organism.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- ❖ define pollution and pollutants;
- ❖ identify and list major types of pollutants that contaminate our air, water and soil;
- ❖ explain the critical importance of a temperature range for the living organisms;
- ❖ understand and trace the pathways of major pollutants in the ecosystem;
- ❖ explain the reasons for high noise levels in the urban areas; and
- ❖ discuss the hazardous effects of radiations and the need for safeguards to prevent accidental release of radioactivity.

9.2 WHAT IS POLLUTION?

Pollution *is defined as any undesirable change in the physical, chemical or biological characteristics of environmental components i.e., air, water and soil that adversely affect the life forms and life support systems of the biosphere*. You can also say that pollution is unfavourable alteration of our environment mainly due to human activities. *The agent that contaminates the environmental component is called the* ***pollutant***.

A normal constituent of the environment becomes pollutant if its concentration increases beyond the threshold, destroying its usefulness. A pollutant is also a new substance (biotic or abiotic) or energy (heat, sound, radioactivity etc.) that is added to or formed in any component of the environment and builds up to a level where usefulness of that component is damaged.

Pollutants can be grouped into two broad categories:

i) **Non-Biodegradable Pollutants:** Pollutants that remain in an unchanged form in the environment for a very long time such as pesticides, heavy metals, rubber and nuclear wastes. Plastics also fall in the same category. Such substances are not broken down or decomposed by bacteria.

ii) **Biodegradable Pollutants:** Generally pollutants such as paper, garden waste, domestic sewage, agro-based residues, and fertilizers breakdown into simple products by bacterial decomposition process. These simple products are raw materials of nature and are reutilized in the ecosystem. These biodegradable pollutants pose a threat when their input in the environment exceeds the decomposition capacity.

Pollutants can enter the environment either through point or non-point sources (Fig.9.1). **Point sources** are distinct and confined sources that discharge the pollutants/effluents through a chimney or through a discharge channel such as pipes or tunnels from industries or municipal areas. **Non-point sources** or area sources are diffused sources discharging pollutants over a large area. Some of the examples are run-offs from construction sites and agricultural fields.

Persistent organic pollutants (POPs) are nonbiodegradable chemical substances that accumulate through food chain in the humans and cause health problems. Nine organic chlorinated agro pesticides derived from chemicals like Aldrin, DDT, Chlordane, Dieldrin and three types of chlorinated industrial products derived from chemicals like Dioxin and Polychlorinated Biphenyls are listed as POPs.

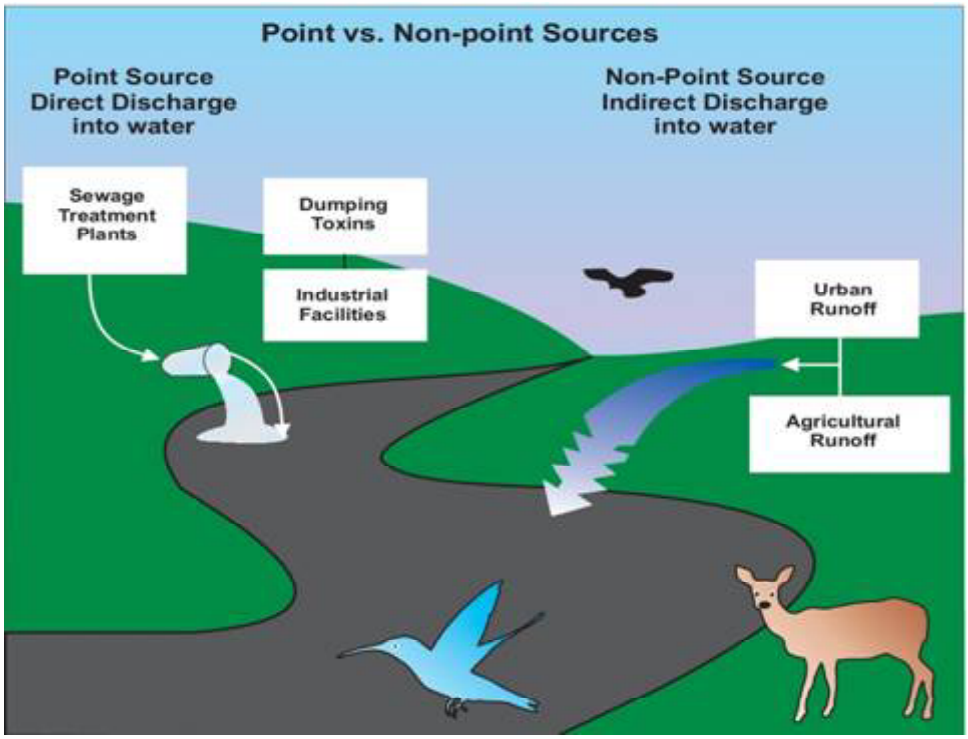

Fig. 9.1: Point and non-point sources of water pollution

9.3 CAUSES OF ENVIRONMENTAL POLLUTION

Industrial processes and pace of increase in human population led to the increase in the consumption of energy and natural resources. Growing use of the resources has ensured the steady rise in the emissions of gases, chemicals, wastes and other materials into air, water, soil and eventually in the biosphere. Resources and energy are required by humans for fulfilling their needs as well as greed for food, housing, transportation, entertainment and luxuries. With ever increasing human population, demand for resources and energy sources like wood, minerals, water, soil, coal, oil and gas increases. In Table 9.1 you can see how during more than last fifty years of 20th century there an increasing trend in the usage and build up of resources that affected the environment adversely.

Table 9.1: Increasing trend in the resource usage, buildups and their effects on environment

Items	Concentrations in 1950	Concentrations in 1995	Effect on Environment
Coal use	884 million tons oil equivalent.	2083 million tons of oil equivalent	Climate change
Oil production	518 million tons	2953 million tons	Climate change
Natural gas production	180 million ton soil equivalent	2128 million ton soil equivalent	Climate change
Fertilizer use	14 million tons	125 million tons	Water Pollution

Items	Concentrations in 1950	Concentrations in 1995	Effect on Environment
CFC production	42 thousand tons	300 thousand tons	Ozone layer depletion
Nuclear Arsenal	304	45100	Global security
Human population	2.55 billion	More than 5.6 billion	Changed land use and resource use patterns

Source: Vital Signs, 1995, World Watch Institute

The obvious reason for the presence of pollutants in our homes, offices and other indoor areas is that there are many potential indoor sources of pollution (Table 9.2).

Table 9.2: Some examples of usage sources that lead to indoor and outdoor pollution

SOURCES	POLLUTANTS
	Predominantly Indoor
● Particleboard, foam insulation, furnishing, ceiling tiles, tobacco smoke	Formaldehyde
● Building materials – concrete, stone, water and soil	Radon
● Fire proofing, thermal and electrical insulation, acoustics	Asbestos, mineral wools, synthetic fibres
● Adhesives, solvents, paints, varnishes, nicotine cooking, cosmetics, tobacco smoke	Organic substances, aerosols, volatile organic materials
● Pesticides, paints, spills in laboratories, sprays	Mercury, Cadmium
● Consumer products, domestic dust, debris, infected organisms	Aerosols of varying animal composition, allergens, viable microorganisms
	Predominantly Outdoor
● Coal and oil combustion, smelters, fires	Sulphur oxides
● Photochemical reactions	Ozone
● Automobiles, smelters	Lead, Manganese
● Soil particulates, industrial emissions Cadmium	Calcium, Chlorine, Silicon,
● Petrochemical solvents, vaporization of unburnt fuels	Organic substances

	Indoor and Outdoor
• Fuel combustion	Nitrogen oxides
• Incomplete fuel combustion	Carbon monoxide
• Fossil fuel combustion, metabolic activity	Carbon dioxide
• Resuspension, condensation of vapours, combustion products	Suspended particulate matter
• Petroleum products, combustion, paint , metabolic action, pesticides,	Organic substances, heavy metals
• Cleaning products, agriculture, metabolic insecticides, fungicides products	Ammonia

In the following sections you will read about what causes pollution in various environmental components.

SAQ 1

Fill in the blanks:

i) The agent that contaminates the …… component is called pollution.

ii) Plastics are …… type of pollutants.

iii) Sulphur dioxide can be absorbed in small …… .

iv) Of all animal species, …… have inevitable spirits and capacity of adjusting to and manipulating the environment.

v) Our …… consumption strategies and living styles have compelled to live in polluted environment.

9.4 AIR POLLUTION

More number of people are killed due to choking caused by smoke and fumes generated by fire as compared to that killed by being burnt.

Have you ever felt that air is as much a resource as water or food? To stay alive the average adult human being exchanges about six times more amount of gases per day as compared to daily consumption of food and water. This is the reason why air quality is important to us. You might have read about the composition of normal air. For most of the living beings oxygen is the immediate requirement from the environment. We can live for days without food and water but only for few minutes without oxygen. Any significant change in the normal composition of air is harmful. Dry air contains almost 78% nitrogen, 21% oxygen, 0.04% carbon dioxide and small amounts of other gases. Air also contains variable amount of water vapour.

9.4.1 Types of Air Pollutants

Broadly air pollutants can be grouped into following categories.

1. **Natural Pollutants:** These pollutants are released from natural sources or as a result of natural activity. Some examples are: pollens and volatile organic compounds from plants; gases like sulphur dioxide and hydrogen sulphide from volcanic eruptions and decay of organic

materials; particles from wild fires and sea. In general natural emissions are low in concentrations and do not cause serious damage.

2. **Primary Pollutants:** These pollutants are emitted directly into the air as a result of natural or human activity (Fig. 9.2). Examples include sulphur dioxide, nitrogen oxides, carbon dioxide, carbon monoxide, hydrocarbons and particulates released from fuel burning.

3. **Secondary Pollutants:** Secondary pollutants are produced as a result of chemical reactions between primary pollutants and normal atmospheric compounds under the influence of electromagnetic radiations from the sun (Fig.9.2). For example, the primary pollutant sulphur dioxide (SO_2) reacts with oxygen (O_2) in the atmosphere to form sulphur trioxide (SO_3), a secondary pollutant. Sulphur trioxide further reacts with water vapour to form another secondary pollutant sulphuric acid (H_2SO_4), which is a component of acid rain. Another example is the formation of ozone on a bright sunny day over the urban areas. Nitrogen dioxide (NO_2) absorbs ultra violet radiations that reach the earth's surface and splits into nitrogen oxide (NO) and oxygen atoms (O). These oxygen atoms combine with oxygen molecules to form ozone (O_3). NO_2 also contributes in the formation of other secondary pollutants, peroxy acetyl nitrate (PAN) and nitric acid (HNO_3). **Smog**, a mixture of smoke and fog is formed by complex reactions between oxides of nitrogen and a wide range of hydrocarbons triggered by sunlight. It is formed mostly in urban areas especially in stagnant air. The main reason is vehicular overpopulation.

Ozone is both protector and a cause of problem for us. In the stratosphere ozone layer protects us from harmful UV-radiations. In the lower atmosphere it acts as powerful oxidizing agent and causes damage to crops, vegetation, fabrics etc. and harm to human beings. Some people are affected even at a low concentration of 0.001 ppm. The oxidizing agent is a chemical that takes away electrons from other chemicals.

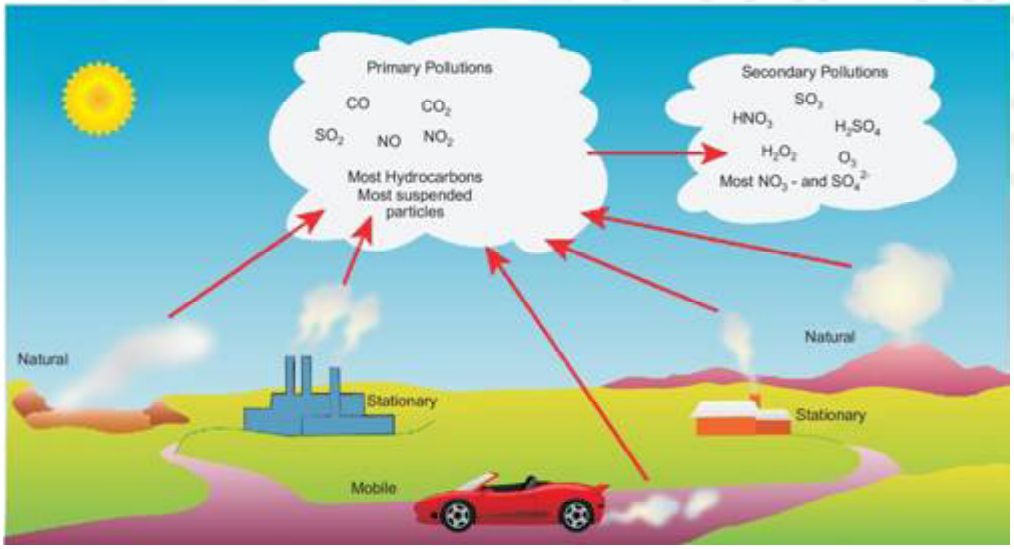

Fig. 9.2: Primary and secondary pollutants in the atmosphere result due to natural and human activities.

9.4.2 Major Air Pollutants

Let us now study Table 9.3 to know about major air pollutants, their sources, and an overview of their effects on humans and the environment.

Table 9.3: Major air pollutants, their sources and effects on humans and environment.

Pollutants	Sources	Effects
• **Oxides of Carbon (CO_x)** - Carbon dioxide (CO_2) - Carbon monoxide (CO)	Combustion of coal, oil and other fuels for energy production, manufacturing and transport; biomass burning	CO_2 has a major role in green-house effect, produces weak carbonic acid adding to acid rains; CO affects human health by binding to haemoglobin, which may result in asphyxia.
• **Oxides of Sulphur (SO_x)** - Sulphur dioxide (SO_2) - Sulphur trioxide (SO_3) - Sulphate (SO_4)	Combustion of sulphur containing fuel e.g. coal, petroleum extraction and refining; paper manufacturing; municipal incineration; ore smelting for metal extraction	SO_2 can cause severe damage to human and other animal lungs and is important precursor to acid rain; adverse effects include corrosion of paints, metals and injury or death to animals and plants.
• **Oxides of Nitrogen (NO_x)** - Nitrogen oxide (NO) - Nitrogen dioxide (NO_2) - Nitrous oxide (N_2O) - Nitrate (NO_3)	Burning of fuels; biomass burning; by-product in the manufacture of fertilizers	Form the secondary pollutants: peroxy acetyl nitrate (PAN) and nitric acid (HNO_3); suppression of plant growth and tissue damage; cause irritation to eyes.
• **Hydrocarbons (HCs) also called Volatile Organic Compounds (VOCs)** - Methane (CH_4) - Butane (C_4H_{10}) - Ethylene (C_2H_4) - Benzene (C_6H_6) - Benzopyrine ($C_{20}H_{12}$) - Propane (C_3H_8)	Evaporation from gasoline tanks, carburators; burning of fuels, biomass; municipal landfills; microbial activity of sewage; industrial process involving solvents	Can have carcinogenic effect on humans; higher concentrations are toxic to plants and animals; can convert into harmful compounds through complex chemical changes that occur in atmosphere; some are more reactive with sunlight and produce photochemical smog

Pollutants	Sources	Effects
• **Other organic compounds]** - Chlorofluorocarbons (CFCs), - Formaldehyde (CH_2O) - Methylene chloride (CH_2Cl_2) - Trichloro ethylene ($C_2H\ Cl_3$) - Vinyl chloride (C_2H_3Cl) - Carbon tetrachloride (CCl_4) - Ethylene Oxide (C_2H_4O)	Aerosol sprays; foam and plastics for making disposable fast food containers; refrigeration	CFCs cause reduction in stratospheric ozone thus allowing greater penetration of ultraviolet light at earth's surface; intensified UV radiations cause skin cancer and can have lethal effects on various life forms
• **Metals and other inorganic compounds** - Lead (Pb),Mercury (Hg) - Hydrogen sulphide (H_2S) - Hydrogen fluoride (HF	Oil wells and refineries; transport vehicles; municipal landfills; fertilizer, ceramic, paper, chemical and paint industries; pesticides; fungicides; aluminium production; coal gasification	Cause respiratory problems, toxicity and even death to humans and other animals; damage to crops; prove to be carcinogenic
• **Liquid droplets** - Sulphuric acid (H_2SO_4) - Nitric acid (HNO_3) - Oil - Pesticides e.g. DDT and malathion	Agricultural pesticides; fumigation; oil refineries; reactions of pollutants in the atmosphere	Contribute to acid rains; corrosion; damage to various life forms
• **Suspended particulate matter (SPM-solid particles)** - Dust, soil, sulphate salts, heavy metal salts, fine particles of carbon (soot), silica, asbestos, liquid sprays, mist etc.	Fuel combustion; building constructions; mining; thermal power stations; stone crushing; industrial processes; forest fires; refuse incineration	Have chronic effects on respiratory system; deposition on the surface of green leaves thus interfering with absorption of CO_2 and release of O_2; blocking of sunlight; particles size that range from 0.1 to 10 mm, cause lung damage

Pollutants	Sources	Effects
• **Photochemical oxidants** - Ozone (O_3), peroxyacyl nitrates (PANs), - Formaldehyde (CH_2O) - Acetaldehyde (C_2H_4O) - Hydrogen peroxide (H_2O_2) - Hydroxyl radical (HO)	Photochemical reactions in the atmosphere that involve sunlight, oxides of nitrogen and hydrocarbons	Produce haze; irritation to eyes, nose and throat; respiratory problems; blocking of sunlight

9.4.3 Air Pollution and Atmospheric Problems

Apart from causing damage to materials, plant and animal communities and health problems in humans, air pollution affects the atmospheric processes. Acid rain, smog, global warming and ozone depletion are some of the effects of pollution in our atmosphere. Let us look into some examples of the problems of air pollution in our atmosphere.

1. **Suspended Particulate Matter (SPM) :** SPM in the ambient air is complex and variable mixture of different sized particles with many chemical components. Larger particles are trapped by nose hair (vibrissae) and breathing tubes. Particles smaller than 10 mm in size, known as PM 10, are respirable suspended particulate matter (RSPM). Finer particles of size less than 2.5 mm are known as PM 2.5. They can be inhaled deep in the lungs and cause a lot of trouble. Study of ambient air quality of some Indian cities conducted by Central Pollution Control Board (CPCB) in recent years indicate that many Indian cities such as Raipur, Kanpur, Delhi, Gwalior and Ludhiana have RSPM more than 200 microgram per cubic metre. Standard level of RSPM is 60 microgram per cubic metre.

There was a decreasing trend in the levels of SO_2 and NO_2 in the past decade. This could be due to low sulphur diesel introduced in Delhi and prohibition from plying of commercial vehicles more than 15 years old in Delhi. The use of unleaded petrol has drastically lowered the level of lead in the air in India.

2. **Acid Precipitation :** Acid rain or acid precipitation (Fig.9.3) includes wet acidic depositions like rain, snow, fog, mist or dew and deposition of dry acidic particulates from the air. Acid precipitation occurs in and around the areas where major emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) occur as a result of anthropogenic activities. Hydrochloric acid emitted from coal fired power plants also adds to acid rain problems. Acid depositions have disastrous effects on the life forms as well as the materials. Soil fertility is adversely affected because acidic water in soil releases immobile heavy metal ions which are highly injurious to plants and other soil biota. Apart from damaging forests and lakes, acid rain corrodes and harms building materials such as steel, paints, plastics, cement, limestone, sandstone and marble.

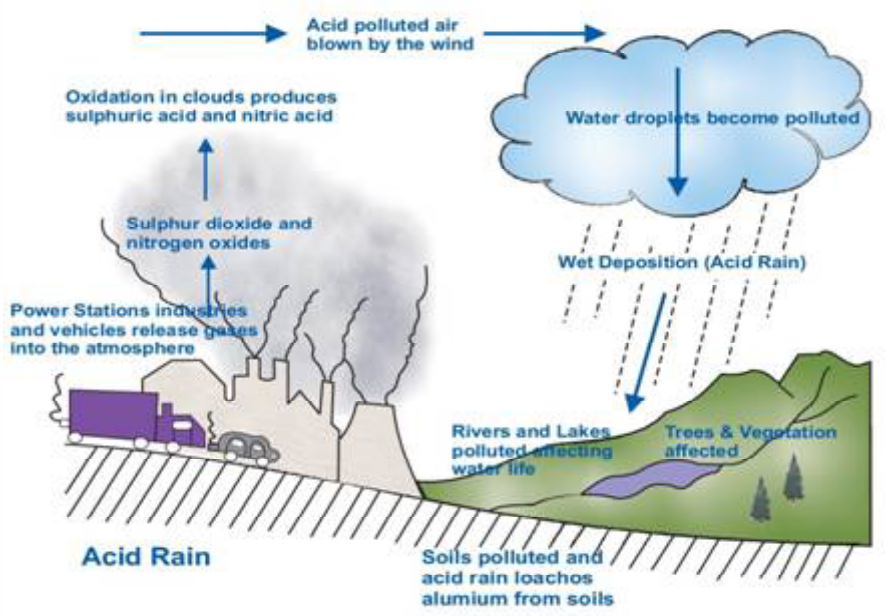

Fig. 9.3: Acid precipitation and its pathways.

3. **Atmospheric Inversion :** Atmospheric or temperature inversion (Fig.9.4) occurs when a stable layer of warmer air lays above the cooler air. The normal phenomenon of temperature decline along the increasing height reverses and thereby, convection air currents that normally disperse the pollutants are prevented. An inverted temperature gradient occurs, air circulations are restricted and pollutants are trapped in the lower atmosphere within the stagnant air mass. Such atmospheric inversion is responsible for dangerous levels of air pollution over polluted cities in India.

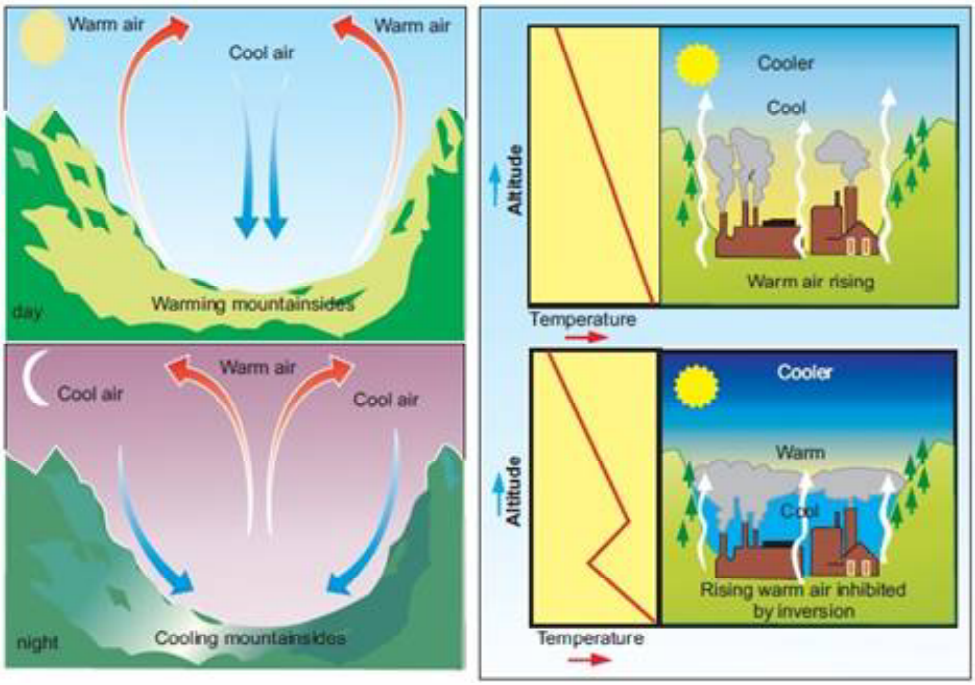

Fig. 9.4: Temperature inversion phenomenon. (a) Sun heats the ground during the day, warms the air near surface. Warm air rises up carrying dust and pollutant aloft. (b) At night the heat from the grounds devoid of greens as well as the paved streets quickly escapes into the sky

9.4.4 Case Study: Bhopal Gas Tragedy

In 1969, as part of its global empire, Union Carbide Corporation set up its pesticide formulation unit in the northern end of the city of Bhopal in central India. In December 1979, its Methyl Iso Cyanate (MIC) plant with an installed capacity of 5000 tonnes went into production (Fig. 9.5).

Fig. 9.5: Methyl Iso Cyanate (MIC) plant.

On the night of December 2, 1984 during routine maintenance operations in the plant, at about 9.30 p.m., a large quantity of water carrying catalytic material entered Methyl Iso Cyanate (MIC) storage tank no. 610. In the early hours of December 3 forty tons of toxic gases were released from the plant as a result of contamination of the storage tank and spread throughout the city. The result was a nightmare that still has not ended. No alarm ever sounded a warning and no evacuation plan was prepared. The gas leak lasted less than 1 hour, yet the accident killed about 2500 people. About 100,000 were seriously injured by the gas which causes burns on contact and severe irritation to eyes, nose, throat and lungs (Fig. 9.6). Only a few ppm of inhaled gas causes violent coughing, swelling of lungs, bleeding and death.

Fig. 9.6: Disastrous effect of Methyl Iso Cyanate on human population during Bhopal gas tragedy.

Some of the findings of ICMR on the health status of the persons who directly or indirectly suffered by the exposure are as follows:

- Fibrosis of the lungs, neurotic depression, anxiety and psychosis was reported in 22.6% of exposed people.
- Studies from 1987 to 89 show that gas exposed children (up to age 5 years at the time of disaster) suffered two to four times more from fever, breathlessness, vomiting and cough compared to children among similar unexposed populations.
- As late as in1990, spontaneous abortion rates among the exposed women were more than three times that among unexposed women.

SAQ 2

Match column A with Column B:

Column A		Column B	
a)	Natural pollutants	i)	Anthropogenic activities
b)	Photochemical Oxidants	ii)	A stable layer of warmer air lays above the cooler air
c)	Acid Precipitation	iii)	Methyl Iso Cyanate (MIC)
d)	Atmospheric inversion	iv)	Oxides of nitrogen and hydrocarbons
e)	Bhopal Gas Tragedy	v)	Volatile organic compounds from plants.

9.5 WATER POLLUTION

Any physical, biological or chemical change that degrades the water quality results in water pollution. Water being a universal solvent can dissolve various types of substances in it. For this property, contamination of water becomes inevitable.

Fig. 9.7: Day to day human activities that cause water pollution.

Visible forms of pollution like formation of colour and foam in water discourages the use of water. Therefore, such visible pollutants sometimes tend to become more important issues than many more serious pollutants that solubilize in water and are not visible to the naked eyes.

Polluted water is a threat to our health and survival of aquatic life and other life forms. The pollution in non-flowing water bodies like ponds, lakes and underground water becomes localized and confined, making it more serious. The major human generated sources of water pollution are sewage, garbage and refuse, industrial and agricultural wastes like fertilizers and pesticides.

9.5.1 Types of Water Pollutants

Water pollutants are divided into following major categories. The types, sources and effects of water polluting agents shown in Table 9.4 are sometimes interrelated.

1. **Biological Agents :** Pathogenic organisms like viruses, bacteria and protozoans are serious water pollutants as far as human health is concerned. Cholera, bacterial and amoebic dysentery, gastroenteritis, typhoid, polio, flu, viral hepatitis and worm infections are important water borne diseases. Some insects that have aquatic larvae transmit malaria, dengue, yellow fever and filariasis. In our country generally onset of rainy season is accompanied by such epidemics. Overpopulated areas, unplanned industrial and human settlements, lack of proper civic amenities are some of the contributory factors. Water gets contaminated due to human wastes, animal wastes, domestic sewage and wastewater discharges from tanneries and slaughter houses.

2. **Chemical Agents :** Chemical pollutants can be **inorganic** in nature like nitrates, phosphates, acids, salts and toxic heavy metals. **Organic** chemical pollutants include oil, gasoline, pesticides, dyes, paints, plastics, cleaning solvents and detergents. **Radioactive substances** that make the third category of chemical pollutants are released into water bodies as a result of processing of uranium ore and wastes from research laboratories.

Organic wastes and inorganic nutrients like phosphates and nitrates enrich the water bodies and cause eutrophication due to excessive growth of certain plants. Inorganic salts ionise in water, enrich it and also render hardness to it. The effects in water bodies include colour changes of water (iron oxide gives red colour and iron sulphate gives yellow colour) and foaming by detergents. Such changes are harmful to the organisms dependent on these water bodies.

3. **Physical Agents :** Suspended solids, sedimentary solids and temperature are the physical factors that affect the quality of water. These pollutants adversely affect water bodies by silting, clogging waterways, filling the dams and making the water muddy. Aquatic animals face problems in breathing through gills in such waters. Suspended organic and mineral solids adsorb toxic substances like heavy metals and pass them in food chain. Thermal pollution occurs when heat-laden water from industries enters the water body.

Table 9.4: Major water pollutants, their sources and their effects.

Pollutants	Sources	Effects
Biological agents Bacteria, parasitic fungi, and protozoans	Human sewage; animal and plant wastes; decaying organic matter; industrial wastes (oil refineries, paper mill, food processing units); natural land and urban runoffs	Oxygen requiring bacteria feed on these biological wastes and deplete oxygen in the water body; life is destroyed in absence of oxygen; foul odours, poisoned live stock result.
Chemical agents ***Inorganic chemicals and minerals*** Acids, salts, metals like lead and mercury, crop nutrients like phosphates and nitrates.	Natural run off from land; industrial wastes; acid deposition; leaded gasoline; lead smelting; pesticides; agricultural runoffs; mining; oil fields; domestic sewage; food processing industries; detergents containing phosphates	Toxic to various life forms and humans through food chain, can cause genetic and birth defects; increased solubility of harmful minerals in water; make water unfit for domestic, agricultural and industrial uses; salinity build up in soil; upsets ecosystem of water bodies and cause eutrophication
Organic chemicals Pesticides, herbicides, detergents, chlorine compounds, oil, grease and plastics	Agriculture, forestry; pest control industries; home and industrial wastes; water disinfection processes; paper industry; bleaching process; machine and pipeline wastes; oil spills.	Toxic to aquatic life forms as well as organisms that depend on such water bodies; eutrophication of water bodies
Radioactive substances r	Nuclear wastes from research laboratories and hospitals; processing of uranium ore; nuclear plants	Radionuclides enter the food chain and cause birth and genetic defects; causative agent for cance
Physical agents Particulates and heat	Soil erosion, runoffs from the agriculture; mining, forestry and construction activities; power plants, industrial cooling	Filling of water ways, harbours and reservoirs; increase in temperature lowers the solubility of oxygen in water; reduction in biotic life in the water bodies.

9.5.2 Marine Pollution

Oceans are the ultimate sink of pollutants that are either directly dumped in the form of wastes or reach there as run-offs through streams, canals or rivers or accidental spills like oil spill. Major pollution of marine waters occurs near the coastlines where large cities, harbours and industrial centres are situated. The pollution of oceans, seas, estuaries, salt marshes and other similar water bodies is called as **marine** or **ocean pollution**. About 25% of the total Indian population lives in coastal areas and dependent on marine resources. The kind of pollutants encountered here are sewage, municipal discharge, agricultural run-offs, sludge, industrial effluents, waste heat generated from industries during cooling, processes, oil spills and discharge from marine vessels, oil and grease discharge from shipping industry and accidental discharge of oil from tankers. About 210 million gallons of petroleum enter the seas world over each year as a result of extraction, transportation, and consumption of oil and its products. About 180 million gallons of oil come into seas annually from natural seepage. After an oil spill, the aromatic hydrocarbons that are low boiling are the primary cause of immediate killing of number of aquatic organisms (Fig. 9.8). The floating oil can coat the feathers of marine birds, especially diving birds and few of marine mammals such as seals and others. This oil coating destroys the animals natural insulation and buoyancy, and most of them drown or die of exposure from loss of body heat. Marine pollution is also causing immense harm to coral reefs. Millions of tonnes of plastics reach the oceans. Researchers estimate as much as 2,45,000 tonnes of plastics floating on sea water, but there is also considerable down below. Plastics have also been found in the stomach of sea birds and fish.

Fig. 9.8: Oil spill in ocean killing animals.

9.5.3 Thermal Pollution

Thermal pollution occurs when the temperatures of a water body or air in the atmosphere are raised or lowered and subsequently deviate from normal levels. If the temperature of tropical oceans is lowered by even one degree,

the environment can become lethal to some corals and some reef species. Raising the water temperature can have similar effects on sensitive organisms. Thermal pollution occurs when waste heat is released into a water body. Human causes of thermal pollution are altering of vegetation cover as well as discharging of heated water from steam generators. Metal smelters, processing mills, petroleum refineries, paper mills, food processing factories and chemical manufacturing plants use water for cooling purposes. Eventually this water gets heated and is released as effluent from the industrial units.

The solutions to the problem of chronic thermal pollution lies in retaining the heated water and effluents discharged by the power plants and other industrial unit in a holding unit and be cooled prior to their discharge into the water body.

9.5.4 Water Quality Parameters

There are several parameters applied to assess the quality of water. Water samples are tested for these parameters to ensure that water is fit for consumption. Dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), most probable number (MPN) and total dissolved solids (TDS) are some such parameters.

1. **Dissolved Oxygen:** It refers to the amount of oxygen gas (O_2) that is dissolved into the water of any water source. Higher amounts of dissolved oxygen indicate that water quality is good. Low concentrations of oxygen content in the water indicate the presence of organic waste pollutant in water.
2. **Biological Oxygen Demand:** BOD is a measure of oxygen used by microorganism such as bacteria to decompose the organic matter like sewage, dead plant leaves, grass blades and food wastes. If the amount of organic wastes is high in the water source, more bacteria will be present to consume oxygen. Under such polluted conditions demand for oxygen will be high and so the BOD values will be high. With high levels of BOD, levels of DO in the water decrease.
3. **Chemical Oxygen Demand:** It is the amount of oxygen required to degrade or breakdown the organic chemical compounds of wastewater. A water body that receives effluents from chemical industries shows high values of COD.
4. **Most probable Number:** The water polluted with organic wastes such as sewage/sludge will have high population of bacteria like *E.coli* and coliforms. With the help of MPN test both *E.coli* and coliforms can be detected and enumerated. MPN method statistically predicts the number of these organisms present in the water body. Coliform is present in human intestines and isn't necessarily harmful to us. But its presence indicates the presence of human waste in the water. Polluted water will show high values of MPN.
5. **Total Dissolved Solids:** The amount of salts and solids dissolved in water is measured by testing the TDS and salinity contents. Some of the dissolved substances that make the water quality poor are calcium, phosphorus, iron sulphates, carbonates, nitrates, chlorides, and other

salts. Heavy metals also fall in this category. Excessive amounts of TDS degrade the quality of water.

SAQ 3

Fill in the blanks with the appropriate word given in the parentheses.

i) …… (Water/Alcohol) being a universal solvent can dissolve various types of substances in it.

ii) Polluted water is a threat to our health and survival of …… (aquatic/terrestrial) life.

iii) …… (CPCB/MHRN) is monitoring the water quality of water resources at various locations in the country.

iv) The productivity of an ecosystem reflects the rate at which its producers …… (manufactures/photosynthesise).

v) The oil coating destroys the …… (animals/humans) natural insulations and buoyancy.

vi) The release of heated water into a water body changes its temperature and concentrations of dissolved …… (oxygen/chlorine) in the water body.

vii) …… (BOD/COD) is a measure of oxygen used by bacteria to decompose the organic matter.

9.6 SOIL POLLUTION

All the terrestrial organisms including humans interact directly with the surface layer of land i.e., soil as it provides us the basic necessities of life, food, shelter and clothing. The vital source, soil, is only about 15 cm deep on the land surface throughout. Apart from natural causes we, the human population contribute to the degradation of our land surface mainly by three ways: by using it (agricultural and developmental activities); by taking things out of it (mining and deforestation); by putting things into it (waste disposal).

The major fallout of our over indulgence with our land areas are as follows:

1. **Loss of Biodiversity :** Natural flora and fauna are destroyed due to cutting of vast areas of forests as land is required to fulfill the agricultural and developmental needs, desires and greed of ever growing population of humans. According to International Union for Conservation of Nature (IUCN) it is estimated that by the year 2050 up to 50,000 plant species will become extinct or threatened. Presently about 4,500 animal species and 20,000 plant species are considered by the scientists to be threatened.

2. **Soil Erosion** : It is the process of loosening, detachment and removal of soil components especially the topsoil particles. Soil erosion is caused by wind blows and water flows. But these forces can damage only if the land surface becomes devoid of vegetation cover. Excessive loss of topsoil

reduces soil fertility and results in deposition of eroded soil in the riverbeds i.e., silting of water bodies.

3. **Acidity and Alkalinity :** Increase in the acidic or alkaline content of the soil reduces its fertility and is not good for certain types of crops. Minerals like calcium carbonate and alkaline compounds tend to get deposited in the soil if the climate is dry or rainfall is low. This increases the alkalinity of soil. Unmindful use of land and wrong agricultural practices are the main human generated reasons for such state of soil.

4. **Land Pollution by Waste Deposition :** We can call our land area as an ultimate garbage can as waste generated mainly by human activities is dumped in it as well as buried in it. The major types of wastes and their sources are listed in Table 9.5. As in other Asian countries, in India most of the solid waste is land filled. All types of waste is dumped in the landfills and when water seeps through them it gets contaminated and in turn pollutes the surrounding areas. This contamination of soil and ground water through landfills is known as leaching. The uncovered, untreated and unsegregated solid wastes are also left in open dumps. The rainwater run-off from such dumpsites contaminates nearby land and water bodies.

Table 9.5: Major types of wastes generated from different sources that pollute our land areas

Urban	Industrial waste	Domestic waste	Rural waste	Nuclear Plant waste
Municipal; sewage; industrial effluents; domestic effluents; hospital waste	Slag; lime sludge; brine mud, scraps of metals, glass, ferrous and non-ferrous metals, wool, thread and paper; fly ash; plastics; wastes from tanneries and other small scale industries, waste water effluents	Organic waste from kitchen, crockery, tin cans, plastics cans, bottles and bags; glass bottles, cloth rags, paper pieces; straw, board boxes; ash	Pesticides, herbicides; agricultural runoffs	Radioactive hazardous wastes

The pollutants once enter any component of the biosphere (ecosphere) can cycle through all the components i.e., air, water and soil and can enter the organisms (Fig. 9.9). Let us take the example of pesticides, the chemicals that are used to eliminate the pests. For use in the fields, pesticides are dusted or

sprayed on plants or else mixed in the soil of the fields. Spraying and evaporation enable the entry of pesticides in the atmosphere. Rainfalls bring back these chemicals to land area and water bodies. Run-offs from agricultural lands bring the pesticides into the water bodies. Irrigation from such water bodies takes back pesticides in the field areas. Persistent chemicals and pollutants follow this pathway for much longer time and enter the food chain. If not biodegradable these pollutants can bioaccumulate and bio magnify in the higher levels of food chain (Fig.9.10).

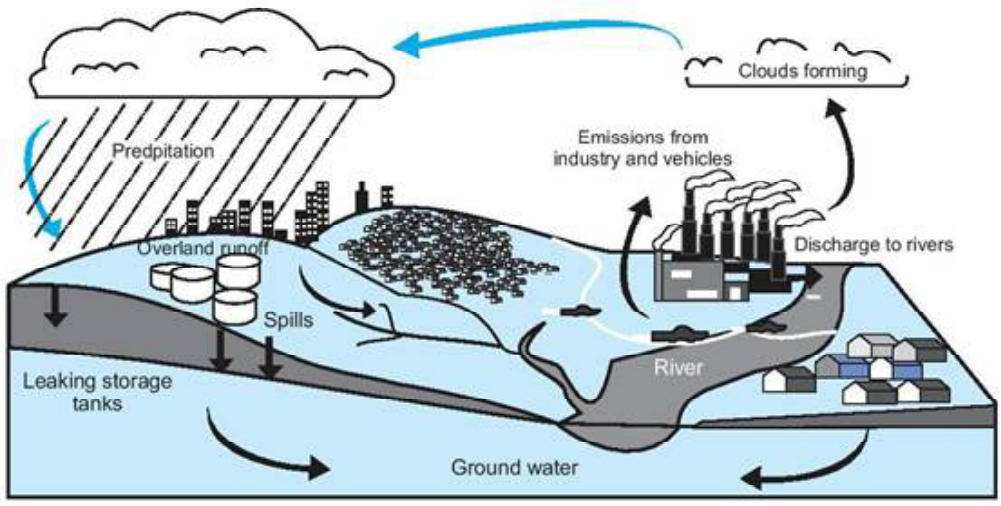

Fig. 9.9: Movement of chemicals through the components of the environment.

Bioaccumulation refers to the entry of a pollutant in a food chain. It is the increase in the concentration of a pollutant from the environment to the first organism in the food chain. Biomagnification is the phenomenon of increase in the concentration of a pollutant from one link in a food chain to another.

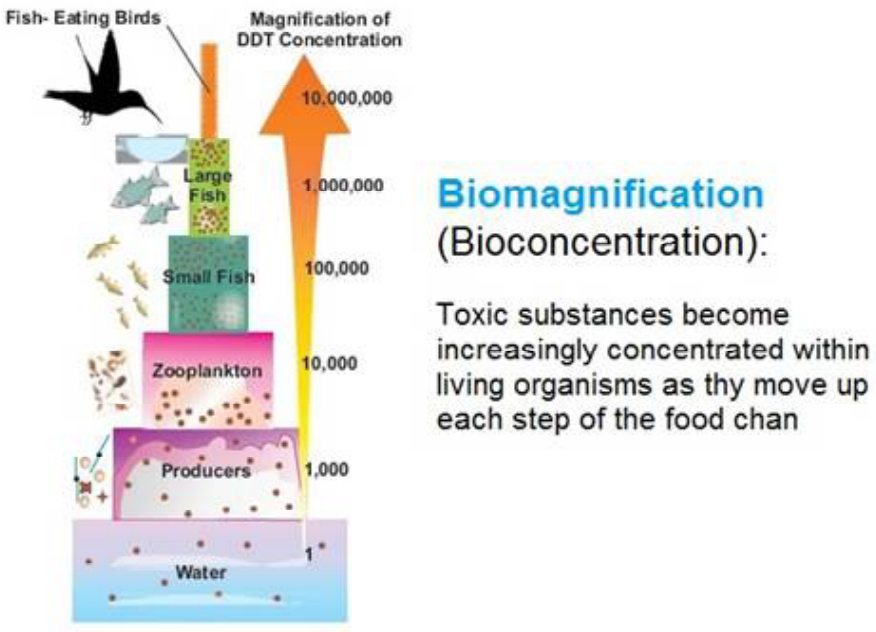

Fig. 9.10: Bioaccumulation and biomagnification of pollutants in the food chain.

9.7 NOISE POLLUTION

Sound is the medium for communication. It is almost impossible to lead our day-to-day life without sound. However, sound is annoying and harmful if it becomes noise. **Noise is any unwanted or exceedingly high levels of sound that can annoy, cause stress or impair the hearing ability.** The main sources of noise are industrial operations, machines, vehicles, railways, aircrafts, military arms and ammunition, construction work and recreational appliances. Loudness or the intensity of the sound is measured by measuring on a scale called decibel (db). A tenfold increase in the sound intensity is represented as 10 db on scale. The instrument is called decibel meter. Apart from pressure sound has pitch also. High pitched sound is more annoying than low pitched sound of same intensity. The unit that measures both pressure and pitch of the sound is called decibel–A (dbA). Noise can affect by interfering with communication, causing health and behaviour disorders and diminishing the hearing. Increased adrenalin levels, hypertension, migraine, high cholesterol levels, gastric ulcers, easy irritability, insomnia, increased aggressive behaviour and other psychological disorders and permanent damage to hearing ability may be caused in humans by high sound levels.

Noise pollution control measures include: (i) reduction of noise at source, (ii) interruptions in the path of transmission and (iii) protection of the receiver. Comparatively little attention has been paid to control noise pollution in our country. Awareness, motivation, legislations and their effective implementations are required to control the menace of noise pollution.

Monitoring of ambient noise levels by CPCB on Deepawali day at certain locations in Delhi and Mumbai showed that noise levels were much higher than the prescribed limits of 45 dbA during night time applicable to residential area. Aware generated by mass media and initiative of school children against the use of cracker for Deepawali celebrations can contribute in the control of noise and air pollution.

SAQ 4

Read the following statements and write True (T) or False (F):

i) Natural flora and fauna are destroyed due to cutting of vast areas of forest. [ ]

ii) Excess loss of top soil increases soil fertility and results into deposition of eroded soil in the riverbeds. [ ]

iii) Bioaccumation refers to the entry of pollution in a food chain. [ ]

iv) Fat-insoluble pollutants may be retained for a long time and biomagnify. [ ]

v) Noise is a wanted and exceedingly high levels of sound. [ ]

vi) Awareness, motivation, legislation and their effective implementations are required to control the menace of noise pollutions. [ ]

9.8 SUMMARY

In this unit you have read about the concept of pollution and pollutants of air, water and soil resulting from human activities. Environmental degradation also occurs due to noise and radioactive pollution.

- Pollutants are the agents that cause undesirable changes in the quality of air, water and soil. Anthropogenic activities are primarily responsible for pollution and environmental degradation. The natures of pollutants largely depend on factors like our life style, occupation, habits, traditions and awareness etc.
- Unmindful use of resources, by-products of industrial processes, waste generation, lack of will on the part of people to treat and manage the effluents and wastes are the contributory factors in polluting the environments. Biodegradable pollutants breakdown easily but nondegradable pollutants when introduced in any component of the ecosystem can cycle through all the environmental components i.e. air, water and soil.
- In the ecosystem pollutants affect the humans and other life forms directly or indirectly by causing damage to materials and crops. Persistent pollutants such as heavy metals and persistent organic compound enter the food chain, get biomagnified at the higher levels of food chain and eventually reach the human beings, causing a variety of health problems. Public awareness of the causes and problems caused by pollution, and active involvement of individuals and communities, apart from strict environment law and their strict implementations are essential to control environmental pollution. Use of ecofriendly technologies are highly effective in combating the problem of pollution caused by industry..

9.9 TERMINAL QUESTIONS

1. Define pollution and discuss various sources of air pollution.
2. Describe Bhopal Gas Tragedy and its after effects.
3. What is water pollution? Explain various parametres applied to assess the quality of water?
4. What is soil pollution? Describe the phenomenon of biomagnification by giving example.
5. Discuss noise pollution and its effects on humans.

9.10 ANSWERS

Self-Assessment Questions

1. i) Environmental ii) Non-degradable iii) Particulates iv) Humans v) Resource.
2. a) v b) iv c) i d) ii e) iii.
3. i) Water ii) Aquatic iii) CPCB iv) Photosynthesise v) Animals vi) Oxygen vii) BOD.
4. i) T ii) F iii) T iv) F v) F vi) T.

Terminal Questions

1. Refer to Section 9.2 and sub-sections 9.4.1 & 9.4.2
2. Refer to Sub. Section 9.4.4.
3. Refer to 9.5 and Sub-section 9.5.4
4. Refer to Section 9.6.
5. Refer to Section 9.7.

9.11 FURTHER READING

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Acknowledgement

1. Fig. 9.5: Methyl Iso Cyanate (MIC) plant.
   (Source:http://www.aristatek.com/Newsletter/NOV09/Images/ts_files/image002.jpg)
2. Fig. 9.7: Day to day human activities that cause water pollution.
   (Source:https://commons.wikimedia.org/wiki/File:Water_pollution_due_to_domestic_garbage_at_RK_Beach_02.jpg)
3. Fig. 9.8: Oil spill in ocean killing animals.
   Source:https://pixnio.com/science/biology-pictures/oil-spill-duck-kill

UNIT 10

WASTE MANAGEMENT

Structure

10.1 INTRODUCTION

In the previous unit you have learnt about environmental pollution and the factors responsible for generations of pollutants. In the present unit we shall discuss the waste and as to how it can be disposed off with minimum harm to the environment.

You know that living beings require food. They use food for their growth and development and for producing energy. In this process they also generate wastes. Industries also use raw materials, process them to yield useful products and are left with wastes which may sometimes exceed 50 per cent of the raw materials used. We have learnt that unlike natural ecosystems which can cope with the demand for food as well as the disposal of the wastes, in the case of industries, the waste can go on accumulating unless properly disposed off. Some of this waste is hazardous in nature, and may need special care with regard to diposal.

Although hazardous waste chemicals make up to 15 per cent of the total industrial wastes, their extremely dangerous nature requires that they be properly and carefully disposed off. If this waste is not judiciously disposed off, the natural resources can be seriously

contaminated and may pose a serious threat to the quality of environment in general and human health in particular. Various methods of hazardous waste disposal have been described in this unit. You will also learn in this unit about the concept of hazardous waste management, i.e., what treatment a waste should undergo before disposal, and what are the after-effects of improperly disposed wastes in the long run. A special mention will be made about waste management in India.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- ❖ define and classify the hazardous waste chemicals and distinguish' them from toxic chemicals;
- ❖ explain the pre-requisites of hazardous waste management;
- ❖ compare and contrast various methods for disposal of hazardous wastes;
- ❖ describe how hazardous waste is being disposed off presently in our country; and
- ❖ appreciate the impact of improper management of hazardous waste chemicals.

10.2 HAZARDOUS WASTES

Every day millions of tonnes of municipal solid waste, industrial waste and biomedical waste is generated in our country. This is a valuable material and energy resource if recycled and reused.

Municipal solid waste is generated mainly from residential and commercial complexes in urban areas and consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. The amount of municipal solid waste has been increasing rapidly and its composition changing with increasing urbanization and change in lifestyle and food habits. In 1947, cities and towns in India generated an estimated 6 million tonnes of solid waste. In 1997, it was about 48 million tonnes, and in 2008 it become 68.8 million tonnes. Waste disposal is a major problem with more than 25% of the municipal solid waste not being collected at all. Most Indian cities lack adequate capacity to transport waste and there are no sanitary landfills to dispose it of. The existing landfills are neither well equipped nor well managed and are not lined properly to protect against contamination of soil and groundwater.

Hazardous wastes are chemical by-products of an industry, a factory or a chemical plant. They may result from household activities or even from a hospital or a research laboratory. Armed conflicts, where nuclear or chemical weapons are used, also release enormous amounts of hazardous wastes. A chemical produced by any of the above sources which may endanger human health, pollute the environment or carry hidden risk to life if managed or disposed off improperly is called **'hazardous'**. A waste is considered as hazardous if it has any one of the following characteristics:

The four broad categories of garbage are:
Organic waste: kitchen waste, vegetable, flowers, leaves, fruits.

Recyclable: paper, glass, metals, and plastics.

Soiled: hospital waste such as cloth soiled with blood and other body fluids.

Toxic waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish etc.

- Ignitability - catches fire easily;
- Corrosiveness - wears away other materials;
- Reactivity - reacts strongly with water or explodes on reaction with other chemicals;
- Radioactivity - releases ionizing radiations;
- Toxicity - produces symptoms of metabolic disorders, poisoning, disease, mutations, cancer or malformations.

10.2.1 Toxic Versus Hazardous

A compound, microorganism or an agent which causes symptoms of ailments such as vomiting, giddiness, diarrhea or the like, is said to be pathogenic. If it induces genetic changes on consumption, it is said to be mutagenic. If it causes formation of galls or morphological abnormalities, it is known as teratogenic. And if it causes cancer, it is said to be carcinogenic.

Generally, the terms **"toxic"** and **"hazardous"** are used interchangeably as if they are synonymous. But this is not true. **"Toxic"** defines the capacity of a substance to produce injury after entering the metabolic processes of the consumer, an animal, a plant or a human being. This may result in disease, genetic changes, abnormally or may cause cancer.

The term 'hazardous' denotes the potential of a substance to pose threat to life or material through any one of the properties mentioned above, namely, toxicity, ignitibility, corrosiveness, reactivity, explosiveness or radioactivity. The term "hazardous" is thus broader and includes "toxic" wastes in its spectrum.

You can see that some substances may be hazardous on more than one account. For example, benzene is toxic as well as ignitable; strong acids and alkalis form corrosive mixtures which sometimes explode if improperly handled.

SAQ 1

Fill in the blanks using appropriate words and compare your answers with those given at the end of this unit:

i) A compound which induces genetic changes on consumption is said to be .....if it causes formation of galls or morphological abnormalities it is known as ..... and if it causes cancer, it is said to be .....

ii) A waste is proposed as hazardous if it has any one of the following characteristics:

   a) ....., i.e., catches fire easily

   b) ....., i.e., wears away other materials

   c) ....., i.e., reacts strongly with water

   d) ....., i.e., releases ionising radiations

   e) ....., i.e., produces symptoms of poisoning

iii) A complete definition of "hazardous waste" includes the physical, chemical or biological properties of a waste which because of its quantity or concentration may

a) cause or significantly contribute to an increase in ..... or an increase in serious ..... or incapacitating ..... illness, or

b) pose a substantial presence or ..... hazard to human health or the environment when improperly ....., ..., transported or ..... off, or otherwise managed.

10.3 CONCEPT OF WASTE MANAGEMENT

Hazardous wastes have become an important environmental and public health issue which concerns many countries in the world. In the modem framework of hazardous waste management, a four pronged strategy has been adopted:

i) Minimising the quantity of waste

ii) Recycling of industrial waste

iii) Treatment of the waste

iv) Collection, transport and disposal of waste in an environment friendly manner. The generalized scheme of recycling is given in figure 10.1.

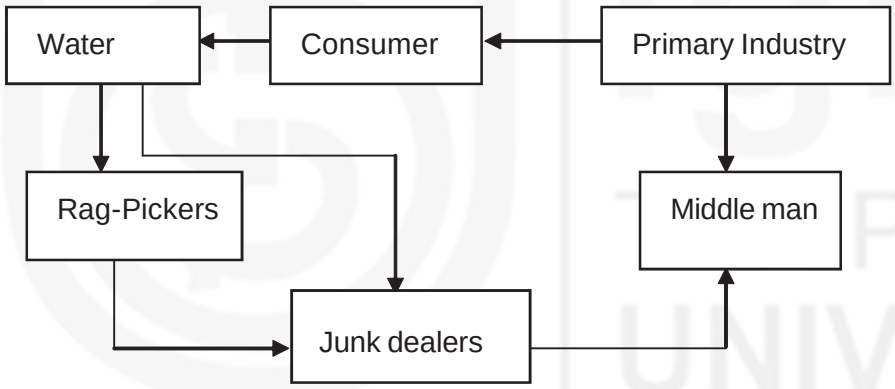

Fig. 10.1: Recycling of Wastes.

10.3.1 Waste Minimisation

The first priority in hazardous waste management is to reduce the quantity of waste to minimum. Three major waste reduction schemes which are often used can be summarised as below:

i) Process Modification: Often the industrial process can be altered in such a way that the use of raw materials is optimised and the amount of hazardous waste is reduced to barest minimum.

ii) Waste Concentration: The waste can be concentrated using evaporation, precipitation or decantation techniques which mean that the volume of waste can be considerably reduced using these methods. Incineration, viz., oxidation of inflammable. Waste is often practised in order to reduce the volume of waste to be handled.

iii) Waste Segregation: Segregating the hazardous waste streams from non-hazardous streams decreases the volume of hazardous wastes; thus, making it easier to treat.

Recycling: Some Benefits

- Conserves resources;
- Saves energy;
- Prevents emissions of many greenhouse gases and water pollutants;
- Supplies valuable raw materials to industry;
- Stimulates the development of greener technologies;
- Reduces the need for new landfills and incinerators;
- Creates jobs.

Various ways of Reusing things:

- Turn empty jars into containers for leftover food or pots for growing plants.
- Use cloth napkin or towels.
- Refill bottles.
- Use durable ceramic mugs.
- Donate old magazines or surplus equipment.
- Reuse boxes.
- Purchase refillable pens and pencils.

10.3.2 Recycling Industrial Wastes

Many substances in refuse wastes have value. They include glass, wood fibre from paper products, plastics and metals. Scientists have developed ways of recycling many wastes so that they can be used again. Almost all materials are recyclable. However, in some, more energy will be used in recovery than the recovered value warrants.

Scraps and Used Metals

Scrap metal is produced in large quantities in mills and factories. Old used metal from discarded vehicles, machine, aircrafts, ships, buildings etc. (Fig. 10.2) can be melted and recycled for useful purposes (Fig. 10.3). Aluminum scrap and aluminum utensils, for example, can be collected, melted and shaped into new utensils. We can meet the growing demand of such scarce metals as copper, zinc, lead, platinum by recycling the metal scrap.

Fig. 10.2: The richest one we have – our mountains of scrapped cars – offers a rich, inexpensive, and ecologically beneficial resource that can be "mined" for a number of metals.

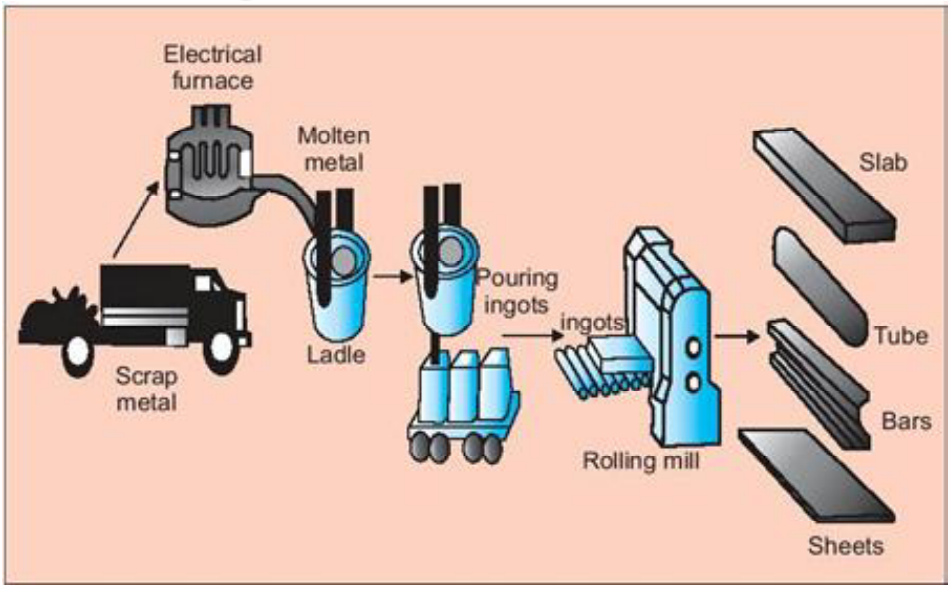

Fig. 10.3: "Minimills" remelt and reshape scrap iron and steel.

SAQ 2

A. Fill in the blanks using appropriate words :

i) Hazardous waste must undergo the following four steps before it can be disposed in an environmentally sound manner.

a) ..... of the quantity of waste

b) ..... of industrial waste

c) ..... of the waste

d) ..... and disposal of waste

ii) Minimisation of the volume of waste is achieved through the following three ways:

a) ..... modification

b) ..... of waste and

c) ..... segmentation.

iii) Transfer of waste “as is” without reprocessing, to another facility is known as waste ..... When a transfer “as is” is not possible, and it needs reprocessing for material recovery before it can be used in factory, then it is known as waste .....

B. State whether the following statements are **true** or **false**.

a) The first priority in hazardous waste management is to reduce the quantity of waste to minimum.

b) Incineration is an excellent method of waste disposal but its cost of operation is high.

c) There is no way for effective, cheap and environmentally safe disposal of hazardous wastes.

d) When a waste requires treatment before use it is known as **waste reuse**.

10.3.3 Treatment of Hazardous Wastes

After material recovery, the waste water containing hazardous waste chemicals should be detoxified and neutralised through treatment. There are many technologies available for treating hazardous wastes before they are ultimately disposed off. Their aim is to modify the physical and/or chemical properties of the wastes so that they are rendered harmless. Selection of a treatment process depends on many factors such as the nature of the waste, the desired characteristics of the output stream, and economic and energy considerations. The treatment technologies can be divided into the following groups, namely:

- physical treatment
- chemical treatment

- biological treatment
- solidification, and
- incineration

Physical treatment: This is conducted using various methods such as phase separation. Phase separation includes three steps, namely: lagooning, prolonged storage in tanks and sludge drying in beds. Lagooning and tank storage are collectively used to separate particulate impurities.

Chemical treatment: This is used to facilitate complete breakdown of hazardous wastes and more usually to modify the chemical properties of the wastes, e.g., to reduce water solubility or to neutralise acidity or alkalinity. The techniques involve oxidation, chemical reduction, neutralisation, heavy metal precipitation, oil/water separation and solvents/fuels recovery.

Biological treatment: The gross impurities obtained from treatment of sewage are collectively known as sludge, which is given biological treatment, before disposal. This is known as sludge processing which has become important since improvements in industrial waste water treatment. The typical technologies for sludge processing include conditioning, digestion, composting, thickening or dewatering and solidification.

i) **Conditioning:** In this step the sludge is exposed to atmosphere for a stipulated period until a desired consistency is reached.

ii) **Digestion:** In this process the sludge is treated with bacteria which break down the long chain compounds into simpler ones.

iii) **Composting:** In this step the organic matter in the waste sludge is converted into a usable stable material.

Box 10.1 : Waste Water Treatment

Domestic and municipal waste is rich in organic matter. If this kind of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetations.For the removal of organic waste, sewage is treated in a tank or in ponds for several days (Fig. 10.4). In doing so, the heavy particles settle down to the bottom by themselves, while the finer particles are made to settle down by adding alum and caustic soda.

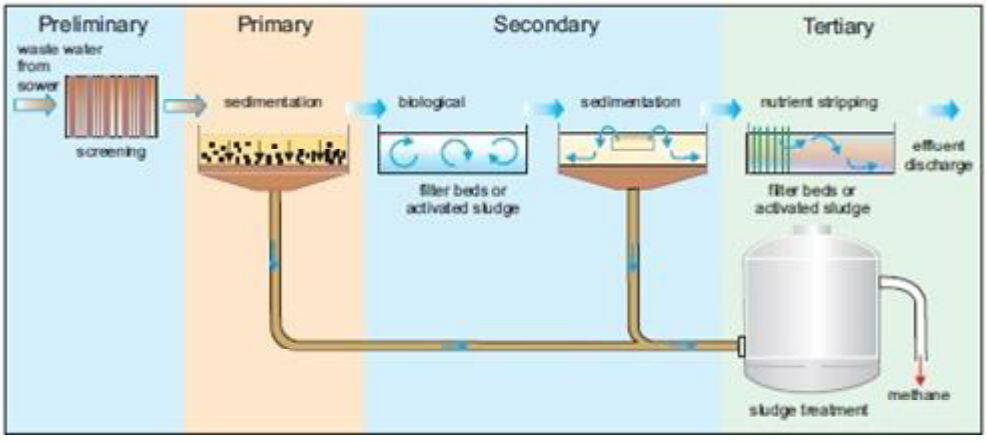

Fig. 10.4: Sewage treatment processes.

The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes organic wastes but also removes hydrogen sulphide which is generally dissolved in waste water, adds oxygen to the filtered water, thus help in water purification. Treatment of water with appropriate doses of chlorine, known as chlorination, That kills the harmful germs and makes the water usable.

Solidification: This process converts the liquid waste into insoluble, rock-hard material and are used as pre-treatment prior to landfill disposal. This is usually done by mixing the waste with various reactants to produce a solid mass. The basic aim of solidification process is to immobilise the hazardous constituents of the waste, so that these do not leach out at the landfill disposal site.

Incineration: Apart from the above mentioned methods, incineration is also a method of detoxification, in which oxidation of waste detoxifies the waste from its toxic proportion, about which you will read in section 10.4.2.

10.3.4 Solid Waste Management

Before disposal, a waste should be considered for the following possibilities:

- Reduction in raw materials and solid waste quantities
- Reuse of waste materials
- Materials recovery
- Energy recovery

I) **Reduction in Raw Materials and Solid Waste :** This can be achieved by : i) reducing the amount of materials used in the manufacture of a product, ii) increasing the life of the product, and iii) reducing the amount of materials used for packing the consumer goods.

II) **Reuse of Waste Materials :** Reuse of waste materials now occurs most commonly in those situations where a product has utility in more than one applications. For example, the paper bags used to bring home groceries are used to store household wastes. Soup and vegetable containers are used to store cooking medium, like ghee or oil. Plastics bottles are reused to store water.

III) **Material Recovery and Recycling :** A number of materials present in municipal and industrial wastes are suitable for recovery and recycling. About 10-15 per cent of solid wastes are recoverable. Most suitable materials are the wastes generated by paper, cardboard, glass, ferrous metals, non-ferrous metals (mostly aluminium), plastics and rubber. On the contrary, leather, textile and food wastes are unsuitable candidates for materials recovery. Fly ash from thermal power plants can be used to make bricks for construction.

IV) **Energy Recovery :** After segregation of wastes in the above-mentioned categories, the remainder is considered for the recovery of heat by burning (incineration). Because, about 70 per cent of the components that comprise solid waste are organic, the potential for recovery of heat energy is high. The energy content in the waste matter is converted to a form that can be used more easily. The remainder (ash) is also more compact and weighs less, occupying a smaller volume.

SAQ 3

Fill in the blanks using appropriate words:

i) After material recovery, the waste should be ..... and ..... through treatment, which means to modify the physical and/or chemical properties of the wastes in such a way that the wastes are rendered ……..

ii) Selection of a treatment process depends on many factors such as nature of the wastes, desired characteristics of the ..... and economic and ..... considerations.

iii) Physical treatment is conducted using various methods such as phase separation, which includes three steps, namely ....., ……. in beds and prolonged ……..... in tanks.

iv) Sludge processing includes, ……....., ..., ... ……. or dewatering and solidification.

v) Incineration, which is ..... of wastes, is another method of detoxification of inflammable wastes. This method minimises the ……..,.....……..... of waste to be handled as well.

10.4 DISPOSAL OF WASTE

As cities grow in size with a rise in population, the amount of waste generated will increase. The local corporations in cities adopt disposal of waste. In this process tremendous scope exists for reducing, reusing and recycling the waste as shown in figure 10.5

Amongst the various categories of waste, hospital waste like soiled bandages, disposables, cultures, anatomical wastes, chemical wastes, discarded medicines pose grave environmental risk. This waste is highly infectious and needs to be managed in a scientific manner.

The final disposal of the hazardous wastes also needs to be carefully planned. There are four different ways in which hazardous wastes can be finally disposed. These four different ways are as follows:

- Landfill disposal.
- Incineration
- Dumping at sea
- Underground disposal

We shall now discuss each of the above method of disposal of wastes.

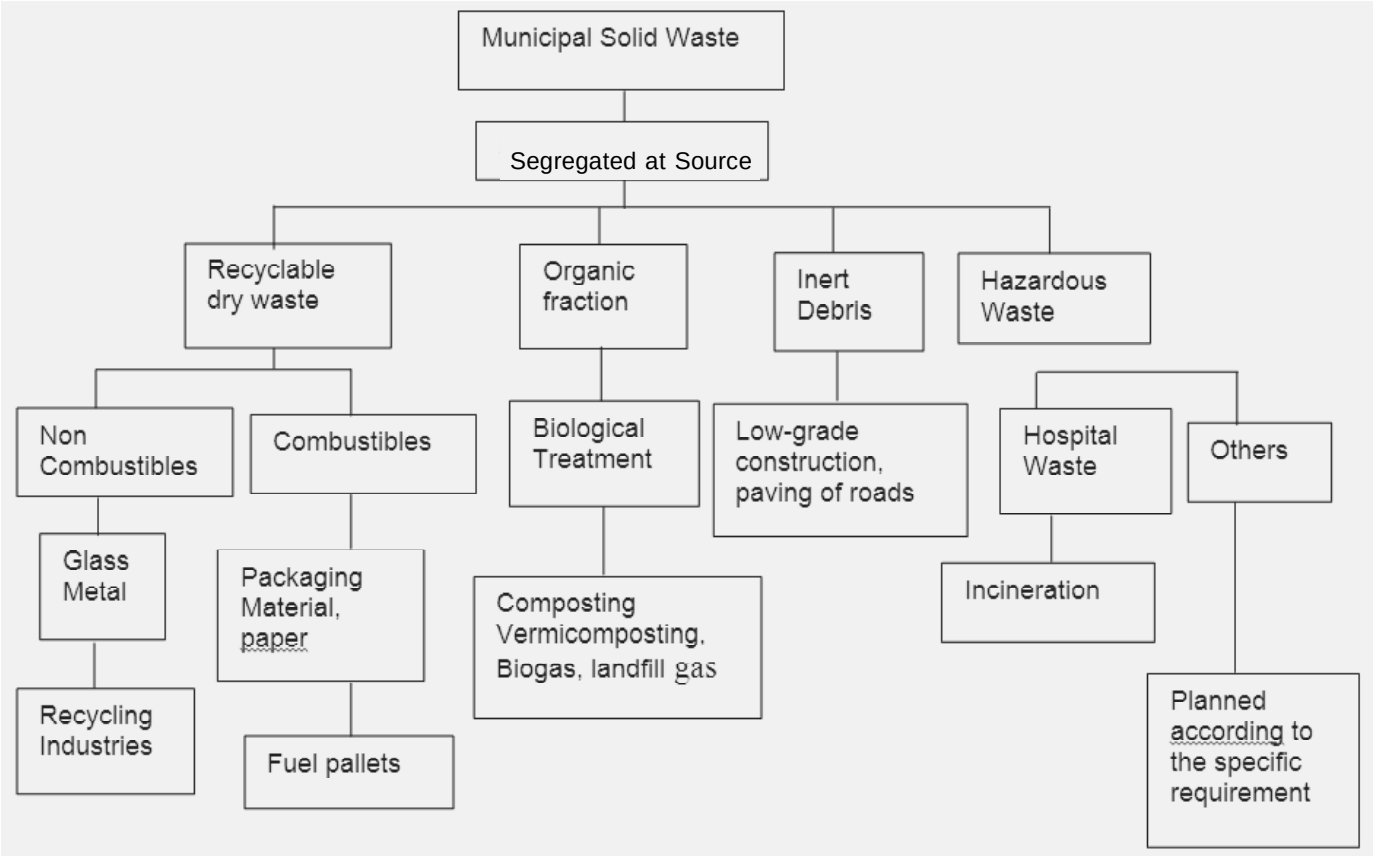

Fig. 10.5: Steps involved in the management of municipal solid waste.

10.4.1 Landfill Disposal

The disposal of hazardous waste by landfilling is an important method of disposal in many countries. Landfilling means under ground storing of harmful substances. This involves hauling the refuse to an area allocated for this purpose. In India, such areas range from unsanitary **open dumps** to properly operated **sanitary landfills. Open dumps** are a poor method of waste disposal because they cause environmental problems. For example, they can ruin the appearance of ah area and provide a home for rats and other rodents who spread disease. If garbage is exposed, it rots and smells foul. Most dumps allow some burning, which fills the surroundings with smoke. In addition, rain water can drain through refuse and carry harmful substances to streams.

Properly operated **sanitary landfills** cause little damage to the environment. The area to be filled with waste must be lined with a nonporous substance such as clay, or high density polyethylene (HDPE)-plastic membrane to

prevent the wastes from leaking to the surrounding areas. The wastes are packed and dumped at the site and covered with earth each day. The cover of earth prevents insects and rodents from getting into refuse. Operators of these sites forbid burning. In time, sanitary landfill sites become filled up, many communities then cover the site for a final time and use the area for recreational purpose.

A typical landfill site consists of an artificial double liner at the bottom and a cover at the top. The cross section of a conceptual design of a double lined hazardous landfill is shown in Fig. 10.6.

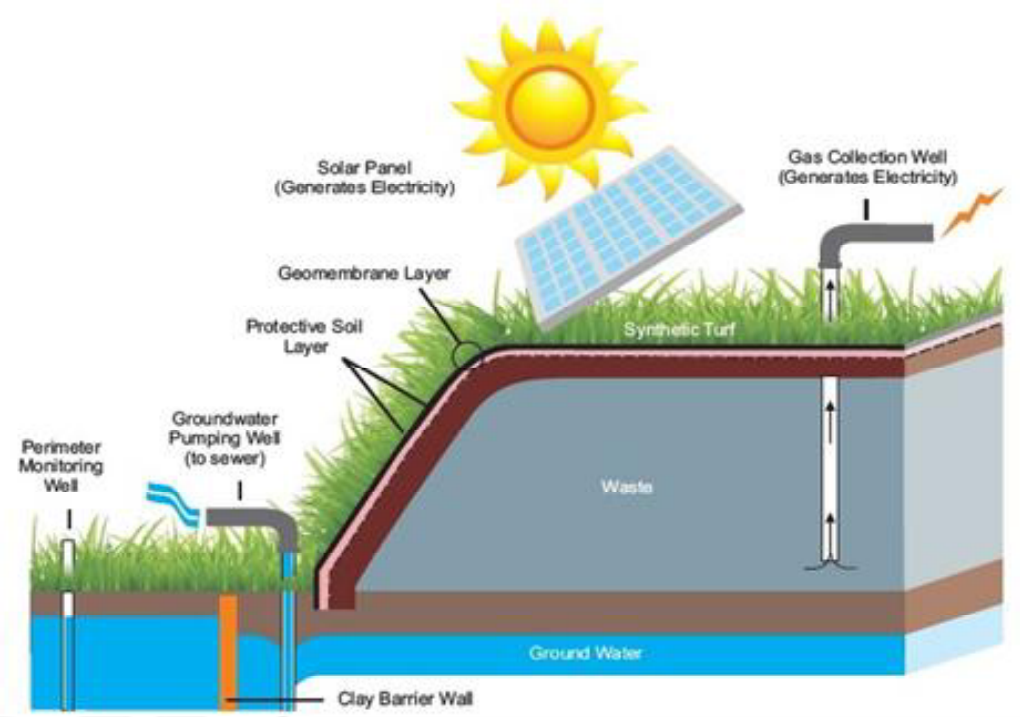

Fig. 10.6: Outline of a typical landfill site.

10.4.2 Incineration

Incineration burns waste products. This is another method many industries and large cities use if they do not have enough vacant areas for disposal sites nearby. Most hazardous wastes are detoxified in this process. This is also an excellent method of waste minimisation, waste detoxification and disposal, but its cost of operation is very high, if the heat content of waste is not reutilised.

The selection of incineration depends on the type and characteristics of the waste. A typical incinerator consists of a combustion chamber, burner chamber, precooler, scrubber, exhaust fan and stack to let out the gases (Fig 10.7).

10.4.3 Dumping at Sea

Another method of disposal of hazardous wastes involves dumping wastes at deep sea, designed to prevent contamination of groundwater. Disposal at sea,

of waste generated on land, is based on the misconceived notion that the enoromous volume of water available for dilution, enables the seas to be used as a dump without permanent damage. However, this is an erroneous conviction.

Disposal of waste at sea is controlled by international legislation and by the national legislation. The international legislation bans the dumping of extraordinarily hazardous wastes such as organic silicon compounds, halogenated organics, mercury and its compounds, cadmium, carcinogenic waste and plastics into the sea.

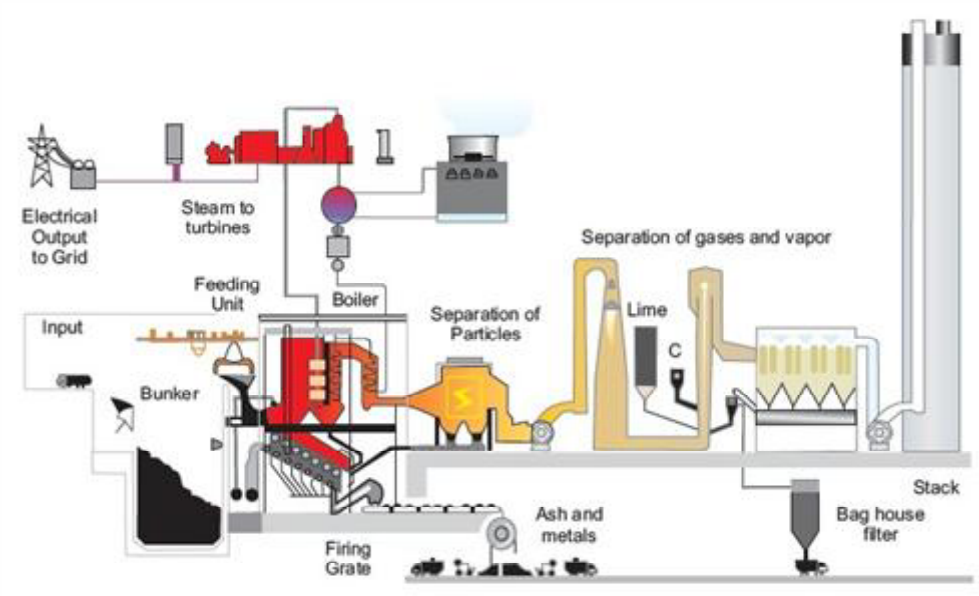

Fig. 10.7: A typical hazardous waste incineration unit.

10.4.4 Underground Disposal

It may be excessively expensive to dispose off certain hazardous wastes, such as radioactive nuclear wastes, in an environmentally acceptable manner at landfill still sites or incinerate them at thermal treatment plants. These wastes are generated in all operations associated with the use of nuclear energy for national defence or peaceful purposes such as mining of radioactive ore, production of nuclear fuel, laboratory experiments and medical treatment. Underground disposal may provide an environmentally and economically viable option in case of radioactive wastes. The underground disposal of hazardous waste is acceptable only in inactive or partially active mines that meet specific geological and technical criteria. Worldwide, only one deep-mine disposal facility is currently in operation: a worked-out halite/potash salt mine at Herfa Neurode in the Federal Republic of Germany (now united Germany).

Thus, in principle you have learnt that there are four methods of waste disposal.

You will see in the coming sub-sections as to how these methods are actually practiced under field condition.

SAQ 4

Fill in the blanks using appropriate words:

i) Problems of hazardous waste disposal arise from the fact that (a) waste in general has no perceptible ……..... value to the generator; (b) the chemical and physical ……..... may not be known; and (c) mixing of ..... wastes for convenience could create an acute hazard.

ii) Insanitary open dumps are a poor method of waste disposal because it provide home for ……..……... garbage rots and smells ……..... burning of garbage fills the surroundings with ……..... and rain water may carry ……..... substances to streams.

iii) Properly operated sanitary ……..... cause no damage to the environment. The area to be filled with waste must be lined with ……..... substance such as clay or HDPE-polyethylene membrane, to prevent the waste from ..... to the surrounding areas.

10.5 WASTE MANAGEMENT IN INDIA

We would now briefly discuss generation and disposal of hazardous waste in India.

10.5.1 Sources of Waste Generation

In general, hazardous waste generation can be broadly grouped into two categories, viz., Process-oriented and Pollution Control-oriented. The process-oriented waste is generated during the processing of raw materials to get the finished products; while pollution control-oriented waste originates from the treatment of gaseous and liquid effluents.

In India, there are industries generating large quantities of solid waste with relatively less concentration of hazardous constituents, (e.g., metallurgical industry like iron and steel, fertilisers, thermal power stations.). On the other hand, there are other groups of industries dealing with pesticides, electroplating, metal finishing, chlor-alkali and photographic chemicals which generate comparatively less quantity of solid waste but with high concentration of toxic and hazardous constituents. The later type of wastes requires special handling, storage, treatment and disposal techniques.

Nearly 15 per cent of the total solid waste generated by the industries, comes under the hazardous waste category. Though hazardous

wastes account for a small proportion of all wastes, their impact can be disastrous as they not only seriously affect the environment but also endanger the human health through inclusion in the food chain.

10.5.2 Prevalent Methods of Disposal

In the absence of proper regulatory control over handling, treatment and disposal, the hazardous wastes are mostly disposed wherever the space is easily available and accessible to the waste generators. Presently, the following methods of disposal of hazardous industrial wastes are followed in our country:

- Disposal along with city refuse
- Disposal on river beds and banks
- Open-pit burning
- Disposal in low lying areas, estuaries and seas
- Burning in self-designed incinerators.

Most of the heavy metal bearing and highly toxic wastes such as pesticides, solvent distillates, phenolics and cyanide waste are being disposed off using above mentioned methods. From the standpoint of impact what is significant is the method of disposal and the compatibility and complex interaction of these wastes with the receiving environment. Let us study what are the harmful effects of disposal of wastes in an improper way.

Ministry of Environment, Forest and climate change has notified solid waste management rules 2016. The rules make in mandatory for every waste generator to segregate and store separately recyclable, non-recyclable and hazards wastes and separately hand over these to the municipal workers.

10.6 IMPACT OF IMPROPER WASTE DISPOSAL

Improper disposal of hazardous waste causes adverse effects on human health and the environment. The normal practices of waste disposal such as insanitary open dump, landfilling, discharge in water courses, or open-pit burning will need modification when dealing with hazardous wastes. The principal hazard of improper waste disposal is contamination of soil and groundwater. This arises largely from the waste containing hazardous substances deposited landfills or on the ground. Fig. 10.8 illustrates in a simplified manner the mechanisms through which hazardous substances can enter the human environment after being “disposed of” in a landfill.

Fig. 10.8: Possible mechanism through which hazardous substances enter the human environment after being disposed off in landfill.

With regard to hazardous waste disposal sites, at least five different routes of human exposure are possible:

i) direct ingestion through drinking

ii) inhalation of contaminants that volatilise from heated water

iii) absorption through the skin during washing and bathing

iv) ingestion through consumption of goods derived from plants or animals exposed to polluted groundwater, and

v) absorption through the skin when handling contaminated soil.

A worldwide awareness has been created amongst the public against the improper and uncontrolled dumping of hazardous wastes. Such practices have brought about the death of livestock and ill-health in humans.

Plastics are indispensable part of our life. These are not biodegradable, but can be reused and recycled. Yet, single-use plastic products such as bottles, bags, packaging materials and cups and plates thrown carefully pose a big problem in India. These clog drains and even kill animals that accidentally swallow it in to their gut. Their segregation and recyclable can solve the problem.

SAQ 5

Fill in the blanks using appropriate words:

i) Presently, the principal methods of industrial waste disposal in our country are :

a) Disposal along with …….....

b) Disposal in ..... areas

c) Disposal in river beds and …….....

d) Disposal into ..... and sea

e) ……..... burning

f) Burning in self-designed.....

ii) The principal hazard of improper waste disposal is the contamination of ……..... and …….....

iii) Some wastes pollute rivers or lakes and others contaminate ……..... and poison people.

iv) Certain harmful wastes may pollute the ……..... or create a ..... hazard.

10.7 SUMMARY

In this unit we have learnt that:

- As a basic principle, hazardous wastes should be so managed that adverse effects to the welfare of the community are minimised.
- Wastes can be reused or recycled, in order to minimise the volume of waste to be disposed. Toxic waste must be treated before disposal. This can be done using chemical, physical or biological means. After detoxification, the waste should be carefully transported avoiding mixing of non-compatible chemicals.
- This follows disposal of waste into a properly operated sanitary landfill. The waste can also be incinerated or dumped in underground salt mines.
- We have also learnt about the harmful effects of improper disposal of wastes in India as well as in other countries.
- Management of city waste with emphasis on minimisation, reuse, and recycling, is one of the best means of conservation of resources.

10.8 TERMINAL QUESTIONS

1. What is the difference between Toxic and Hazardous Wastes?
2. State if the following statements are True or False.

   i) Toxic refers to an extrinsic property.

   ii) Exclusive list system of waste classification has been followed in most of the countries.

iii) Oily sludge has to be landfilled.

iv) Hospital waste has to be incinerated.

v) Pollution control facilities do not generate hazardous waste.

3. What strategy should be adopted for hazardous waste management?

4. State the kind of chemical wastes which need special kinds of technologies if they are to be incinerated.

5. Give one example each of waste reuse and waste recycle.

6. Differentate between process oriented and pollution control oriented waste generation with suitable examples.

10.9 ANSWERS

Self-Assessment Questions

1. i. mutagenic, teratogenic, carcinogenic

   ii. a) ignitability b) corrossiveness c) reactivity d) radioactivity e) toxicity

   iii. a) Mortality, irreversible, reversible b) potential, treated, stored, disposed

2. A. i) d) minimisation, c) recycling, b) treatment, a) collection, transport

   ii) a) process, b) concentration, c) waste

   iii) reuse, recycling

   B. i) True ii) True iii) False iv) False

3. i. detoxified, neutralised, harmless

   ii. output stream, energy

   iii. lagooning, sludge drying, storage

   iv. conditioning, digestion, composting, thickening

   v. oxidation, volume

4. i. economic, properties, non-compatible

   ii. home, foul, smoke, harmful

   iii. landfills, non-porous, leaking

5. i. f) city refuse, e) low-lying, d) banks, e) estuaries, b) open-pit, a) incinerators

   ii. soil, groundwater

   iii. food

   iv. air, fire

Terminal Questions

1. **Toxic** refers to the capacity of a substance to produce injury, kill or impair an organism while **hazardous** refers to the probability that injury will result from the use of the substance.
2. i) False ii) True iii) False iv) True v) False vi) False
3. For an effective hazardous waste management system, the following strategy has to be adopted.
   i. Minimisation of hazardous waste generation by using low-waste or nonpolluting technologies.
   ii. The possibility of reusing the generated waste, either as raw material or for recovery of valuable products should be investigated before its ultimate disposal is considered.
   iii. The waste should be detoxified or neutralised through physical, chemical, biological treatment or sludge processing and solidification.
   iv. The unavoidable hazardous waste should be segregated from the nonhazardous ones and collected and stored separately. Finally, the hazardous wastes should be disposed off properly in a secured landfill site.
4. Wastes having chlorine, sulphur, nitrogen and phosphorus contents, polychlorinated biphenyls and those containing heavy metals and carcinogenic substances need special incineration technologies with due precautions.
5. Process wastes such as waste card board can be **reused** in paper industry for making paper pulp. An example of waste **recycle** is as follows. Baghouse dust from scrap steel process can be chemically reacted with waste sulphuric acid to make a useful fertiliser which is technically known as spent pickle liquor.

10.10 FURTHER READING

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Acknowledgement of Figures

1. Fig. 10.2: The richest one we have – our mountains of scrapped cars – offers a rich, inexpensive, and ecologically beneficial resource that can be "mined" for a number of metals.

   (Source: http://image.superstreetonline.com/f/editorials/smog-test-leg)

2. Fig. 10.5: Steps involved in the management of municipal solid waste.

   Source: CPCB Report on Management of Municipal Solid Waste

   (Source: http://image.superstreetonline.com/f/editorials/smog-test-leg)

3. Fig. 10.8: Possible mechanism through which hazardous substances enter the human environment after being disposed off in landfill.

   (Source: https://bawehali.files.wordpress.com/2011/06/landfill.jpg)

UNIT 11

GLOBAL ENVIRONMENTAL ISSUES

Structure

11.1 INTRODUCTION

This is the last unit of this Block on 'Environmental Issues and Concerns'. In Block 2, you must have acquired a good knowledge about the importance of various natural resources, their uses in development and the effect of developmental activities on the environment. More importantly, the need to properly manage the natural resources and environmental conservation have led to the concept of environmental quality management and use of eco-friendly technologies. In Unit 6, Block 2 biodiversity i.e. its value and services have been discussed in detail.

However, in this Block, we discussed the threats to biodiversity and its conservation in Unit 8. In Unit 9, we described the pollution of the environment and how the human health is being affected by the environmental pollution. This was followed by Unit 10 on 'Waste Management' where we focused our discussion on solid waste management.

With a wide exposure to various aspects of the environment in the previous units, it is quite appropriate now to know about various environmental issues which are a matter of concern for *people across the national boundaries*.

This unit covers *global* issues. These issues have become topics of hot discussions at various fora in last few decades. **Global issues** are so named because *their impacts and damages affect not only the countries that caused the problems but they go beyond their national boundaries and extend to the global scale.* Also, the solutions to these issues require efforts at the international level. In this unit, we would discuss some global issues such as *global warming* and *climate change, ozone layer depletion* and *acid rain*.

These **global issues** had been matter of debate for long. Here, we have discussed the causes as well as the effects of these phenomena and some of the measures taken to deal with these issues.

To meet the challenges posed by the above issues, measures have been initiated at international level in the form of conventions and treaties. Broad features of such conventions and treaties have been briefly enumerated in the unit at appropriate places. In addition, some useful websites have also been listed for further relevant information.

Thus, this unit is a window to the major global concerns. Let us start our journey and join hands to save the environment.

According to IPCC, the climate change is defined as a change in the state of the climate that can be identified (e.g., by using statiscal tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Expected Learning Outcomes

After completing the study of this unit you should be able to:

- ❖ define and list important global environmental issues;
- ❖ give reasons of global warming and relate it to the phenomenon of climate change;
- ❖ discuss the harmful effects of global warming and climate change;
- ❖ explain the causes and effects of ozone layer depletion;
- · describe acid rain, its causes and its harmful effects, especially on agriculture, environment, materials and buildings;
- ❖ discuss the impact of the above global issues on human communities and environment; and
- ❖ give names and objectives of various international conventions and treaties related to above environmental issues.

11.2 GLOBAL WARMING AND CLIMATE CHANGE

Climate refers to characteristic atmosphere conditions of a place over long periods of time. Climate can be classified according to latitude as **tropical, subtropical, continental** and **arctic**. It is also referred to as **Mediterranean, monsoon, desert** type etc. The **temperature** and **precipitation** are two important factors among others which influence the climate.

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The UNFCCC thus makes a distribution between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Solar radiation warms the Earth's surface and the atmosphere. About one-third of the radiation is reflected back into space, about 20% is absorbed by the atmospheric gases and the remaining amount reaches the earth surface and is absorbed by it. The energy so absorbed is remitted in the form of infrared radiation. The atmospheric gases absorb some of this radiation and hence do not allow all the emitted energy to escape into the space. Thus, some of the heat is trapped by these gases and the atmosphere becomes warmer. It is this phenomenon which raises the average temperature of earth from -18°C to +15°C and is very vital for life on the earth. The situation is analogous to a **greenhouse** which traps heat and its glass walls do not allow the heat to go out thereby increasing the inside temperature. Therefore, this effect is called **greenhouse effect**.

The gases such as carbon dioxide, methane, ozone, chlorofluorocarbons and

water vapours are responsible for greenhouse effect and are called *greenhouse gases*. The contribution of water to greenhouse effect being about two-thirds and that of carbon dioxide being about one-quarter. The other gases nitrogen (N_2), oxygen (O_2), argon (Ar) present in the atmosphere are incapable of absorbing infrared radiation. The concentration of water vapours in the atmosphere has not changed significantly but that of greenhouse gases has shown a marked increase since the industrial revolution. The anthropogenic (human) activities such as generation of energy from fossil fuels and deforestation have increased CO_2 concentration.

The increase in the concentration of CO_2 and other greenhouse gases leads to an **enhanced greenhouse effect**. This is casing an increase in the global temperature which is known as **global warming**. Studies suggest that temperature has already increased by 0.3°C - 0.6°C since 1860 and the last two decades of the twentieth century were the warmest particularly the year 1998. From 1850 onwards, the decade 2000-2010 had been the warmest one particularly the two years 2005 and 2010 were the warmest years.

This global warming would change global *climate patterns* and cause a *rise in sea levels*. It is estimated that the sea-level may rise by 0.5 m to about 1m.

The rise in sea level is due to thermal expansion of water in oceans and melting of glaciers and polar ice-sheets. This has serious implications for people living on coastal areas and islands.

The other effects of global warming being a *more vigorous hydrological cycle* which may cause more severe floods, rainfall and droughts and *ecological changes* affecting agricultural productivity and survival of forests. A warmer climate may also increase the *infections* or *diseases* such as malaria, dengue, yellow fever and viral encephalitis.

The increasing concern about the climate change led the World Meteorological Organisation (WMO) and United Nations Environment Programme (UNEP) to establish the **Intergovernmental Panel on Climate change (IPCC)** in 1988. Its First Assessment report was completed in 1990. The Third Assessment report (in 2001) includes results of research about the changes in climate up to the year 2000. It projects an increase in the surface temperature by 1.4°C – 5.8°C by the year 2100 which is higher than 1.0°C – 3.5°C as predicted in the Second Assessment report. Such a warming would be even greater than that which has occurred over last 10,000 years. If the rate of change is temperature is so fast then the ecosystems and organisms would not be able to adapt to the changed environment.

The Fifth Assessment Report was completed in November 2014. IPCC assessments provide a scientific basis for governments to develop climate related policies.

More detailed information is available at the following websites:

http://www.ipcc.ch/report/ar5/index.shtml

The UN General Assembly decided to launch negotiations in December 1990 which started in February, 1991. This led to the **United Nations Framework Convention on Climate Change (UNFCCC)** which was adopted in May

Some of the highlights of the 5th Assessment Report are as follows:

- Since the 1950s, many of the observed changes have occurred at a very fast rate. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.
- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983–2012 was likely the warmest 30-year period of the last 1400 years.
- Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.
- The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 0.19 m.

1992. It was ratified by 50 countries and came into force in March 1994. Till November, 2011, 194 countries and 1 regional economic organization (the Europian Union) became party to this convention. As of 5th Oct 2016, 144 Parties have ratified the Convention out of 197 Parties.

The UNFCC aims to *stabilise concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable the economic development to proceed in a sustainable manner.*

The Parties to the UNFCCC adopted the **Kyoto Protocol** in 1997 which requires the developed countries and economies in transition (Annex 1 countries) to reduce their overall emissions of greenhouse gases by 5.2% below the 1990 levels.

In July 2001, the Sixth Conference of Parties, COP 6 was held in Bonn where a political agreement was held to help the countries to move towards the adoption of Kyoto Protocol. This agreement was formalised in October-November, 2001 as **Marrakesh Accords** at the COP 7 held at Marrakesh, Morocco. The United States unilaterally withdrew but the compromises on key issues such as *funding, technology transfer, adverse impacts of climate change and response measures, flexibility mechanisms and compliance* were arrived at. The details of Marrakesh Declaration are available at

https://unfccc.int/cop7/documents/accords_draft.pdf

https://cop23.com.fj/knowledge/marrakech-accords-2001/

The full text of UNFCCC and Kyoto Protocol are available at.

https://unfccc.int/process-and-meetings/the-kyoto-protocol/what-is-the-kyoto-protocol/what-is-the-kyoto-protocol

http://unfccc.int/2860.php

http://newsroom.unfccc.int/

http://unfccc.int/kyoto_protocol/items/2830.php

The Eighth session of COP (COP 8) was held at New Delhi from 23rd October – 1st November 2002. The details of the *Delhi Ministerial Declaration on Climate change and Sustainable Development* and other decisions are available at web site http://unfccc.int/cop8/

The COP 21st meeting was held in Paris, France from 30th November to 11th December, 2015 and COP 22 was held from 7th to 18 November, 2016 at Marrakesh, Morocco. The COP 23 was organised by Fiji in Bonn from 6-17th November, 2017. The 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) was held from 2-14 December 2018, in Katowice, Poland. The main objective of the Polish Presidency at COP24 was to adopt a decision ensuring full implementation of the Paris Agreement (the so-called implementation package - the Katowice Rules).

India is party to the UNFCCC. It signed the treaty on 10th June, 1992 and

ratified the same on 1st November 1993. As the greenhouse gas emissions by India are not very significant and in view of the low financial and technical capacities, India does not have binding of greenhouse gases mitigation commitments.

The Ministry of Environment, Forest and Climate Change is the nodal agency for climate change issues. Various initiatives taken are available at the site http://www.moef.gov.in/

Other websites providing useful information on climate change are given below:

1) http://www.unep.org/climatechange/

2) http://www.moef.nic.in/ccd-napcc .

3) http://www.moef.gov.in/content/science-express-climate-action-special

The climate change would affect pattern of rainfall. This may cause floods in some areas while drought in others. The soil moisture may also change. As the climatic factors related to agricultural productivity would change; there would be serious implications on food production. The shortage of food production may lead to malnutrition in people and also the escalation of prices of food commodities.

India is also highly vulnerable to climate change. Our economy depends upon climate sensitive sectors such as agriculture and forestry. Also, our coastline is also densely populated and hence, is under potential threat by rise in sea-level. In case of any natural disaster, people are forced to migrate and there is a chance of heavy loss of human lives and property.

In June 2008, Government India laid down its National Action Plan on Climate Change (NAPCC). The National Action Plan on Climate Change identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively.

There are Eight National Missions which form the core of the National Action Plan, representing multi-pronged, long-term and integrated strategies for achieving key goals with reference to climate change.

This is to be achieved through the following eight missions:

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a Green India
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

As a second step, after the National Action Plan on Climate Change (NAPCC) was announced, all States were asked to prepare their State level action plan

to deal with the challenges of climate change. Broadly, the State level action plans are envisioned to be an extension of the NAPCC at various levels of governance, aligned with the eight National Missions.

You can see the following website for detailed information on the effects of climate change in the context of india:

http://www.terrin.org/climate/impacts.htm

SAQ 1

What are greenhouse gases? Give some examples.

SAQ 2

What is full form of UNFCCC?

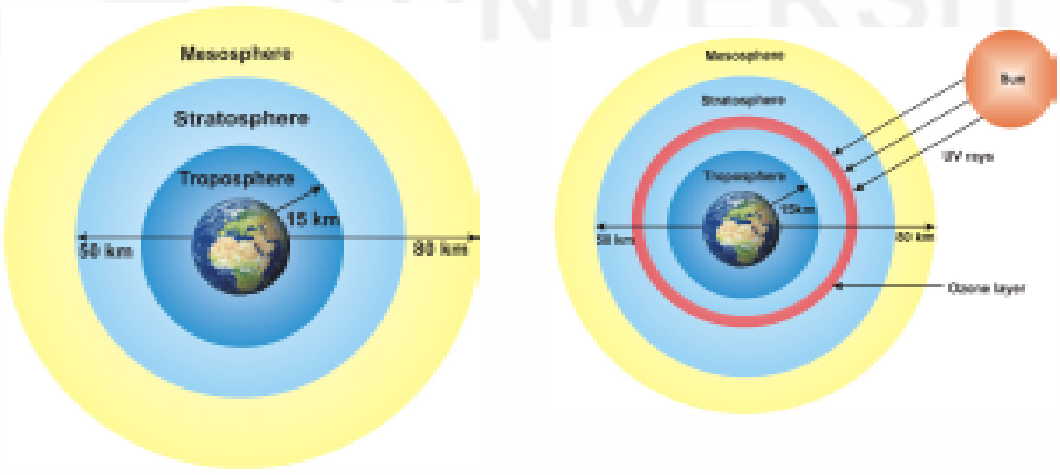
SAQ 3

Discuss the harmful effects of global warming.

11.3 OZONE LAYER DEPLETION

You know that our earth is surrounded by an envelope of atmosphere that contains nitrogen, oxygen, carbon dioxide, ozone, water vapours, dust particles and many other substances emitted as a result of human activities.

The atmosphere of the earth can be divided into three zones i.e. *troposphere*, *stratosphere and mesosphere* as shown in Fig. 11.1(a). The stratosphere extends from 15 to 50 km and the ozone layer is present in this region.



(a) (b)

Fig.11.1: (a) Various atmospheric zones and (b) Ozone layer.

The air we breathe in contains oxygen. In oxygen (O_2), two oxygen atoms are joined together whereas in ozone (O_3) three oxygen atoms are bonded together. The peak concentration of ozone is present in the stratosphere being

about 300 ppb (parts per billion) at about 25 kms near the equator and at about 15 kms in polar regions.

This ozone layer of the stratosphere absorbs about 99% of the ultraviolet solar radiation, Fig. 11.1(b). The ultraviolet radiation has wavelength between 0.1nm and 0.4 nm. It can be further sub-divided into UVA, UVB and UVC in the increasing order energy, see Fig.11.2. The UVB and C are highly energetic and are dangerous to the life on earth, whereas UVA is least energetic and is not dangerous.

UVA is not absorbed by the ozone layer in the atmosphere whereas most of UVB is absorbed and its only 2% to 3% reaches the surface of the earth. Thus, the ozone layer acts as a filter for UVB rays and protects us from the harmful effects of the UV radiation. UVC is absorbed by oxygen and also by ozone in the upper atmosphere.

The concentration of ozone is measured in *Dobson Unit* (DU) where one Dobson unit is equivalent to 1 ppb ozone. The measurements of ozone in the atmosphere began in 1957 by the British Antarctic Survey which in 1985 pointed out significant ozone depletion over Antarctica during spring. The data indicated a decrease in the ozone concentration from about 300 DU in 1970 to about 200 DU in 1984 which increased to around 250 DU in 1988 but dropped to approximately 88 DU in 1994. Thus, the general trend in ozone

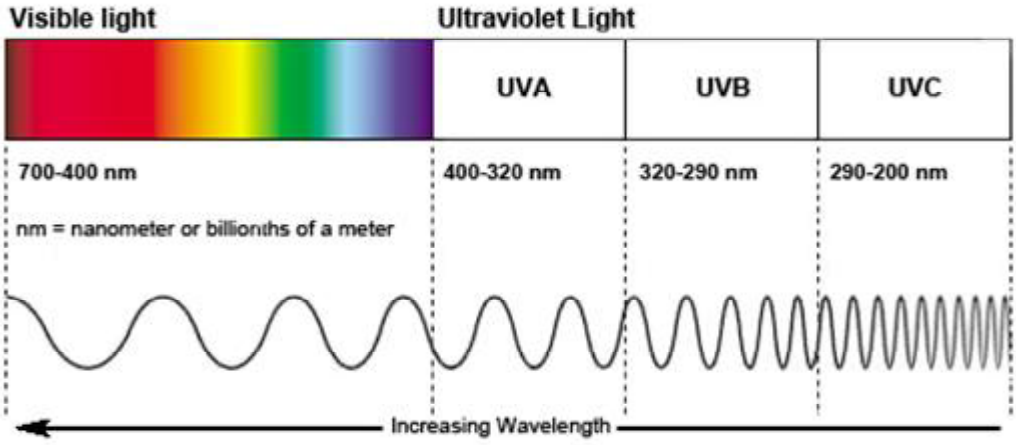


Fig.11.2: Various regions of ultraviolet radiation.

In 1974, Mario Molina and F. Sherwood Rowland suggested that Chlorofluorocarbons (CFCs) are responsible for ozone depletion. The CFCs were used as propellants in spray cans used for packaging shaving creams, hair sprays, deodorants, paints, insecticides etc. CFCs also find use in refrigeration, air conditioning and blowing of foams (used in furniture, bedding, packaging etc.).

The CFCs are very stable unreactive compounds. They are present in the

The group of compounds containing bromine and fluorine and one or two carbon atoms called Halons, are used as fire extinguishers whereas other chlorine containing compounds such as carbon tetrachloride (CCl_4) and 1,1,1–trichloroethane (CH_3CCl_3) are used as solvents and in dry cleaning.

lower region of the atmosphere where they can stay unchanged even for about 100 years as they have atmospheric life-times ranging from 75 to 140 years. When they reach the higher atmosphere, they are broken by the UV radiation and in this process, the highly reactive chlorine atoms are released from them. These chlorine atoms then undergo a series of reactions and deplete the ozone layer. The decrease in the concentration of ozone allows more UVB radiation to reach the earth which has harmful effects on human health, animals, plants, microorganisms, materials and air quality. Some of these are mentioned below:

Effect on Human and Animal Health: Exposure to UVB can cause cataract and skin cancer in humans. It also affects the immune system thereby increasing the risk of infectious diseases.

Effect on Terrestrial Plants: The UVB radiation also affects the physiological and development, processes in plants. The photosynthesis in plants may be impaired leading to decrease in size, the productivity and the quality in many species. It can also cause mutations in plants. Hence, the biodiversity would be affected.

Effect on Aquatic Ecosystems: As the phytoplankton are the starting point in the food chain, reduction in phytoplankton on exposure to UV radiation would affect the fish productivity. In addition, the UV radiation can also damage the early development stages of many aquatic animals.

Effect on Materials: UVB also increases the rate of degradation of polymers

Thus, the depletion of the ozone layer is a matter of concern world wide. An international convention was held in Vienna on March 22, 1985 which led to an international agreement on 16th September 1987 known as **Montreal Protocol** on substances that deplete the ozone layer. A schedule was agreed to completely phase out the ozone depleting substances (ODS), CFCs, Halons, $CHCl_3$ and CH_3CCl_3.

The UN General Assembly in January 1995 resolved that 16th September be observed each year as 'International Day for the Preservation of the Ozone Layer' to commemorate the signing of Montreal protocol.

India acceded to the Montreal Protocol on 17th September, 1992. Seven out of twenty substances controlled by the Montreal Protocol are produced and used in India. These are CFC-11, CFC-12, CFC-113, Halon-1211, Halon-1301, Carbon tetrachloride and 1, 1, 1-trichloroethane. The Ministry of Environment, Forest and Climate Change (MOEF) coordinates all matters related to the Montreal Protocol. An *Ozone Cell* has been set up to support and help in the implementation of Montreal Protocol. Many projects are being funded by Multilateral Fund established with UNDP, UNEP, UNIDO and World Bank as implementing agencies, to phase out Ozone Depleting Substances (ODS) and support activities.

In addition, the *National Ozone Unit* (NOU) is entrusted with monitoring and implementation responsibility. Many fiscal measures including exemption from customs and excise duties and other benefits have been announced by the Government of India to those entrepreneurs who are shifting to non-ODS technology. The regulatory measures include Ozone Depleting Substances (Regulation) rules, 2000 which have also been notified in the Gazette of India and cover several aspects of production, sale, consumption, export and import of ODS etc.

More information can be obtained from the following:

- Ministry of Environment , Forest and Climate Change, Ozone Cell,
  India Habitat Centre, Lodhi Road,
  New Delhi-110003.
  Email : ozone-mef@nic.in
  Website: http://www.ozonecell.com
  New website: http://ozonecell.in/

Other useful UNEP sites for the detailed text of Montreal Protocol and amendments, Parties, reports, events are:

http://www.unep.org/
http://ozone.unep.org/en/treaties-and-decisions/montreal-protocol-substances-deplete-ozone-layer
http://www.unep.org/ozone/treaties.shtml

In India, the production of CFC-11, 12 and 113 has been phased out from 1st August, 2008 and there consumption has been phased out from 1st January, 2010. For Carbon tetrachloride, the production and consumption has been phased out from 1st January, 2010 for Halon-1211 and 1301, the production and consumption has been phased out from 1st January, 2002. The consumption of methyl chloroform has been phased out from January 2001.

United Nations has released a report in November, 2018 which says that the ozone layer is healing, because of the steps taken such as decreased use of CFCs. The ozone layer above the Northern Hemisphere should be completely healed by 2030s. Over the Southern Hemisphere, it should be healed by 2050s. Since 2000, the ozone layer has increased by 1-3 percent in every ten years.

It would be interesting to watch the video given in the following link:

- https://www.youtube.com/watch?v=PXV6ppONgUk

SAQ 4

Ozone is present in which zone of atmosphere?

SAQ 5

What are CFCs? Why are they harmful?

SAQ 6

When is ozone day celebrated?

11. 4 ACID RAIN

To understand **acid rain,** we have to first know what is meant by an acid. According to Arrhenius definition of acids and bases, *acids* are those substances which release hydrogen ions (H^+) in aqueous solutions. Acids can

be described strong or weak acids. For example, hydrochloric acid (HCl) is a strong acid while acetic acid (CH_3COOH) (present in vinegar) is a weak acid. The strength of an acid is given by its pH value.

The pH of an acid is defined as follows:

$pH = - \log [H^+]$

where $[H^+]$ denotes the concentration of the hydrogen ions.

The pH scale ranges from 0 to 14. Acidic substances have pH less than 7 whereas basic substances have pH greater than 7. Water (distilled) has pH value of 7.0.

Even in the unpolluted environment, rain is slightly acidic and has pH of about 5.7. This is because atmospheric carbon dioxide dissolves in rain water and forms carbonic acid as shown below:

$$CO_2(g) + H_2O\ (aq) \rightarrow H_2CO_3\ (aq)$$

Carbon dioxide — Water — Carbonic acid

Carbonic acid is a weak acid and releases H^+ ions on ionisation as shown below:

$$H_2CO_3\ (aq) \rightleftarrows 2H^+ + HCO_3^-$$

Any form of precipitation such as rain, snow or fog is called **acid deposition** if it has pH less than 5.7. Acid deposition can be classified as ***wet deposition*** or ***dry deposition*****. Wet deposition** includes acids deposited in rain and snow or even fog. **Dry deposition**, on the other hand, refers to deposition of acidic particles and gases in the **absence of moisture.** These deposits stay on the surfaces of water bodies, buildings, vegetation etc. and get washed by the rain to the ground. This acidic water then causes damage the plants, soil and other forms aquatic of life.

The wet deposition in the form of **acid rain** or *acid snow* contain nitric acid and sulphuric acid which are formed by the reaction of oxides of nitrogen and oxides of sulphur, respectively, with water.

When fossil fuels such as coal or oil containing sulphur impurities are burnt, then oxides of sulphur i.e. sulphur dioxide (SO_2) and sulphur trioxide (SO_3) are produced. Similarly, when any organic matter with high nitrogen content is burnt, oxides of nitrogen (NO_x) i.e. nitric oxide (NO) and nitrogen dioxide (NO_2) are produced. The oxides of nitrogen also originate from forest fires, electric power plants and motor vehicles.

Besides fossil fuels, oxides of sulphur originate from natural sources such as volcanoes and forest fires. The decay of organic matter leads to the generation of hydrogen sulphide (H_2S) gas which also can get converted to sulphuric acid in the atmosphere.

These oxides are gases. These oxides such as SO_2 and NO_x on *atmospheric oxidation* and *reaction with water* give sulphuric acid and nitric acid, respectively as shown below:

$$SO_2 \xrightarrow[H_2O]{O_2} H_2SO_4$$

Sulphuric acid

$$NO_x \xrightarrow[H_2O]{O_2} HNO_3$$

Nitric acid

Both sulphuric acid and nitric acid are strong acids.

The acid precursors and the acids formed by them remain in the air and can move to large distances. This long range transport of acids can go beyond the boundaries of the nations from where these pollutants (gases) originated.

Hence, acid rain is regarded a global issue.

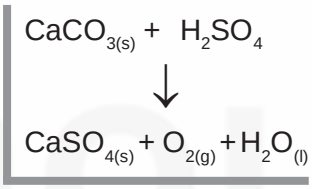
Effects of Acid Rain

The pH value of acid rain water is around 4. There are many damaging effects of such acidic water. These are discussed below:

Effect on Crops and Plants: The acid rain has detrimental effects on crops and forests. The acid rain can dissolve important minerals and nutrient present in the soil. Soil bacteria and fungi that play important role in nutrient cycling and nitrogen fixation are also affected. Thus, soil fertility is reduced and plant growth is affected.

Effect on water Bodies and Aquatic Life: Water bodies like lakes, rivers and ponds are also affected by the acid rain. The accumulation of acid in them over a period of time lowers the pH and affects the aquatic plants and animals. Many aquatic plants and different types of fish have different tolerance levels for such conditions and hence, cannot survive.

Effect on Human Health: The gases responsible for the acid rain and the acids present in acid rain can affect human health especially the lungs and the respiratory system. The dry depositions from air can cause heart and lung problems such as asthma and bronchitis.



Effect on Materials: Acid rain also damages bridges, buildings, statues and monuments. It can cause corrosion of metals and paints. Many historic monuments are under careful watch now. One such monument in India is Taj Mahal in Agra. The colour of Taj Mahal has already been affected. Buildings made of marble and limestones ($CaCO_3$) are affected by acid rain.

SAQ 7

What is the pH of normal (unpolluted) rain?

SAQ 8

Name the acids mainly present in acid rain.

SAQ 9

Why do buildings made of marble get discoloured over a period of time?

11.5 ACTIVITIES

1. Browse various websites related to the issues mentioned in this unit.
2. Make a list of useful websites other than those mentioned in the unit.
3. Participate/ Organise discussions, seminars, debates on these at appropriate fora and compile people's opinion on these issues.
4. Popularise, to the extent possible, these issues and concerns through schools/colleges/ universities/NGOs.

5. Display posters, banners etc. related to these issues in your locality / organisation to create public awareness.

6. Celebrate various occasions like the Environment Day, Ozone Day etc. actively in your locality/institution.

11.6 SUMMARY

- In this unit, we have tried to draw attention to various issues which are a matter of worldwide concern because of their harmful effects on human health and the environment.
- We have discussed some *global issues* such as global warming and climate change, ozone layer depletion and acid rain which are debated at various levels. These issues were briefly explained and their causes and effects on human health and environment were discussed.
- In all the sections of the unit, various agreements in the form of international conventions, treaties and protocols have been given to emphasise the measures taken to deal with these issues. Also, some useful websites have been mentioned at appropriate places so that more information can be obtained about various aspects of these issues.

11.7 TERMINAL QUESTIONS

1. Explain 'greenhouse effect'.
2. Discuss the effects of climate change with special reference to India.
3. Differentiate between dry deposition and wet deposition.
4. Name different zones of atmosphere.
5. Explain the harmful effects of UV radiation on human health.
6. What is ozone hole?
7. Why is normal rain acidic?
8. List the sources of oxides of nitrogen and sulphur in the atmosphere.
9. Briefly explain the harmful effects of acid rain.

11.8 ANSWERS

Self-Assessment Questions

1. Gases present in the atmosphere which absorb the radiation (heat) and do not allow it to escape are called green house gases. The examples of green house gases are carbon dioxide, ozone, methane and chlorofluorocarbons.
2. The full form of UNFCCC is United Nations Framework Convention on Climate Change.
3. Global warming will lead to climate change which can in turn affect the pattern of rain fall and soil moisture. The change in climatic factors related

to agriculture productivity would affect food production. The climate change would also cause rise in sea level which would be dangerous for the people living near the coast lines.

4. Stratosphere
5. CFCs are chlorofluorocarbons. They are harmful because they cause the depletion of the ozone layer.
6. 16th September
7. About 5.7.
8. Nitric acid and Sulphuric acid.
9. Buildings made of marble get discoloured due to acid rain in the due course of time because of the following reaction:

$$CaCO_{3(s)} + H_2SO_4 \longrightarrow CaSO_{4(s)} + CO_{2(g)} + H_2O_{(l)}$$

Terminal Questions

1. Greenhouse effect refers to a situation when the heat is trapped inside a system (such as the atmosphere of the earth) similar to that trapped in glass walls of a green house which cannot escape and, therefore, results in the increase in temperature of the system.
2. Climate change affects the pattern of rainfall and soil moisture. Since India is a country where the economy is largely based on agriculture, the change in rain fall patterns clearly affects the agricultural productivity. This will have serious implications on the crop yield. Also, lot of people live near the coast line. If the sea level rises, the lives of these people and human settlements near these areas would be badly affected.
3. Dry deposition means settling of acidic particles and gases in the absence of moisture. These deposits can settle on tree leaves, buildings and other places. Wet deposition means any type of precipitation in the form of rain, snow or fog.
4. Troposphere, stratosphere and mesosphere.
5. The UVB radiation can cause cataract and skin cancer in humans. It can also affect the immune system in humans which increases in the risk of infectious diseases.
6. The depletion or thinning of ozone layer is called ozone hole.
7. Normal rain is acidic because the atmospheric carbon dioxide dissolves in rain water and forms carbonic acid (H_2CO_3).
8. Oxides of sulphur originate from the burning of fossil fuels such as coal or oil which contain sulphur impurities. The oxides of nitrogen are produced when organic matter containing high nitrogen content is burnt.
9. Acid rain dissolves the important minerals and nutrients present in the soil and reduce the soil fertility. This affects the growth of the plants. It also affects the soil bacteria and fungi. The accumulation of acid rain in water

bodies affects aquatic plants and animals. The acid rain also the affects the fish population of the water bodies. In humans, acid rain can cause health problems related to lungs and respiratory systems. Acid rain also damages monuments, buildings, bridges, metals, paints etc.

11.9 FURTHER READING

- Environmental Science, G. Tyler Miller and Scott E. Spoolman, Cengage Learning, 16th Edition, 2018
- Environmental Science, Daniel D. Chiras, Jones & Bartlett Learning, 10th Edition, 2016.
- Links to Climate Change at
  http://enfor.nic.in/
- News related to global warming
  EPA Global Warming site: Newsroom
  https://www3.epa.gov/climatechange/
- Environmental News Network Special Reports on Climate Change and Global Warming

  http://www.enn.com/search/?q=special+report
- Intergovernmental panel on Climate Change

  http://www.ipcc.ch/
- http://www.nationalgeographic.com/environment/global-warming/ozone-depletion/
- https://www.ctc-n.org/
- http://www.unep.org/climatechange/
- https://www.epa.gov/ozone-layer-protection/health-and-environmental-effects-ozone-layer-depletion
- http://www.moef.gov.in/sites/default/files/GEF%20India%20Enabling%20Transformation_0.pd
- https://www.epa.gov/acidrain/what-acid-rain
- https://www.britannica.com/science/acid-rain

  http://timesofindia.indiatimes.com/life-style/health-fitness/health-news/pollution-turning-countrys-rainfall-acidic-says-study/articleshow/57462230.cms