Indira Gandhi National Open University
School of Sciences

ENVIRONMENTAL GEOGRAPHY

BLOCK

3

ENVIRONMENTAL PROBLEMS AND MANAGEMENT

UNIT 8
UNDERSTANDING POLLUTION

UNIT 9
AIR POLLUTION

UNIT 10
SOLID AND LIQUID WASTE

UNIT 11
BIODIVERSITY LOSS

GLOSSARY

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ENVIRONMENTAL GEOGRAPHY

BLOCK 3: ENVIRONMENTAL PROBLEMS AND MANAGEMENT

Environmental problems comprising air, water, soil, and noise pollutions are manifold in recent times. The increasing load of pollutants in environment has started posing prodigious challenges to the environmentalists and scientists as the level of pollution has reached such extreme levels that human beings are not able to get fresh breathable air, clean potable water and fresh food.

Today, the human species are considered as the higher form of life on the planet Earth because of the abilities that humans have the power of reasoning and communication. Therefore, we need to understand the severity of environmental problems and must take initiation to formulate management solutions for sustainability. The environmental problems not only destroy plant, animals and other organism's life but ultimately may kill the so called 'Homo Sapiens'. By considering the critical state of pollution, solid and liquid wastes, and loss of biodiversity, several countries have recently been promoted their efforts to address issues related to planning and management through science and technology. However, the progress of innovation in controlling the environmental problems is not yielding the desired success so far.

This block introduces you to the environmental problems and management dealing with the basics of pollution, air pollution, solid and liquid waste, and biodiversity loss in four units.

Unit 8: Understanding Pollution

This unit introduces the meaning, concept and types of pollution. Undesirable elements in the environment that cause health impacts not only to human beings but also the whole environment. The causes and effects of air, water, soil and noise pollution types are explained briefly in this unit.

Unit 9: Air Pollution

We see several natural and human made pollutants in our environment. They are interlinked in a particular way and affecting the atmosphere. To understand particularly air pollution, we have explained the sources and types of air pollutants, air pollution standards, effects and management of air pollution in this unit.

Unit 10: Solid and Liquid Waste

This unit introduces solid and liquid wastes. We have explained the wastes and their types and classification. Wastes are generated on a large scale because of human activities that affect public health and the environment as well. You will learn the effects of solid and liquid wastes and their management.

Unit 11: Biodiversity Loss

Biodiversity is important in ecosystem functions and their stability and is also essential for the survival of humankind. The concept of biodiversity and its loss, what are the factors affecting biodiversity loss, and measures that are to be taken for saving bio-diversity have been explained in this unit.

We hope after studying this block, you will better understand the environmental problems and management by studying pollution and its types, air pollution, wastes and the loss of biodiversity. Our best wishes are with you in this endeavour.

UNDERSTANDING POLLUTION

Structure

8.1 INTRODUCTION

You have studied about the concept of ecosystem and biogeography the relationship between human and environment in the previous Blocks of this course. Pollution existed since human civilization started using fire; but however, the severity of adverse impact of pollution and alertness towards these issues came to surface in recent times. Industrialization and the use of natural resources like coal and petroleum have aggravated the crisis of pollution. Indoor pollution seems to have been taken for granted by our previous generations. Around the middle of the twentieth century, large-scale expansion of industries and manufacturing, rapidly accelerating urbanization further aggravated and deteriorated the environment. The dawn of atomic weapons and other products of modern technologies intensified the situation to a shocking level. In this Unit, we are going to discuss the meaning and concept of pollution, sources and types of pollution and its effects on the human and their environment

Expected Learning Outcomes

After studying this unit, you should be able to:

- define the meaning and concept of pollution;
- describe the various types and sources of pollution; and
- explain the effects of pollution.

8.2   MEANING AND CONCEPT

The scientists and scholars have defined the pollution in their own terms. The term pollution is derived from the Latin word **"*Pollutionem*"** *which means to defile or make dirty*. Pollution is entry of unwanted elements in the environment. Pollution takes place in the form of solid, liquid and gaseous elements which adversely affects the human and environment. According to E.P. Odum (1971) pollution is "an undesirable change in the physical, chemical and biological characteristics of air, water and soil which affects human beings in various ways". Mishra (2006) defined pollution as "the introduction of substances or energy which are liable to cause hazards to human health, harm to living resources and ecological systems, damage to structure or amenity, or interference with legitimate use of the environment".

Major concepts in these definitions says that pollution is created by substances or energy that may be a result of human activities or natural catastrophes. Pollution is an increment added by human to bio-geo-chemical cycles. Examples of natural pollution are volcanic eruptions, forest fires, etc. Today, the problem of pollution has become a major provocation to scientists, environmentalists and humanists as the pollution of various types has gone to such a level that we are not able to inhale fresh air, drink fresh water and eat fresh food. If human beings have to survive, they need to fight and overcome this extensive and lethal trouble before it swallows them and their very persistence.

8.3   TYPES OF POLLUTION

You have now understood about pollution which could be in many forms. The presence of any pollutant, which is an agent or substace that can contaminate the Earth's sphere, in the environmnet is called as environmental pollution. According to Odum, the pollutants are of two categories: *Biodegradable Pollutants* and *Non-biodegradable Pollutants*. Biodegradable pollutants are those, which decompose themselves in natural processes during the course of time for example tree leaves, domestic wastes etc. Non-biodegradable pollutants are those, which do not decompose themselves and remains in environment for example plastics, pesticides, nuclear waste, etc. Pollutants can enter into environment through point source which includes sewage wastes, industrial effluents, chimneys, etc, or non-point source that discharge in large scale, for example, agricultural runoff, mining areas, construction sites, etc.

Figure 8.1 shows the four major types of pollutions include-:

- Air pollution
- Water pollution
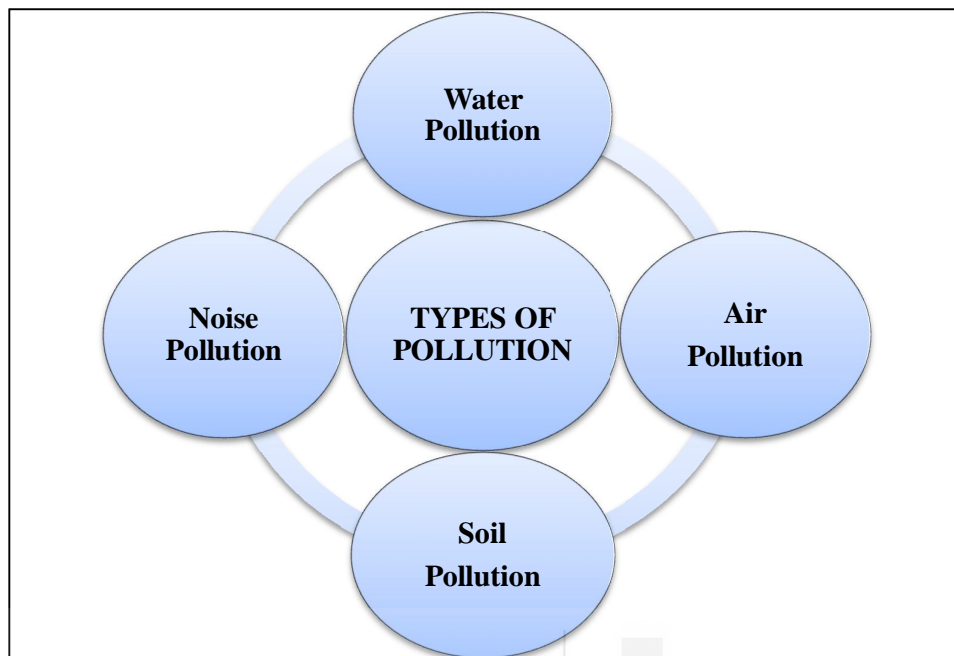- Soil pollution
- Noise pollution

Figure 8.1: Types of pollution

Let us discuss each type separately in the following sub-sections.

SAQ 1

What is pollution and its type?

8. 4   AIR POLLUTION

Do you know WHO says that air pollution is one of the biggest killer in Southeast Asia. Nobody is safe from air pollution in the world. United Nations warned that out of every ten people on the planet Earth, nine people are now breathing polluted air. Air makes our living planet breathe; it's the fusion of gases that constitute atmosphere, giving life to the plants and animals that make the Earth such a lively place to survive. **Air pollution** refers to physical, chemical or biological modification of the air in the atmosphere. Broadly speaking, it refers to the contamination of air enveloping the Earth's atmosphere. It includes both indoor and outdoor pollution. Air Pollution causes many diseases ranging from skin allergies to death of human beings. It may also harm other living organisms such as animals, vegetation and crops, and may degrade the natural or built-up environment.

Particles that pollute the air are called **pollutants**. Nitrogen oxides, hydrocarbons, sulphur oxides, and dust particles, carbon monoxides are few examples of pollutants. The sources of pollutants comprise human and natural activities which directly or indirectly emits these pollutants into the air, water, land and vegetation. The vehicles generates the pollutants, burning practices and smoke from forest fire, combustion-fired power plants, marine vessels, wood, coal, fuel or natural gas, burning fire places and stoves, furnaces, fumes from paints, chemical, dust and burning of crop waste are some of the processes that generates pollutants. Of all these pollutants, some are generated by human induced activities whereas some are natural. The

natural sources comprising the dry land areas without vegetation, forest fire, volcanic activities, etc. are natural sources which produces these pollutants.

8.4.1 Air Pollutants

Air pollutants are toxic elements which affect the quality of air and these pollutants are generated from various sources. Based on the size of the pollutants, these are classified into two categories. The size of pollutants are measured by;

a) **Part per million (PPM):** It is based on volume measurement and indicates the volume of pollutants contained in one million volume of air at standard temperature and pressure. The standard temperature is 25 degree Centigrade (^0C) and pressure is 760 mm.

b) **Micrograms per cubic meter (μg/m^3):** It indicates the mass of pollutants to the volume of air. One microgram is equal to 10^{-6} grams.

Carbon monoxide (CO_2), sulphur dioxide (SO_2), nitrogen oxide (NO), hydrocarbons, chlorofluorocarbons (CFCs), and particulate matters are some of the major types and sources of air pollutants. We will briefly explain you about some of these major air pollutants.

Carbon monoxide (CO_2): Carbon monoxide is very harmful and poisonous to all the living beings. This major pollutant is concentrated in living set-ups such as urban areas and it is generated from incomplete combustion of fossil fuels and fire power plants. Petrol or diesel vehicles exhaust the gases that contains high toxic CO_2 gas.

Sulphur dioxide (SO_2): It is a responsible compound behind the occurrence of acid rains in urban centres worldwide. About 90 per cent emission of sulphur dioxide comes from burning of fossil fuels, such as coal which contains 6 per cent of sulphur, ore smelters and oil refineries do also emit some amount of sulphur oxides.

Nitrogen oxide (NO): It is emitted from combustion of fuel in petrol or diesel vehicles. The oxides of nitrogen (NO_x) including nitrogen dioxide, nitric oxide, and nitrous oxide are responsible for causing acid rain. It leads to the development of haze like situation in urban areas.

Hydrocarbons: It comprises of various gases such as methane (CH_4), ethane (CH_6), propane (CH_8) and butane (CH_{10}). Hydrocarbon is naturally produced from decompositions of various organic matters and types of plants and trees. Hydrocarbon emitted from vegetation may be a major cause behind the smog in urban areas and large portion of hydrocarbon is generated by human activities.

Chlorofluorocarbons (CFCs): These are organic compounds comprising of chlorine, fluorine and carbon. CFCs can be sustained for long time in the atmosphere for nearly about 50 to 100 years. These are responsible for depletion of ozone layer resulting in the warming of earth's atmosphere and changing climates. They are used in air-conditioning, refrigeration, the manufacture of aerosol sprays and blowing agents in foams, etc.

Particulate matter: It comprises of solid particles, aerosols and these particles do not have any chemical composition and could be complex in nature. It includes smoke, soot, dust, asbestos fibres, pesticides and combination of ammonia, with either sulphuric or nitric acid are also part of particulate matter.

8.4.2 Causes of Air Pollution

a) ***Burning of fossil fuels:*** Pollutants like smoke, carbon dioxide (CO_2), carbon monoxide, nitrous oxide emitting from vehicles including trucks, jeeps, cars, trains, airplanes into the atmosphere leads to the emission of enormous amount of pollution.

b) ***Mining activity:*** Mining is a process in which minerals below the Earth's surface are extracted. During this process, dust and chemicals are released in the air causing massive air pollution.

c) ***Indoor air pollution:*** Household cleaning products, painting supplies emit toxic chemicals in the air and cause indoor air pollution.

d) ***Agricultural activities:*** Insecticides, pesticides and other agricultural chemicals generates a huge amount of air pollutants. They emit harmful chemicals into the air and often lead to air pollution. Stubble burning also creates the air pollution soon after the paddy harvest. Farmer's burns their crop residue to clear the agricultural fields for sowing next crop also belongs to this category.

8.4.3 Effects of Air Pollution

You would be knowing that the air pollution kills about 800 people every hour, accounting for more than 3 times people dying of malaria, tuberculosis and AIDS combined each year. More than 90 per cent of children live in air polluted areas which exceeds the World Health Organization (WHO) guidelines across the world. The air pollution affects not only the health of human beings but also poses danger to other life forms on the Earth.

a) ***Global warming -*** It is a process of warming of the Earth's surface leading to the rise in temperature, sea level rise and melting of glaciers. Warming of the land and sea surface are the major cause behind the happening of disasters severely affecting the human beings. These disastrous conditions had already displaced many inhabitants from their native places worldwide. So, we need to take steps for preventing global warming to conserve our precious environment.

b) ***Acid rain -*** Due to burning of fossil fuels, dangerous gases like sulfur and nitrogen oxides are ejected into the atmosphere. The water droplets in the atmosphere combine with these air pollutants which falls in the form of acid rain on the ground. Acid rain causes immense damage to human beings, animals, natural vegetation and agricultural crops.

c) ***Respiratory and heart troubles*** - Millions of people die due to direct or indirect effects of air pollution. Children are exposed to air pollutants and they commonly suffer from respiratory infections, pneumonia and asthma etc.

d) *Depletion of ozone layer -* Ozone layer is depleting due to the presence of chloro-fluoro-carbons and hydrocarbons in the atmosphere. As ozone hole is increasing, the amount of incoming solar radiation is also increasing, which may cause various skin infections and eye problems.

SAQ 2

a) Name two pollutants of air.

b) What are the major causes of air pollution?

8.5   WATER POLLUTION

You might have known that the water covers 70 per cent of the Earth and only 2.5 per cent is fresh water i.e. drinkable. Water is a very important natural resource for mankind and the environment. As Earth's population continues to grow, people are putting great pressure on the planet's water resources. Let us now understand the water pollution. **Water pollution** occurs when pollutants (chemicals or chemical particles that make water contaminated) are is charged directly or indirectly into the water bodies without proper scientific treatment to get rid of harmful compounds (Eschool today, 2016). So, in simple language, we can say that poorer quality of water is highly unsafe or harmful to humans and other living things referred to as water pollution. Both the anthropogenic and natural phenomena are affecting the quality of water over the surface of the Earth. The human activities such as solid waste disposal, toxic or waste water, sewage flow are polluting the water. Water pollution is affecting rivers, lakes, oceans and quality of drinking water all over the world. It affects not only human beings but also functioning of ecosystems that prevails in the water. It was identified that 80% of the water pollution is caused due to domestic sewage. There are mainly three types of water pollution commonly identified are groundwater pollution, surface water pollution and Seawater pollution.

8.5.1 Groundwater Pollution and its Source

The use of ground water has been increasing with the passage of time due to rising water demand. The human concentration in urban centres has created a great pressure on these water sources. The ground water pollution is happening because of harmful human activities such as hazardous waste disposal system, faulty agricultural practices and improper use of fertilizer causing groundwater pollution.

The pollutant which affects the quality of groundwater comprises pathogens, nitrogen, chloride, sulphate, dissolved organic carbon, heavy metals, halogenated solvents, fuels and lubricants, etc. which are generated from various sources. The sources of pollutant comprises the underground storage tanks, septic tanks, landfill sites, large industrial facilities, fertilizer applications, spills, pesticide applications, hazardous waste sites, surface impoundments, salt water intrusion, sewer lines, shallow injection wells, mining and mine drainage, waste piles, etc All of these are sources which generates the pollutants that affects the quality of ground water. The storage

tanks, septic tanks and landfill sites are major sources among all these sources of pollutants.

8.5.2 Surface Water Pollution and its Source

The surface water pollution comprises pollution of major water sources. This includes oceanic and land surface and both are interlinked for the pollution because most of the pollutants are carried by river into the oceans. The rivers, lakes, ponds, etc. are polluted majority because of anthropogenic activities. Human beings discharge the polluted water into it through different modes. Construction activities, construction of dams and reservoirs, recreational works, industrial uses, irrigation, sewers, etc. produces enormous quantity of pollutants that is sufficient to pollute all these sources of water.

Drain water going to rivers directly without or with partial treatment, pesticides, herbicides, and chemicals, bacteria from sewage or livestock operation, food processing waste such as pathogens, heavy metals from industrial effluents and chemical wastes like sulphur dioxide, fertilizers including nitrates and phosphates and silt in storm water run-off of major sources of water pollutants over land areas. .

8.5.3 Seawater Pollution and its Source

Ocean water is polluted because of huge transportation of cargo ships, oil spills, and oil mining and military practices and testing of weapons in the oceans. These anthropogenic activities are creating pollution in the oceans. The natural activities such as volcanic eruption, discharge of massive amount of waste into the oceans that changes the chemical and ecological status of water.

The pollutants like mercury, arsenic, chromium, selenium, etc metals affect the chemical and biological composition of oceanic water. Sedimentation is another major cause of oceanic water pollution. Research studies noted that nearly 6 million pounds of garbage, mainly plastic end up piling in the oceans every year.

- *Mercury*- It is a major pollutant over the Earth's surface and is widely found in the environment.

- *Arsenic*- It is extensively spread on the Earth's surface and it is found during the dissolution of ores and minerals. It is used in the by- products of mining, coal burning and copper melting.

- *Chromium* - It is found in ores deposited by nature and is an industrial element which is used for protective coating on the other metals. Besides it is also used in cement, paint, paper etc.

- *Selenium* - It occurs in nature as selenite and with combination of sulphide, copper, lead, nickel, silver etc. Selenium has overwhelming effect on both terrestrial and marine life.

- *Sediments* - The erosion in the upper reach of the rivers bring large sum of sediments into the oceans that degrade the quality of water. The sedimentation into the ocean affects the marine life of the ocean. The

process of wildfire, deforestation, logging, overgrazing, construction activities, mining operations and landslides produces huge amount of sediments that eventually gets directly or indirectly disposed into the sea or oceans.

8.5.4 Causes of Water Pollution

a) *Industrial misuse:* Industries generate massive quantity of waste which contains toxic chemicals. They contain pollutants such as lead, mercury, sulphur, nitrates, etc. Lots of industries do not have appropriate waste managing system and drain the waste into the fresh waterbodies, rivers, canals and finally into the sea.

b) *Mining activities:* Mining activities release a number of metallic, mining waste and sulphides from the rocks which are the cause of water pollution.

c) *Oil leakage:* Oil leak from the tankers of the ships and large liners in huge quantity enters into the sea and pollute the sea water affecting marine animals and plant life including birds.

d)   *Leakage from the landfills:* Landfills are huge mound of garbage. When it rains, the landfills leak and pollute the underground water with huge variety of contaminants.

8.5.5 Effects of Water Pollution

a) *Health:* Intake of polluted water is one of the most important cause of ill-health. Polluted water sources are the cause of the lethal diseases like cholera, dysentery, diarrhea, jaundice, etc. Most of the diseases of the digestive system in India are caused by polluted water. Toxic pollutants mainly consist of heavy metals, pesticides and many other pollutants. The ability of waterbody to support aquatic life, as well as its fitness for other uses depends on many trace elements. Some metals may lead to severe toxic effect on human health, animals and the aquatic life.

b) *Environment:* All organic materials have been broken down or decomposed by micro-organism and other biological activity (biodegradation). Organic and some of the inorganic compounds show a biochemical oxygen demand (BOD) because oxygen has been used for its degradation process. All aquatic life is almost dependent on oxygen, therefore, aquatic life releases negative or adverse effects in water. The sewage from domestic and animal sources and industrial wastes such as food processing, paper mills, tanneries, distilleries, sugar and other agro- based industries are typical source of pollution (Chand, 2016).

SAQ 3

What are the impacts of water pollution on human health?

8.6   Soil Pollution

Soil pollution comprises of presence of human induced chemicals and other modifications in the soil. Human activities of using fertiliser, insecticides and

pesticides are major elements which affect the quality of soil. Mining, agriculture and deforestation are important energy intensive activities that impacts the soil directly or indirectly. Modern agricultural production requires the use of excessive quantity of fertilizers and pesticides. The solid wastes leaching of waste from landfill sites, or direct discharge of waste in the soil leads to soil pollution.

There can be serious consequences of soil pollution. It affects humans, animals, plants and water as well. The effects are very disastrous, if the garbage is not segregated into organic and recyclable waste. Infected soil may lead to many types of cancer, cause problems in the human respiratory system and problems of skin diseases. Landfill sites also cause serious problems like foul smell and becomes the site of breeding of mosquitoes and flies which usually act as vectors for carrying the parasites and virus. It also breeds rodents like rats, insects and mice who in turn spread diseases and often becomes the cause of spreading epidemics.

8.6.1 Causes of Soil Pollution

The sources of soil pollution consists of various elements that produce pollutants. These may include petroleum, hydrocarbon from rupture of underground storage tanks, leakage of dry cleaning chemicals, leaching of pollutants from landfill sites, surface water runoff that carries pollutants, percolation into soil from open source insecticides and pesticides etc.

a) *Surface mining:* Mining of coal and metallic ores provide huge amount of soil pollutants. Industries that mine and process ores, drills for oil and gas or burn coal also generate large volumes of hazardous wastes. Mining produces wastes like sodium, calcium, sulphate, chloride and carbonate, etc. which becomes the cause of soil pollution.

b) *Deforestation:* Deforestation is felling and clearance of trees and conversion of forested tracts into other type of landuses. The process of deforestation results into many undesirable environmental impacts on soil stability and soil quality. It also increases the instability in soil, increases erosion and brings reduction in biodiversity. Deforestation process decreases the water holding capacity of the soil and loosens the soil particles that also increases the potentiality of soil removal.

c) *Salinity*: Acids in soil are naturally found, but it is increasing by the use of acid forming fertilizers. The increased soil salinity has negative effect on structure, microbial diversity and plant active soils. The soil salinity can be measured by electrical conductivity of water saturated soil. Salt affected soil not only adds to environmental pollution but also reduces the quality and productivity of soil.

d*) Soil erosion:* Soil erosion is a natural process but is largely accelerated by human activities. Removal of top layer of soil is known as soil erosion. Running water and wind are active agents of gradation which causes soil erosion. Different chemicals like preservatives, insecticides, pesticides, fuels, and other industrial and agricultural chemicals absorbed by the soil particles also degrade the quality of soil particles.

e) *Fertilizers:* It plays a very important role in augmenting agricultural production. Fertilizers comprises of several elements such as carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), boron (B), copper (Cu), chlorine (Cl), Manganese (Mn), molybdenum (Mo), zinc (Zn), cobalt (Co), and nickel (Ni). Healthy agricultural production depends on the proper application of all these fertilizers but increase in any one of these leads to will hamper agricultural productivity and ultimately soil pollution.

f) *Pesticides:* Now a day's extensive use of synthetic pesticides are commonly used for raising agriculture production. Although, the productivity increases but the quality and composition of soil changes.

g) *Animal waste:* The concentration of animal waste can make the soil polluted and many a times, animal concentration crumbles the soil composition through grazing.

8.6.2 Effects of Soil Pollution

a) *Health:* Plants grown on polluted soil transfers the same to the human beings. This may badly affects the health of the people. Soil pollution may cause muscular blockages, skin infections and breakdown of the nervous system. Human beings are affected indirectly by these pollutants. They suffer from problems like food poisoning as they consume vegetables grown from infected soils. High absorption of mercury and lead may lead to kidney and liver diseases.

b) *Air and water contamination:* Polluted soil causes air contamination by releasing unstable compounds into the atmosphere. So, more the toxic contaminants in the soil, higher is the level of toxic particles emitted into the atmosphere. Soil pollution can also lead to water pollution if the hazardous heavy metals percolate into the groundwater. It may also pollute storm water runoff, by transporting harmful chemicals into the lakes, streams, rivers or oceans.

c) *Increase in soil salinity:* Salinization, is an effect of salt accumulation in the soil. Rising accumulations are linked to soil pollution. Unscientific agricultural practices and irrigation discharge, nitrate and phosphate into the soil contributes to increasing levels of salt in the soil. Increased salinization may not allow the plants to absorb moisture and will cause groundwater pollution.

SAQ 4

a) What is soil pollution?
b) How salinization effects the soil?

8.7   NOISE POLLUTION

You now really need to understand the research studies which shows that the oceans are 10 times noisier today than 40 years ago. It is the troubling noise which may harm the stability of humans or animal life. Noise pollution is

mainly caused by loud music, people talking over phone, machines, transportation systems, vehicles, trains, and aircrafts and improper urban planning and designing of structures etc. Even electrical appliances at home have a beeping noise. Understanding noise pollution is necessary to curb it in time in order to avoid health related problems.

8.7.1 Causes of Noise Pollution

a) *Inappropriate urban planning*- The crammed houses, large families sharing small space, fight over parking space, and frequent arguments over basic amenities leads to noise pollution which may disrupt the environment and society as well.

b) *Social occasions*- Noise hit the highest point in most of the social events whether it is parties, marriage, pub, disc or place of worship. In markets, you can see people selling clothes by making loud noise to catch the attention of buyers. People play songs on full volume and dance till late nights which makes the condition of people living nearby pretty worse.

c) *Industrialization*- Industries use big machines which produce large amount of noise. Various equipment like generators, compressors, grinding mills and exhaust fans also contribute in producing huge noise.

d) *Household activities*- Electronic gadgets like mobile, Television, pressure cooker, mixer grinder, washing machine, vacuum cleaners, cooler, air conditioners are contributors to the noise pollution inside and outside the rooms.

e) *Transportation*- Huge number of vehicles on roads, airplanes flying over residential areas, underground trains produce a lot of noise. This leads to a condition where in a normal person loses the ability to hear properly become of noise.

8.7.2 Effects of Noise Pollution

a) *Health problems*- Too much noise pollution in working areas such as offices, construction sites, bars and even in homes may influence our psychological and mental health. Many studies have indicated that the aggressive behavior, disturbance of sleep, constant stress, fatigue and hypertension are closely associated with excessive noise levels. These may further cause chronic health issues for particularly in the elderly population.

b) *Sleeping disorders*- Loud noise disturbs sleeping pattern and may cause irritation to human beings as well as to the animals and birds. Lack of good night sleep, might lead to problems like fatigue and may affect work performance in the offices and home as well.

c) *Problem of communication*- High volume of noise may not allow two people to communicate properly. Constant blunt noise can give you severe headache and might upset your emotional balance.

SAQ 5

a) What are the things that causes for noise pollution?

8.8   SUMMARY

In this unit, you have studied so far:

- Pollution can be natural or anthropogenic or both. There are mainly four types of pollution identified which includes air, water, soil and noise pollution.

- The contamination of air through various pollutants like nitrogen oxides, hydrocarbons, sulphur oxides, dust particles and carbon monoxides is referred as air pollution.

- The pollution of air mainly occurs due to burning of fossil fuels, mining, and unscientific agricultural practices. Air pollution not only affects human health but also leads to global warming and acid rains.

- Water is polluted through construction activities, discharge of industrial effluents, untreated or partially treated sewage, chemical wastes, excess utilization of fertilizers and pesticides, leachates from landfill sites, leakage of oils in the oceans, and so on.

- Understanding of noise pollution is also essential. The main causes of noise pollution are faulty urban planning, social occasions, industrialization, household activities, and transportation etc.

- The problems associated with pollution are diverse in nature and some of them are acknowledged. But, still it is important to keep a close control on pollutants. It will ensure the healthy living environmental conditions for future generations.

- Adoption of green technology is an effective solution to the problem of pollution.

You will study more about air pollution, solid and liquid waste, and loss of biodiversity in coming units of this block.

8. 9   TERMINAL QUESTIONS

1.   What is pollution? Explain major types of air pollution?

2.   What causes air pollution and water pollution?

3.   Why pollution is considered as a problem?

4.   What are the causes to the problem of noise pollution?

8.10   ANSWERS

Self-Assessment Questions (SAQ)

1. Pollution is the entry of unwanted elements into the atmosphere. Types of pollution are air, water, soil and noise.

2. a) Particulate Matter, Sulphur Dioxide.

b) Burning of fossil fuel, mining activities and so on.

3. Drinking of polluted water can adversely harm the digestive system, and cause many diseases like cholera and diarrheic, etc.

4. a) The presence of harmful chemical can modify the texture and structure of soils which causes to soil which cause to soil pollution.

   b) The increased level of salts in soils is linked to the soil pollution

5. Noise pollution is caused mainly by loud music, machines, vehicles, trains and air-crafts etc.

Terminal Questions

1. The term pollution refers to any substance that negatively affects the environment or the organisms that stay within the natural environment. Different types of pollution includes air pollution, noise pollution, water pollution and soil pollution. Refer to sections 8.2 & 8.3.

2. Majority of the air pollution is caused by burning of fossil fuels for e.g. fossil fuels, coal, oil, natural gas and gasoline to produce electricity and drive our vehicles. Water pollution is caused by disposal of sewage, waste, industrial residues, open source chemicals, herbicide, pesticides and fertilisers etc. into the water. Refer to subsections 8.4.2 & 8.5.4.

3. Air and water pollution causes damage to crops, vegetation and water bodies. The negative effect of air pollution also includes formation of acid rain that adversely affects trees, river water, wildlife and soils. The negative effects of pollution include changing climates, formation of haze, and smog over cities etc. Refer to sections 8.4 to 8.7.

4. Refer to Section 8.7.

8.7   REFERENCES/SUGGESTED FURTHER READING

- Chary, S.N. (2008). *Environmental Studies.* Delhi: Macmillan Publishers.

- Eckholm, E.P. (1977). *The Picture of Health - Environmental Source of Diseases.* New York : W.W. Norton

- Mishra, Archana (2005). *Environmental Studies: System & Solutions.* New Delhi: Selective & Scientific Books.

- Mishra, S.P. (2006). *Environmental Pollution*, Jaipur: India Aavishkar Publisher.

- Pepper, I. et al. (2006). *Environmental and Pollution Science.* New Delhi: Academic Press.

- Anand, S. (2010). *Solid Waste Management.* New Delhi: Mittal Publications.

- Avon, Joan L. and Jonathan, A. Patzed (2001). (eds) *Ecosystem Changes and Public Health*. Baltimin: John Hopling Unit Press.

- Bradley, D. (1977). Water, Wastes and Health in Hot Climates. John Wiley Chichesten.

- Christaler, George and Hristopoles, Dionissios (1998). *Spatio Temporal Environment Health. Modelling*. Boston: Kluwer Academic Press.

- Goudie A., 2001: *The Nature of the Environment.* Blackwell: Oxford.

- Holechek, J. L. C., Richard, A., Fisher, J. T. and Valdez, R., (2003) *Natural Resources: Ecology, Economics and Policy*. New Jersey: Prentice Hall.

- Singh, S. (2015). *Environmental Geography*. Allahabad: Pravalika Publicaitons.

- Smith, W. H. (1989). *Air Pollution and Forests*. Springer.

- Chand, S. (2016). 6 *Major adverse effects of water pollution. http://www.yourarticlelibrary.com/water-pollution/6-major-adverse-effects-of-water-pollution/19766/ accessed on 3/12/2016.*

UNIT 9

AIR POLLUTION

Structure

9.1 INTRODUCTION

In the previous Unit, you have studied about the pollution and its types such as air pollution, water pollution, soil pollution, and noise pollution in general. Now in this Unit, we will explain you about air pollution in particular. We have explained the sources and types of air pollutants in Section 9.2. The industries are mainly responsible for adding a large amount of pollutants in the atmosphere. For the public health perspective and otherwise also, we essentially need to maintain the air quality. For which, the standards of air pollution suggested by the various organizations are discussed in Section 9.3. Air pollutants may cause severe or deadly health risks not only to the human beings but also animals and other forms of life. Section 9.4 gives you an idea with regard to the adverse effects of air pollution. There are some management issues related to air pollution which are explained in Section 9.5.

Expected Learning Outcomes

After studying this unit, you should be able to:

* describe the sources and types of air pollutants;
* explain the standards of air pollution;
* elucidate effects of air pollution, and
* explain management strategies in controlling air pollution.

9.2   SOURCES AND TYPES OF AIR POLLUTANTS

You just recap about the air pollution which is briefly explained in the previous unit. Air pollution may be defined as "*the presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants and animals*". Pollutants harm the natural environment either by increasing the levels of contaminants or by introducing harmful toxic substances. Physical and chemical properties of pollutants are different in nature, explaining the discrepancy in their capacity for producing toxic effects. Central Pollution Control Board (CPCB) of India defined air pollution as "*the existence of more than one contaminant in the atmosphere, in such concentration, for such a period as it is harmful or tends to be harmful, to human beings, animals and plants life*".

The pollutant air comes from both the natural and human-made sources. Rapid industrialization, haphazard growth of population, drastic increase of vehicles on the roads and other activities of human beings as well as natural processes like forest fire or volcanic eruption, etc. have been contributing pollutants in the air and are severely disturbing the balance of natural atmosphere. An air pollutant is a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made.

9.2.1 Sources of Air Pollutants

Pollutants are released from both stationary sources and non-stationary sources. Stationary sources includes commercial and industrial facilities, for example, thermal power plants, chemical plants, paper factories and the municipal waste areas whereas non-stationary or mobile sources comprise of ships, aero planes and automobiles. Air can be polluted through natural processes or by human-made activities. Some of the known natural sources of air pollution are:

- Volcanic eruptions
- Forest fires
- Biological decay
- Radioactive materials
- Pollen grains etc.

You must understand that the natural factors plays a significant role in generating air pollution and some of them are not under human control. Smoke from burning forests and grasses, and also dust storms from desert areas work as pollutants and make the air pollution. Source may be of from a particular country but the effect of the pollution may be felt at global level or everywhere. Volcanic eruption is one of the natural sources of air pollution. The huge amount of volcanic ash and toxic materials from the active volcanoes mix into the atmosphere resulting into the deterioration of quality of air.

Human activities also called anthropogenic activities like burning of fossil fuel, burning of firewood and cow dung, manufacturing industries, mining and construction as well as blasting for construction materials etc. generate a lot of pollutants like carbon monoxide, carbon dioxide, oxides of nitrogen, oxides of sulphur, hydrocarbons, ozone, dust particles and other particulate matters. On the other side, using generators or air conditioners (ACs), burning of wastes, dust from roadside and construction, vehicular movement also generates air pollutants in large amounts.

Following are some of the important sources which generate air pollutants:

- Industries
- Fossil Fuel
- Mining
- Power plants
- Automobiles
- Agro-chemicals

Pollutants from Industries

The industrial units dealing with manufacture of explosives using concentrated nitric and sulphuric acids release thousands of tons of oxides of nitrogen and sulphur into the atmosphere. Industries also release thousands of tons of carbon dioxide into the atmosphere. Caustic soda manufacturing units are responsible for release of chlorine into the atmosphere. Various metallurgical processes are responsible for introducing carbon monoxide, carbon dioxide, hydrogen sulphide and metal particulate into the nature. Polymers and plastics, asbestos, and tobacco are some of the important industries with highly specialized products contributing to the air pollution.

Pollutants from Fossil Fuel

Fossil fuels include crude oil, coal, petroleum, natural gas, etc., occurring naturally in underground reservoirs as they formed from the fossilized, buried remains of plants and animals over the course of millions of years. Fossil fuels generally have rich carbon content. Crude oil can also be found embedded in shale and tar sands. Petrol, diesel, kerosene, gasoline, liquefied petroleum gas, and other non-fuel products such as pesticides, fertilizers, pharmaceuticals, plastics, etc. are produced through the processing of crude oil which is done in oil refineries. Oil particularly petroleum is recognized as a major source of greenhouse gas emissions. Coal is primarily used to generate electricity and the combustion of coal releases air pollutants like sulphur dioxide, nitrogen oxides and mercury. Natural gas burns cleaner than oil and coal, releases with less carbon dioxide but high methane which is however, more than 20 times as effective as carbon dioxide.

Pollution caused by these petrochemical industries at different stages, are as follows:

❖ During drilling some of the low boiling fractions escape into the atmosphere and spill on the land. In case of drilling from below the surface of oceans, crude oil may be spilled on the surface of water and may be swept by the ocean currents to distant places.

137

❖ During transportation of crude oil, there is spilling or leakage particularly occurring in oceans by the tankers.

❖ During fractional distillation in the refineries, a number of fractions find their way into the atmosphere due to leaks or poor recovery that can lead to serious health problems.

Pollutants from Mining
Mining is the process used to extract minerals from the Earth's surface. Processes associated with mining such as blasting, digging, loading and unloading including transportation contribute a lot of dust which pollute the air. The vegetation and top-soil gets destructed by the mining process ultimately causing severe environmental damage. You might observed in several mining places the contamination of surface waters, rivers and streams, and ground waters by mine wastes due to mining activities. Coal, mica and other mining ore industries contribute a lot of mining dust to the air causing severe air pollution.

Pollutants from Power Plants
Power plants are used for generating power or electricity. In most of the conventional power plants, the source of energy is coal. Burning of coal in the power plants contribute carbon dioxide, carbon monoxide and sulphur dioxide as pollutants to the atmosphere. With the advancement of knowledge, nuclear energy is now being used to produce electricity at a much cheaper rate. However, the maintenance and management is crucial in the establishment and generation of nuclear power plants.

Pollutants from Automobiles
Automobiles mostly run on petrol or diesel. The exhaust gases from automobiles inject a number of gaseous pollutants like carbon monoxide and carbon dioxide, etc. In fact, automobiles are major contributors of atmospheric pollutants.

Pollutants from Agrochemicals
The agrochemicals include variety of fertilizers and pesticides, insecticides and fungicides, etc. that causes severe air pollution. The consequences of an increased use of agricultural chemicals are noted either witnessed in short-term or long-term health effects including symptoms like headaches, skin rashes, eye irritations and some chronic effects e.g. cancer, endocrine disruption, birth defects, etc.

9.2.2 Types of Air Pollutants

You now know the various sources of air pollutants. Now, you will study the toxic elements also called air pollutants which are of different types that affect the air quality.

The pollutants are classified into three types:

1. Natural Pollutants
2. Primary Pollutants
3. Secondary Pollutants

1. Natural Pollutants

The pollutants that find their way into the atmosphere as a result of natural phenomena are referred to as **natural pollutants**. Some of the natural pollutants including smoke from forest fires, dispersal of pollen from plants, dust particles from soils and volcanic eruptions, volatile organic compounds discharged from leaves and trees, organic matter from decomposition or putrefaction process, and nuclear residue from natural radioactivity. The natural pollutants have been known to cause atmospheric pollution since very early time; it is perhaps as old as the Earth itself. You may be aware of the process of nature which deals with such pollutants in its own way. These natural pollutants are believed to be less harmful to the environment.

2. Primary Pollutants

A **primary pollutant** is a pollutant that enters directly into the atmosphere as a result of natural and other activities. For example, sulphur and nitrogen compounds, carbon monoxide and carbon dioxide, volatile organic compounds and particulate matter, etc. Major primary pollutants produced by human activity includes:

a) Sulphur oxides (SO_x)

Sulphur dioxide is produced by volcanoes, bogs, swamps, springs naturally and also through various industrial processes. It is passed into the atmosphere when coal and oil burns. Flue-gas desulfurization (FGD) plants, furnace oil of coal power plant, paper mills, iron and steel industries, petroleum refineries, sewage treatment plants, vehicles engines, crackers smoke are some of the important sources of sulphur compounds.

Acid rains are another form of major pollution threat that is caused by sulphur dioxide and nitrogen oxides released into the air in high concentrations. Acid rain occurs when these substances mix and react with water, oxygen and other chemicals in the atmosphere forming more acidic pollutants and fall down as rain.

b) Nitrogen oxides (NO_x)

Especially, the nitrogen oxide is emitted from high temperature combustion. Nitrogen dioxide is responsible for photochemical smog, acid rain etc. Urea is one of the main source of nitrogen in fertilizers. Source of nitrogen compounds are jet engines, fertilizers using Ammonia, fossil fuel combustion, livestock, poultry farm waste, vegetation, biomass burning and energy production, etc.

c) Carbon monoxide (CO)

It is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust from cars, trucks and other vehicles is a major source of carbon monoxide. Kerosene and gas stoves, gas heaters, chimney and furnaces or boilers, generators, water heaters, and so on releases a significant amount of carbon monoxide.

d) Carbon dioxide (CO_2)

It is a greenhouse gas and pollutant which is emitted from combustion. But, it is also vital for living organisms. It is a natural gas in the atmosphere. Other sources are cement manufacturing industries, deforestation, coal, oil and natural gas burning, etc.

e) Volatile Organic Compounds (VOC)

VOCs include methane (CH_4) and non-methane volatile organic compounds (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbons and VOCs are also significant greenhouse gases which play a key role in creating ozone hole and in prolonging the life of methane in the atmosphere.

f) Particulate Matter (PM)

Particulate matter or fine particles are tiny particles of solid or liquid suspended in a gas or air. In contrast, aerosol refers to particles and the gas together. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, etc. The burning of fossil fuels in vehicles, power plants and various industrial processes contribute a large amount of aerosols in the atmosphere by human activities.

g) Toxic metals

Toxic metals such as lead, cadmium, iron, zinc, and copper in the environment also act as pollutants.

h) Chlorofluorocarbons (CFCs)

These are the pollutants that causes the depletion of ozone layer. This in turn helps in allowing more shortwave length energy coming from the Sun to enter into the atmosphere causing global warming.

3. Secondary Pollutants

A secondary pollutant is the one that is formed by the further reaction of primary air pollutants. For example, sulphur dioxide reacts with oxygen in the atmosphere to form sulphur trioxide, which can further react with water.

Major secondary pollutants includes smog and ground level ozone. Smog results from large amounts of burning of coal and petroleum in an area caused by a mixture of smoke and sulphur dioxide. Particulate matter formed from the gaseous primary pollutants and compounds in photochemical smog are also considered as secondary pollutants. Ground level ozone (O_3) is formed from both nitrogen oxides and volatile organic compounds. Ozone layer is found in stratosphere which is different from ground level ozone. Ozone at ground level is one of the major constituents of photochemical smog.

Photochemical and chemical reactions involved in it drives many of the chemical processes that occur in the atmosphere by day and night and contributes in the formation of ground level ozone. Abnormally, high concentrations of ground level ozone brought about by human activities (largely the combustion of fossil fuel, solvents and industry) is a pollutant, and a constituent of formation of smog.

SAQ 1

a. What is a pollutant?
b. What are the sources of air pollutants?

9.3 STANDARDS OF AIR POLLUTION

You have well understood about the sources and types of air pollutants. Air pollutants can be derived from both natural and human made sources. As we know that air pollution is a major environmental risk to health. Standards of air pollution is a system which is developed by several organizations like United State Environmental Protection Agency (USEPA) of USA, Central Pollution Control Board (CPCB) of India and also World Health Organization (WHO). Basically, the system measures the level of pollution of an air pollutant based on health impacts of various pollutants. It generally ranges between the values of zero (healthy) and five hundred (extremely unhealthy). You may have had frequently read in the newspapers, the situation of ambient air which means outside air quality in various cities across the globe. The ambient air quality index shows six categories in different colours that are associated with various health impacts of people as given in Table 9.1.

Table 9.1: Air quality index explaining the health impacts on humans.

AQI	Associated Health Impacts
Good (0–50)	Minimal Impact
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people
Moderate (101–200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure
Very Poor (301–400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity

(Source: Central Pollution Control Board ,CPCB, 2015).

In India, National Ambient Air Quality Standards are the standards for ambient air quality set by the CPCB which is applicable for the entire nation. The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981. A new national air quality index (AQI) has been launched in October 2014 to disseminate information on air quality in an easily understandable form for the general public. The measurement of air quality is based on eight pollutants, namely, Particulate Matter (size less than 10 μm-PM_{10}), Particulate Matter (size less than 2.5 μm-$PM_{2.5}$), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Ozone (O_3), Ammonia (NH_3), and Lead (Pb) for short-term (up to 24-hourly averaging period). Refer to the Table 9.2 for understanding National Ambient Air Quality Standards of India.

Table 9.2: National Ambient Air Quality Standards suggested by CPCB, Govt. of India.

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and Other Areas	Ecologically Sensitive Areas
SO_2 ($\mu g/m^3$)	Annual	50	20
	24 hours	80	80
NO_2 ($\mu g/m^3$)	Annual	40	30
	24 hours	80	80
PM_{10} ($\mu g/m^3$)	Annual	60	60
	24 hours	100	100
$PM_{2.5}$ ($\mu g/m^3$)	Annual	40	40
	24 hours	60	60
O_3 ($\mu g/m^3$)	8 hours	100	100
	1 hour	180	180
Pb ($\mu g/m^3$)	Annual	0.5	0.5
	24 hours	1.0	1.0
CO (mg/m^3)	8 hours	02	02
	1 hour	04	04
NH_3 ($\mu g/m^3$)	Annual	100	100
	24 hours	400	400

(Source: CPCB, 2009; https://www.transportpolicy.net/standard/india-air-quality-standards/).

Ambient (outdoor) air pollution is a measure of the condition or quality of air surrounding us in the outdoors. As we know that the major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. PM_{10} and $PM_{2.5}$ explains the particles with a diameter of 10 microns and 2.5 microns, respectively. PM_{10} can penetrate into the lungs while $PM_{2.5}$ is fine particles, thus, they are able to enter into the blood system. Air quality measurements are typically reported in terms of daily or annual mean concentrations of PM_{10} particles per cubic meter of air volume (m^3). Routine

air quality measurements typically describe such PM concentrations in terms of micrograms per cubic meter ($\mu g/m^3$).

Nitrogen oxide (NO_2) is the main source of nitrate aerosols, which forms an important fraction of $PM_{2.5}$ and ozone (O_3). Sulphur dioxide (SO_2) is a colourless gas with a sharp odour. You might be knowing that NO_2 and SO_2 are mostly produced from the burning of fossil fuels and combustion processes (heating, power generation, and engines in vehicles and ships).

Ozone at ground level is formed by the reaction with sunlight (photochemical reaction) of pollutants such as nitrogen oxides (NO_x) and volatile organic compounds (VOCs). As a result, the highest levels of ozone pollution occurs during the periods of sunny weather.

NH_3 (Ammonia) either directly or indirectly, is a building block for the synthesis of many pharmaceuticals. Pb (lead) content generates in the air mainly through ore and metals processing, waste incinerators and from lead-acid battery manufacturing industries.

SAQ 2

a. What are eight basic pollutants used to measure the air quality standard?
b. Name of the organization that regulates the standards for air quality in India.

9.4   EFFECTS OF AIR POLLUTION

You have understood now the air quality standards. You now know the effects of air pollution in all forms of life from human to plants, animals and also materials related to human welfare. Some of the important effects of air pollution under three broad categories namely effects of human health, effects on wildlife and effects on environment are discussed below.

9.4.1 Effects on Human Health

As we all know that air is very essential for life. If the air is polluted then it will be worsened all the life forms. We could find several alerts in newspapers or television channels with regard to the levels of air pollution in the environment particularly for cities. Polluted air severely affects the children and aged population directly into the eyes, nose, throat and lungs. Toxic air inhalation causes problem not only to the respiratory system but also to our total body system.

The polluted air affects the human health. These are discussed as follows:

- Sulphur dioxide can harm human respiratory system and makes breathing difficult. It irritates the skin and mucous membranes of the eyes, nose, throat, and lungs.

- Nitrogen oxide at higher concentrations cause the breathing problems, headaches, allergies, and impairs the functioning of lungs by causing accumulation of water in the air pores. Nitrogen compounds also contribute in the formation of fine particles and ozone at ground level, both of which are associated with adverse health effects. Longer exposures to NO_2 can lead to the development of asthma and it carries a potential risk to children and the elderly people as well.

- Over exposure to carbon monoxide leads to symptoms like fatigue, nausea, dizziness, disturbances of psychomotor function, vision problems, brain damage, serious effects on cardio-vascular systems, muscle weakness, and may lead to even death. Sulphur and nitrogen oxides combined with carbon monoxide diffuses into the blood, combine with haemoglobin leading to obstruction of oxygen transport.

- Radio-active elements in air cause severe skin diseases, reduction in white blood cells, damage of small blood vessels, heart failure, and deformities which are inherited in succeeding generations.

- The particulate pollutants such as silicon particles, lead, carbon, fibres of asbestos and those of cotton cause diseases like silicosis, fibrosis, etc.

- Air borne spores, pollen grains, bacteria, fungi, fur, hair, etc., cause various allergic reactions like bronchial asthma, fever and dangerous diseases like tuberculosis, dermatitis, etc. Chronic exposure to particles contributes to the risk of developing cardio vascular and respiratory diseases, as well as lung cancer.

9.4.2 Effects on Wildlife

Toxic pollutants in the air affects the animals similar to that of humans. Studies show that air toxicants are significantly contributing to birth defects, reproductive failure, and disease in animals. The toxic air pollutants also affect the aquatic ecosystems. The pollutants accumulated in sediments may bio-magnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air. We could find a number of livestock poisoned by fluorides and arsenic toxicants/pollutants across the world.

9.4.3 Effects on Environment

Along with harming humans, animals, plants health, air pollution can also cause a variety of environmental effects. Nitrogen and sulphur oxides interact with water, oxygen and other chemicals in the atmosphere to form acid rain which can harm sensitive ecosystems such as lakes and forests. Acid rain not only damages vegetation but also soils and waterbodies. Waterbodies including ponds and lakes have become acid, making the water unsuitable for some fish and other wildlife. The result of acid rain is leading to the quick decay of buildings, monuments and statues. High concentrations of nitrogen oxides affects the vegetation through damaging leaves and its growth. It also

reacts with other pollutants in the presence of sunlight to form ozone which can adversely damage vegetation.

Haze is also an important effect of air pollution. It is caused by tiny pollutant particles in the air that leads to the loss of visibility, clarity, colour, texture, and form of what we see. The sources of air pollutants causing to haze may be from power plants, industries, trucks and automobiles, and construction activities. The highest air concentrations of lead are usually found near lead smelters. High levels of ammonia is both caustic and hazardous.

SAQ 3

Write any two effects of air pollution on human health.

9.5   MANAGEMENT OF AIR POLLUTION

Several countries have put up their concerted efforts to control the air pollution by developing certain measures through technological advancements. However, the progress of innovation in controlling the air pollution has not reached greater heights, so far. To control air pollution, the following measures are suggested:

- The establishment of regulatory authority at national level to suggest air quality standards for protecting health of higher life forms. Proper management studies related to emissions inventories, air monitoring and air quality modeling shall be conducted periodically to understand the levels of air pollution and health and environment related problems.

- Strict regulations and stringent punishments on one hand and incentive programs for emitting lower emissions at industrial and other sources on the other hand may be implemented cautiously.

- Use of purified good quality of petrol may minimize the level of sulphur and lead oxides in automobile exhausts. The modified efficient engines in automobiles can help to release the low level of carbon monoxides and hydrocarbons into the atmosphere.

- The industrial machines and vehicle engines should be made energy efficient to use fuels at the maximum level to reduce the release of pollutants.

- Installing treatment plants for purification of air pollutants is also one of the vital solution. It is now very important to pay attention to the usage of alternative and cleaner energy sources. The common alternative sources of energy are wind, water and sunlight. The solar and battery energy operated vehicles needs to be manufactured to reduce the use of fossil fuels.

- The aerosol emissions should be controlled by efficient arresters like filters and precipitators, and scrubbers. The emissions from factories and

industries should be treated by various techniques like settling chambers, wet and gas scrubbers, cyclone separator, etc., before being released into the atmosphere. Use of fuelwood and coal for cooking and other purposes must be controlled by introducing smoke free furnaces.

- Alternatively, deforestation activities needs to be strictly monitored and encourage the adoption of afforestation practices. Every nation should participate in planting trees and follow the slogan "*save and plant trees, save the homes of living organisms and whole of the planet Earth*". You know the fact that the plants and trees absorb carbon dioxide for photosynthesis and thus reduce pollution from the air. Besides, broad leaved trees are particularly able to trap large amount of gases and dust on their leaves and twigs. Trees act as dust or particulate filters and substantially reduces CO_2 emissions.

- The most important and fundamental programme for dealing with environmental problems can be done by the introduction of environmental education at all levels. Every citizen of the nation from her/his very childhood should be sensitized and made aware of the problems of air pollution in particular and environmental pollution as a whole.

SAQ 4

What are the important measures of minimizing air pollution?

9.6 SUMMARY

In this unit, you have studied so far:

- The contaminants in high concentrations that exists in the air is harmful to the all living organisms through air pollution.

- Sources of air pollutants are different in form. It may be from industries, burning of fossil fuel, mining and power plants, agro-chemicals and so on.

- Pollutants are mainly of three types namely natural, primary and secondary pollutants.

- Some of significant pollutants recognized are sulphur and nitrogen oxides, carbon monoxide and carbon dioxide, volatile organic compounds, particulate matter, etc. Ozone at ground level is also one of the prominent source of secondary pollutant.

- The major air pollutants namely PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb are generally considered for measuring the quality of air. Central Pollution Control Board of India has developed a national air quality index by fixing standards for different parameters to qualify the air quality.

- Air pollution affects human health, animals and plants life, and also environment.

- You have also studied several possible measures to control the air pollution.

9.7   TERMINAL QUESTIONS

1. Discuss various sources of air pollutants.

2. Write a note on effects of air pollution on human and environmental health.

3. Discuss various management strategies to reduce the air pollution.

9.8   ANSWERS

Self Assessment Questions (SAQ)

1. a) An air pollutant is a substance in the air that can cause harm to humans and the environment.

   b) There are two sources of air pollution i.e. natural and human made.

2. a) The eight pollutants are PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb.

   b) Central Pollution Control Board (CPCB)

3. Effect of air pollution on human health are respiratory problems, loss of vision, clarity, skin diseases, and so on.

4. Use of good quality of petrol, modernization of industries, use of alternative and cleaner energy sources, etc.

Terminal Questions

1. Sources of air pollutants are stationary sources and non-stationary sources. Refer to Sub-section 9.2.1.

2. Refer to Section 9.4.

3. Refer to Section 9.5.

9.9   REFERENCES/SUGGESTED FURTHER READING

- Chary, S.N. (2008). *Environmental Studies*. New Delhi: Macmillan Publishers.

- Mishra, S.P. (2006). *Environmental Pollution*. Jaipur: Aavishkar Publishers.

- Goudie A., 2001: *The Nature of the Environment.* Blackwell: Oxford.

- Singh, S. (2015). *Environmental Geography.* Allahabad: Pravalika Publicaitons,.

- Smith, W. H. (1989). *Air Pollution and Forests.* New York: Springer.

- Saxena, H.M. (2013). *Environmental Geography.* New Delhi: Rawat Publications.

- National Ambient Air Quality Standards, Central Pollution Control Board Notification (2009). New Delhi.

- *Environmental Standards for Ambient Air, Automobiles, Fuels, Industries and Noise.* Central Pollution Control Board (Ministry of Environment & Forests, Government of India) Padvesh Bhawan, East A1: Arjun Nagar, Delhi.

- https://app.cpcbccr.com/ccr_docs/FINAL-REPORT_AQI_.pdf

SOLID AND LIQUID WASTE

Structure

10.1 INTRODUCTION

You have studied about the pollution and air pollution in the previous Units 9 and 10, respectively. This unit will focus on wastes, their types, impacts, and management. Wastes are one of the major environmental problems. Wastes, in the form of solid and liquid, are creating lots of problems for the local economy in general and the world in particular. Section 10.2 presents you the types of wastes and its classification. Wastes create a huge burden on the global environment. The huge generation of waste leads to the origin of several other environmental issues at the macro level and it affects the overall development of regions. They are of various types and their management is the need of the hour. We have explained the effects of solid and liquid wastes on public health and environment in Section 10.3 followed by the management of wastes in Section 10.4.

Expected Learning Outcomes

After studying this unit, you should be able to:

- explain the different types and classification of wastes;
- describe major effects of solid and liquid wastes; and
- elucidate the different methods of waste management.

10.2 TYPES AND CLASSIFICATION OF WASTES

Since the starting of the industrial revolution particularly, the human beings have been generating wastes. In the present time, in response to the increasing production and consumption patterns, societies are producing a huge amount of wastes. However, we know that nature can assimilate them, but we are producing more wastes than the assimilation rate of nature. Therefore, we are facing this environmental degradation challenge in a big way in the 21st century.

In most simplified terms, **waste** means any materialistic item which is no more useful. Waste is anything that is not required by an individual because of single or many other factors. Further, it can be stated that waste is anything that remains at the end of a process and does not have any utility and functionality for a user. Wastes are normally found in solid and liquid state which are generated from various human and animal activities and are regarded as useless or unwanted. Wastes have been defined in various ways. Gemmell et al. (1984) defined wastes as "*unwanted or undesirable products of life*". Also, they range in character from organic materials like human and animal excreta to metallic, plastic, and chemical by-products of manufacturing industry. Bilitewski et al. (1997) in their paper defined waste subjectively and objectively. Subjectively, '*wastes are portable objects that have been abandoned by the owner*', while objectively, waste defined as '*orderly disposal of garbage as required for the protection of public health and, in particular, of the environment*'. Wastes are seen as a problem in a particular area for the local people and their surrounding environment. Most of the time, wastes are managed until the time, they are within the limit, but when this limit exceeds the capacity, the environmental quality degrades and management efforts are initiated to tackle the problem.

All wastes are not useless, with the advancement of technologies it has become possible to recycle/reuse the waste to manufacture other useful products. Sometimes waste to one user may be a useful material for someone else also. For example, glass materials, paper cardboard and metals can be reused; and peels of fruits, garden wastes, etc. can also be used to make compost (organic manure). Actually, in the present time, nothing is waste because most of the things can be reused and recycled.

10.2.1 Types of Wastes

There are three types of wastes based on their state in nature. They are found in solid, liquid, and in a gaseous state.

Solid wastes are non-soluble wastes or solid portion of rejected materials from various sectors like plastics, glass-made items, food wastes, paper, wood, metals and mining residue, etc. Most of the solid wastes are not recyclable and take long time to get degraded.

Liquid wastes are liquid portions of the wastes which include urban wastewater, sewage, effluents from industries and landfill sites, agriculture runoff and leaching of agricultural chemicals, etc. Liquid wastes are generally transported by using containers or through pipes. The excess amounts of

sewage discharged into a river/water body can alter the fragile ecosystem resulting the death of aquatic species for example fish.

Gaseous wastes include wastes in gaseous form produced by in the result of various human activities from manufacturing industries, chemical factories, etc. The gases comprise of methane (CH_4), carbon dioxide (CO_2), chlorofluorocarbons (CFCs) are also responsible for environmental problems like pollution, climate change and so on. The present discussion in this Unit limited only to solid and liquid wastes.

10.2.2 Classification of Wastes

Wastes can be categorized mainly into two classes based on their source of generation and type of materials. Let us discuss one by one.

1. Classification based on Source

The most common types of wastes which are originated at source particularly found in our societies. These are discussed below:

a. *Domestic waste*: These wastes are produced at the household levels or from dwellings, apartments and residential buildings. These include leftover food, contaminated wastewater by the use of detergent, household garbage, ashes, furniture material, clothes, plastic and so on.

b. *Agricultural waste*: These include wastes from the agricultural area or due to the result of agricultural activity and associated processes. These are organic wastes from plants and animals, spoiled food grains, crop residue after harvesting, contaminated water after the use of chemical fertilisers and pesticides and other agricultural remains.

c. *Industrial waste*: The source of these types of wastes is industries, factories and several other manufacturing processing units. Various types of solid and liquid effluents are major wastes generated from here. It mainly consists of processed wastes, chemicals, tanneries, building material, burning of coal and wood, charcoal and ashes, hazardous solid and gaseous wastes are produced as a result of industrial activities.

d. *Municipal waste*: The waste generated by various municipal activities while constructing roads, public facilities, buildings, railways lines, street cleaning, landscaping of an area, etc. are known as municipal wastes. Municipal solid waste (MSW) is defined to include household waste, commercial and market area waste, slaughter house waste, institutional waste (e.g., from schools, community halls), horticultural waste (from parks and gardens), waste from road sweeping, silt from drainage, and treated biomedical waste. If you observe Figure 10.1, which represents the Indian scenario of the different wastes share in the percentage of total municipal wastes.

e. *Biomedical waste*: Wastes from hospitals, clinics, path labs, experimental labs in the form of blood, diseased organs, the material used during medical operations, poisonous gases during experiments and several such items are termed as biomedical wastes.

f. **Waste from natural disasters:** After the occurrence of natural or human made disasters, various materials are left behind as waste. It includes slag and ash from a volcanic eruption, building debris after the earthquake/landslides, and various remains left behind due to flood, cyclone/tsunamis, fire, structural collapse, etc.

2. Classification based on Type

Based on the physical, chemical, and biological characteristics, wastes are classified mainly into two types: biodegradable and non-biodegradable wastes.

a. **Biodegradable wastes:** These wastes are those leftover materials of organic matter which get degraded from complex to simpler compounds. These include paper, textiles, wood, food wastes, fruit and vegetable peels, etc. These are also produced as a result of various human activities at the household, industrial and commercial levels. National Environmental Engineering Research Institute (NEERI) is one of the Council of Scientific and Industrial Research (CSIR) laboratories established to conduct research and development studies in environmental science and engineering and also render assistance to the industries of the region, local bodies etc. in solving the problems of environmental pollution. NEERI carried out the studies on assessment of status of municipal solid wastes management in metro cities and state capitals of India in 2004-2005 for covering 59 cities (35 metro cities and 24 state capitals) across the country and observed that the waste generation rate varies from 0.12 to 0.60 kg/capita/day. Figure 10.1 shows the composition of wastes in India. It clarifies that nearly 47.5 per cent of waste is biodegradable waste which is generated in India followed by 25.2 per cent of inerts, plastic (9.2%) and 8.1 per cent of paper.
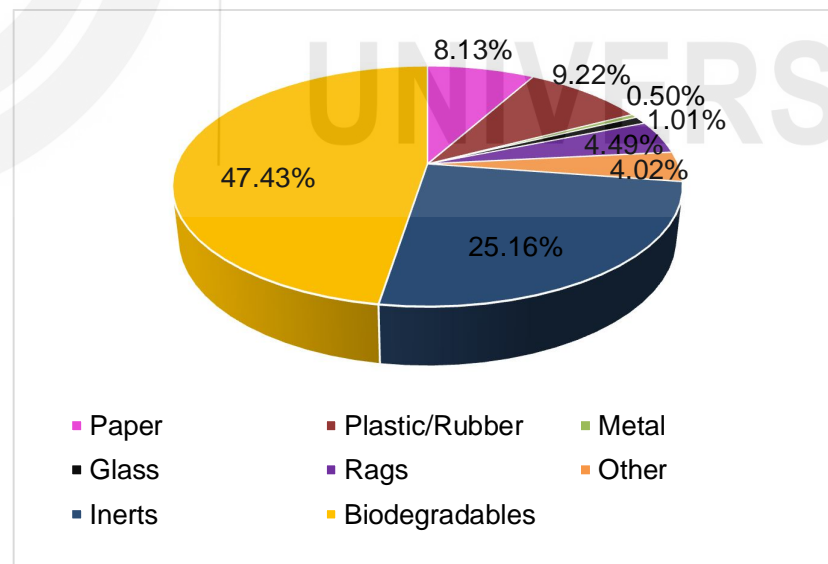

**Fig. 10.1: Composition of Municipal Solid Waste in India
(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)**

b. ***Non-biodegradable wastes***: These wastes include inorganic and to a certain extent recyclable waste products. It includes plastic wastes, glass wastes, cans, metals, etc.

You can understand by refereeing Table 10.1, the degeneration time of the biodegradable and non-biodegradable wastes. These wastes can further be categorized under different types of wastes as follows:

- ***General garbage***: Garbage refers to wastes produced in the process of making, selling, preparing, handling, exporting and disposing of various materials and items. It includes solid as well as liquid wastes which may have an intolerable smell. Further, it invites various vermin, rats, pigs, due to which they require immediate attention for their time management.

- ***Street waste***: Wastes collected from public places like streets, parks, parking areas, pathways, vacant areas etc. It includes huge dirt, dust, plant leaves, plastic wrappers, plastic bottles etc.

- ***Plastic waste***: Various products and goods are made of and sale in different modes of plastics like carrying bags or water bottles which is frequently used. These plastics are mostly single-use plastics and thrown away after use. These single-use plastics are one of the major problems responsible for various environmental pollution across the world and needs attention.

- ***Farm waste***: Farm wastes are similar to agricultural wastes as discussed above. In addition to that, these farm wastes have become a critical problem with reference to the management of agricultural soil and groundwater contamination. This is an important challenge in front of agricultural planners.

- ***E-waste***: Over-dependence of human beings on the electronic products has resulted in the generation of electronic waste. According to India's Ministry of Environment and Forests "*electronic waste comprises of waste generated from used electronic devices and household appliances which are not fit for their intended use and are destined for recovery, recycling and disposal*". Various electronic appliances like television, computer, refrigerator, mobile phone, and air conditioners that have become ubiquitous in today's human life. Their associated discarded material like computer hardware, electronic devices used at homes and offices like mobiles, pen drives, irons, power plugs, wires, televisions, etc. are all e-wastes.

- ***Nuclear waste***: Various types of nuclear waste from nuclear power plants is produced at the time of manufacturing of weapons, during experiments and their testing, etc., which are included under the category of nuclear wastes.

- **Hazardous wastes:** Hazardous wastes are those defined as wastes of industrial, institutional or consumer.

Besides, the above-discussed types, the list of wastes is quite long and besides, many other types of wastes can also be identified.

Table 10.1: The degeneration time for biodegradable and non-biodegradable wastes.

Category	Type of waste	Approximate time taken to degenerate
Biodegradable	Vegetable and fruit peels, leftover foods, etc.	1 week to 1 month
	Paper	2 to 6 weeks
	Cotton cloth	2 to 6 months
	Woolen items	1 to 5 years
	Wood/boards	10-15 years
Non-biodegradable	Tin, aluminum and other metal items such as cans	50-500 years
	Plastic bags	10 to 1000 years
	Plastic bottles	500 years
	Tires	Nearly 2000 years
	Batteries	100 years
	Glass bottles	1 million plus years

SAQ 1

a) What do you mean by wastes? What are major types of wastes?

b) Which of the following statements are *false*? In each case explain why it is incorrect.

1. The peel of orange is non-biodegradable waste.

2. Ashes are considered as domestic wastes only.

3. Electronic products like power plugs, iron, etc. produce E-waste.

10.3 EFFECTS OF SOLID AND LIQUID WASTES

As all we know that the quantity of waste is increasing day-by-day due to rapid growth of population and various services facilitating them to improve economic wellbeing. In doing this, huge waste is generated which is not getting disposed-off properly due to lack of space, workforce and unimproved mechanisms in the urban areas. In a result, it creates lots of problems for local people as well as for the surrounding environment in various ways. You know now some of the major effects of wastes.

10.3.1 Effects on Public Health

Solid wastes dumped at a place provide a suitable environment for the development of the vermin population. These vermin like mosquitoes, flies, rodents and pigs are the major agents of various types of diseases. These diseases become a health problem when they spread into the local community and surrounding area. Mosquitoes transmit malaria, chikungunya, dengue fevers, etc. Flies transmit typhoid, dysentery problems. Rats (rodents) movements create conditions for the spread of the plague. For rats, solid wastes dumping areas are the main sources of food as well as provide

shelters. Besides rodents, other animals like dogs, cats, pigs are also the carriers of various diseases.

The people who are working in these areas are directly exposed to these diseases and are highly vulnerable. Sometimes, while handling solid or liquid wastes, they came across to contact with sharp edges of glass or metal and get skin and blood infections. Further, they are vulnerable to animal bites and associated diseases at solid waste disposal sites. They can experience eye and chronic respiratory diseases including cancer resulting from exposure to dust and hazardous materials. Burns and other injuries are also possible due to careless dumping of chemicals, acid, electronic waste materials leading to serious health hazards. The waste generated from hospitals and laboratories like syringe needles, swabs, bandages, etc. is very dangerous and infectious. Workers working with these chemicals and metals for research laboratories may experience toxic exposure.

10.3.2 Effects on Environment

Solid and liquid wastes have an adverse impact on the environment. The dumping of waste in open areas and drains creates lots of problems. The burning of wastes generate different types of pollution which affect the local population and also the environment. Improper burning of solid wastes led to air pollution at landfill sites. Emission in the form of carbon monoxide, particulate matter, nitrogen oxides, and sulphur oxides creates huge problems for the atmosphere.

Dumping of wastes in storm water drains leads to water pollution. When these drains move from the surrounding agricultural area also affects the local land and quality of groundwater. During the rain, the leaching of wastewater from the landfill sites gets mixed with groundwater and affects its quality. This contamination changes the chemical properties of groundwater which is harmful if it is being used in surrounding areas for agricultural or domestic purposes.

Foul odour produced from the decomposition of the solid and liquid wastes, has a significant effect on the environment. The obnoxious smell created by the huge piles of wastes and around the wastewater drains is unhygienic as well as intolerable when we move nearby. In residential areas also, the waste collection centres smell a lot. The smell is the result of the presence of mixed types of organic material. Further, these sites are affecting the visual attractiveness of the place. These sites located along the roads, highways, public/residential bins provide easy accessibility to animals, scavengers for the collection of food and other materials. Therefore, the environment of these areas is affected by solid and liquid wastes in various ways.

SAQ 2

List out major effects of waste on human and environmental health.

10.4 SOLID AND LIQUID WASTES MANAGEMENT

One must understand that the significance of solid and liquid waste management (SLWM) because the wastes are vulnerable to local environment and public health as well. Both safety and care are very important in the management of wastes. There are several methods generally used in orderly execution of various functions of collection, transport, processing, treatment and disposal of municipal solid and liquid waste.

Actually, waste management is a complex task that depends upon organization and cooperation between households, communities, private enterprises, and municipal authorities. Therefore, solid and liquid waste management include various methods from the generation of waste to its collection, transportation, processing, recovery, and recycling. One should also adopt appropriate mix of processes and technologies for waste's collection, transfer, recycling, and disposal. The preferred waste management strategies can be grouped into various stages of processes. These are discussed below.

10.4.1 Reducing Generation of Wastes at Source

This is the best option in the waste management. Waste generation comprises any activity where materials are identified as having no value any longer and hence either thrown away or gathered (collected) for disposal. Waste generation requires its proper management process for a healthy living. Further, these wastes, useless to one individual, may not be useless to another. The generation of waste must be prevented at the initial stage itself in the planning of design, production, package, use and reuse of products and goods. Therefore, it helps to reduce not only economical costs but also environmental costs including the problems of leachate, emissions, and greenhouse gases. At every stage, raw materials should have the flexibility to convert into goods for consumption purposes.

10.4.2 Storage

Storage involves a system of keeping waste material at a place when they have been discarded by the users in different areas. Different types of storage facilities include small containers, large containers and shallow pits, etc. These all vary in their size, form and material. The small containers are used at the household level; large containers are for institutions, commercial purposes. The different types of wastes are generated in the residential areas and should be removed at the earliest as it is likely to pollute the environment. The quantity and size of storage facilities depend upon the number of users, waste types, and accessibility to these wastes. Therefore, careful planning is done while these facilities are provided in an area. The safety of these structures from being theft or vandalized is also needed to be ensured.

10.4.3 Collection

Collection process of waste involves the ways by which wastes will be collected and transported to the disposal site, where the collection vehicles get emptied (Ramachandra, 2006). This collection process depends on the volume of waste which will be managed by the frequency of collection.

Therefore, the collection process is planned in such a way so that the disposal site doesn't become overloaded. You might aware about Municipal Corporations which are local governing body mainly found in urban areas. It looks after the community services like health, education, housing and transport. The collection of waste is managed by Municipal Corporations and somewhere by franchised service methods. The collection of wastes can be analysed with the help of collection efficiency. It is the percentage of the total waste collected to the total waste generated.

10.4.4 Transportation

This stage includes the transportation of the waste material to the final disposal site. In the process, various modes of transport are adopted depending upon the amount and availability of waste to be transported. It is carried with the help of motorized vehicles or by human and animal-driven transportation methods. The transfer of wastes is also taken place from smaller vehicles as they can access narrow lanes/ streets and larger vehicles to transfer it to the disposal sites. The indiscriminate dumping of collected waste sometimes in non-allocated areas, vacant lots, alleys, ditches that leads to clogging of drains and sewage systems. It will further help to increase of breeding grounds for rodents and insects, these spread diseases.

10.4.5 Waste Processing

The waste processing includes changing of the physical and chemical properties of wastes for further use by recovery and recycling methods. This processing helps to get the best amount of benefits through waste management. The objective of processing the waste is to improve efficiency in waste management, recovering materials for use, and recovering conversion products and energy. Waste processing techniques involve compaction, separating waste components, incineration, and composting.

Figure 10.2: Waste management a) transportation by motorized vehicle b) dry, wet and domestic hazardous waste collecting bins c)
(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)

10.4.6 Recycling and Recovery

You might be knowing that one of the objectives of waste management is to improve efficiency in waste management, the recycling and recovering of waste material. Recovery of recyclable materials and strengthening a waste through recycling process to create a new product plays a very critical role. It

has been stated that recovery is a function of economics. It means the cost of separated items versus the quantity of the number of recovered products. Various recovered products have a different value in the market as they can be recycled and reused in modified form. Plastics, tin, glass, paper and cardboard, etc. related items can be recovered, recycled and further reused for different purposes.

The important recycling materials and their recycling potential is explained in Table 10.2.

Table 10.2: Recycling materials and their conditions.

Recyclable Material	Potential for Recycling	Special Conditions
Aluminium	- It can be recycled easily by shredding and melting as it is not deteriorated in reprocessing. - It requires significantly less energy than producing aluminium ore. - Market value is high.	Separate collection is important
Batteries	- It recovers valuable metals. - It protects environment from heavy metals such as lead, cadmium, and mercury.	- There is a large variety in types and sizes of batteries. - Only some types allow adequate material recovery.
Glass	- It can be melted and sorted into colours. - Recycling glass saves energy compared with processing raw material. - It can be recycled indefinitely because it does not deteriorate through reprocessing. - Good market value.	Broken glass can contaminate and eliminate opportunities for recycling of other material such as paper.
Paper and cardboard	- Paper or cardboard from recycled paper requires less energy during production. - Easy recycle process.	Quality of recycled product decreases with every processing cycle.
Polyethylene terephthalate (PET)	It can be recycled if segregated from other waste.	- Quality of recycled product decreases with every processing cycle. - Recycled products only for specific designated uses.
Other plastics	- Other plastics, such as polyethylene or polyvinyl chloride, can be recycled. - Low market value than PET.	Clean segregated plastics, are subjected to mechanical recycling

		into the same plastic type. • Where recycling is not possible due to mixed plastics, they are then co-processed for energy recovery or used as aggregates in road material.
Electronic waste	• Electronic items can be dismantled and its components reused or recycled. • It contains high value metals.	If recycling is not carried out under controlled conditions, metal is often covered with polyvinyl chloride or resins, which are often smelted or burned, causing toxic emissions.
Metal (steel, copper, nickel, zinc, silver, etc.)	• It can be recycled indefinitely because it does not deteriorate through reprocessing. • Scrap metal has a high market value, especially steel, copper, and silver.	High value metals, such as copper and silver, are incorporated in electronic devices, but extraction can cause severe environmental impacts, if uncontrolled.
Thermocol or Styrofoam	• It can be processed to recover fuel and other by-products. • It can be powdered and made into sheets, which can be used to make furniture.	• Fuel production is through pyrolysis, gasification, and hydrocracking. • Regulated facilities with appropriate environmental controls are required for handling thermocol recycling.
Construction and demolition waste	Demolition waste can be sorted, crushed and reused for production of pavement material, flooring tiles, road construction, landscaping and other purposes.	Standards for recycled products are yet to be stipulated.

(Source: Municipal solid waste management manual Part II: 2016, CPHEEO, MUD, Govt. of India)

10.4.7 Waste Disposal

The final stage of solid and liquid waste management process is the waste disposal. Waste of every type, as discussed above, needs to be disposed-off, properly. Waste disposal should be done in such a way so that it should not harm the local environment as well as the health of the people living nearby. For this purpose, landfill sites are identified under the landuse planning of a region. It requires engineering methods so that its impacts are minimal. The Government of India stipulated regulations of the Solid Waste Management Rules, 2016 for proper disposal of residual wastes in sanitary and lined landfills, etc. The documents are available at *http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php*. The advanced technological tools like Geographic Information System (GIS) software is used in monitoring waste disposable trucks, these trucks installed with Global Positing System (GPS) technology. The GPS enabled trucks can easily be monitored their irregularities in waste transportation and disposal systems.

SAQ 3

Which of the following True or False.

1. Municipal Corporations are designated for solid waste management activities in villages and cities.

2. The objective of processing waste is to improve efficiency in waste management.

3. Glass materials cannot be recycled.

4. Wastes associated with television, computer, refrigerators, mobile phones, and air conditioners are a major part of e-waste.

10.5 SUMMARY

In this unit, you have studied so far:

- The solid and liquid wastes are of various types and classified on various bases.

- It has been found that mismanagement of wastes has to lead to various impacts on the environment and public health.

- Waste management is emerging as an important challenge in the metropolitan cities where they are rising very rapidly. Therefore, efficient waste management is the only option through which we can tackle this problem.

- Various stages in waste management help to handle waste effectively. The various methods of waste management like storage, collection, processing, recycling, recovering and disposal will bring to reduce the pressure on the environment and in the functioning of a healthy urban ecosystem.

You will study about the concept of biodiversity, various factors affect the biodiversity loss and its impacts on environment, and the management of biodiversity loss in the next Unit 11.

10.6 TERMINAL QUESTIONS

1. Define wastes. Classify the waste based on the source of origin.

2. Differentiate between biodegradable and non-biodegradable wastes.

3. Explain the effects of solid and liquid wastes on environment.

4. Discuss in detail the major stages of waste management.

10.7 ANSWERS

Self-Assessment Questions (SAQ)

1. a) Waste means unwanted or useless materials. They are found in solid, liquid and gaseous state.

   b) 1. False. It is degenerated in the environment.

      2. False. Ash can be released from the burning of agriculture residues and also from industries.

      3. True

2. Solid and liquid wastes are leading to spread diseases like fevers, dysentery, plague, bad smell, etc. in humans and also effects the environment in the way of deteriorating groundwater quality and air pollution due to leakages and emissions, the loss of beauty of dumping areas, etc.

3. 1. False   2. True   3. False   4. True

Terminal Questions

1. Based on the source or origin, the most common types of wastes are domestic, agricultural, industrial, municipal and biomedical wastes. Refer to Section 10.2.

2. Based on degradation properties, wastes are of two types: biodegradable and non-biodegradable wastes. Refer to Section 10.2.

3. Refer to Section 10.3.

4. Waste management depends upon organisation and cooperation between households, communities, etc., therefore, solid and liquid waste management uses various methods from the generation of waste to its collection, transportation, processing, recovery, and recycling. Refer to Section 10.4.

10.8 REFERENCES/SUGGESTED FURTHER READING

- Bilitewski, B., Härdtle, G. and Marek, K. (1997) *Waste Management*, Berlin, Heidelberg: Springer.

- Gemmell, A. (1984). *Solid and liquid wastes and the impacts of their disposal.* B.D. Clark, A. Gilad, R. Bisset and P. Tomlinson (eds) *Perspectives on Environmental Impact Assessment*, Dordrecht: Riedell Publishing Company.

- Ramachandra, T.V. (2006). *Management of Municipal Solid Waste.* New Delhi: Teri Press.

- TERI (2014). *Waste to Resources: A Waste Management* Handbook. New Delhi: TERI Press.

- Tchobanoglous, G., Theisen, H., and Vigil, S. (1993). *Integrated Solid Waste Management.* New York: McGraw-Hill.

- Municipal Solid Waste Management Manual-Part I & II. (2016). Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development, Govt. of India, www.moud.gov.in; www.swachhbharaturban.gov.in

- Peter, S., Karl, W. and Jurg, C. (1996*) Concept Framework for Municipal Solid Waste Management in Low-Income Countries.* Urban Management and Infrastructure, UNDP (Habitat), SKAT, Paper 9.

- http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php.

- http://www.pollutionissues.com/Ve-Z/Waste.html#ixzz6rFg1aNUu

- https://www.nhp.gov.in/solid-waste_pg

- https://indiawastemanagementportal.org/ced/

- https://www.epa.gov/report-environment/roe-glossary

BIODIVERSITY LOSS

Structure

11.1 INTRODUCTION

In the previous units, you have studied types of pollution, problems and management of air pollution, solid and liquid wastes. Now, this Unit will explains you about the loss of biodiversity. Biodiversity is one of the major elements of environmental system. It is essential for the survival of humankind. Biodiversity is highly significant with respect to the ecosystem functions and their stability. However, over the time period, reckless human activities have created huge pressure on the biodiversity due to which we have reached a state where there is need for biodiversity conservation. Their management is the need of the hour to make the environment sustainable.

We have introduced the concept of biodiversity in Section 11.2. There are some important factors such as changes in landuse and landcover, unnecessary use of fertilizers and pesticides, changing climates, etc. lead to the enormous loss of biodiversity. We have explained the factors which are

affecting the biodiversity loss and the impacts of biodiversity loss on environment in Sections 11.3 and 11.4.

A large number of endangered animals and plants are located in some particular areas of the world, these are named as biodiversity hotspots. From Section 11.5, you will understand the biodiversity hotspots followed by management of biodiversity loss which is explained in Section 11.6.

Expected Learning Outcomes

After studying this unit, you will be able to:

- understand the concept of biodiversity and biodiversity loss;
- describe the factors affecting loss of biodiversity and its impacts;
- elucidate the biodiversity hotspots and their distribution, and
- explain the conservation strategies for the management of biodiversity loss.

11.2 CONCEPT OF BIODIVERSITY

In simple words, biodiversity is the variability among living organisms or the number of species found in an area, particularly, flora (plants) and fauna (animals). In other words, it is all life on the Earth in the form of plants, animals, and microorganisms as well as the variety of genetic material they contain. It also includes the relative abundance and genetic diversity of organisms from all habitats which includes terrestrial, marine and other aquatic systems. The term '**biological diversity'** or **'biodiversity'** was first used by wildlife scientist and conservationist Raymond F. Dasmann in 1968 in his book titled *"A Different Kind of Country"*. Biodiversity can also be defined in several ways. Heywood (1995) defined biodiversity as "*the total variability of life on the Earth*". Therefore, it can be said that biological diversity means variety within the living natural world, and is commonly used to explain the variety in terms of number and variability of living organisms.

Biodiversity provide all the basic necessities to sustain human life on the Earth. It is significant in various ways. It helps in the formation of soil and also maintains its quality by providing organic matter. Plants improve and controls air quality by purifying it and regulate the composition of the atmosphere by taking in carbon dioxide (CO_2) and releasing oxygen (O_2) in to the atmosphere. Forest cover also helps in controlling soil erosion. They contribute in stabilisation of climate and acts as carbon sinks. Besides, there are several other benefits of biodiversity like prevention and mitigation from natural disasters etc. Last but not the least, biodiversity is the source of food and source of basic requirements like shelter and fuel. The loss of biodiversity will lead to increase in all the problems related to above discussed benefits which we receive from them.

Let us understand the loss of biodiversity. Simply, **biodiversity loss** is defined as the extinction of species. It includes everything from the smallest single-cell organism to the greatest predator which forms the biodiversity of a given area. But when we say biodiversity is declining, it means death of those ecosystems. It is also known as biodiversity loss. Biodiversity includes the totality of species and ecosystems in a specific area. Biodiversity cannot be

recreated once lost. When for some reasons the biodiversity loss exceeds the natural rates, it can be said that the extinction is underway. **Extinction** is a situation which arises from the death of the last surviving individual of a species or group globally or locally. It can be attributed to human interventions through deforestation activities, urban sprawl or land clearance for agricultural activities and many other factors. Due to these activities many ecosystems have collapsed or sometimes a few important species in an ecosystem die due to which the whole ecosystems collapse on its own.

The important fact is that the magnitude of extinction is much greater than expected in the recent times. It is more than hundred times in the last 300 years or so. Earlier, hunting by humans is believed to be the most important driving factor for the loss of large wildlife species. But in recent times, the biodiversity loss is mainly attributed to the direct factors like large scale forest clearance for timber, clearance of forest for agriculture, pollution, urbanization over-exploitation of natural habitats and so on. For example, urban expansion in coastal areas has resulted in the destruction of important coastal habitats and particularly the coastal wetlands including mangroves.

Interestingly, the species richness in a particular area or ecosystem hardly changes. Sometimes, it might experience increase because of efforts by the local community. On the other hand, decline can lead to negative impacts on the ecosystems as well as on the society. It is therefore important not only to look at species (specific), but also at the abundance (the number of individuals) of species. Therefore, biodiversity loss includes the study of both loss of flora and fauna in terms of their quality and quantity as well. Let us continue to study the biodiversity loss as environmental problem and the associated factors affecting them and their conservation techniques to overcome these problems.

SAQ 1

a) What is biodiversity loss?

b) What do you mean by extinction of species?

11.3 FACTORS AFFECTING LOSS OF BIODIVERSITY

You might have understood the concept of biodiversity and biodiversity loss. You now know that there are various factors which lead to the loss of biodiversity. In the last few decades, more than natural factors, human activities have caused the majority of biodiversity loss. We now study some of the important factors which are discussed below:

11.3.1 Loss of Habitats and their Fragmentation

As we know the habitats are the home of flora and fauna. When they are forced to leave their homes may be naturally or due to human activities, it leads to their loss or sometimes extinction. The habitats of plants and animals are increasingly being harmed by exploitation for personal and economic gains and changes in the land use. The land use changes include deforestation and takeover of land for agriculture, industries, and human

settlements. Due to the continuous expansion of human settlements, many habitats are reduced in extent and become fragmented. When we cut down trees to use its lumber, or claim the land for agricultural purposes, we are destroying the unique ecosystems that can't exist anymore else. The fragmentation of habitats divides the species into smaller populations which cannot survive for longer time. Fragmentation also creates physical barrier for biodiversity to move, disperse and colonise new areas. One of the estimates says that 67 per cent of all endangered, vulnerable and rare species are being threatened by habitat degradation and fragmention.

11.3.2 Pollution and Associated Impacts

The biodiversity habitats are threatened by reckless industrial activities and pollution problems. Excessive use of chemicals in agriculture and the incidences of oil spills in sea are some of the examples. The continuous release of pollutants from urban and agricultural sources combined with more and more developmental activities will lead to multiplication of dead zones in the near future. The dead zones are those areas where other forms of life cannot survive. These zones have negative impacts on the biodiversity for their development and survival. Garbage dumped into the water, chemical runoff, pollution from vehicles all have negative effects on biodiversity. Dumping of non-biodegradable materials has become so common in the sea that lead to increasing mortality among birds, fishes and oceanic mammal populations.

11.3.3 Over Exploitation and Illegal Trade

The last few decades have seen the over exploitation of plants and animals by various human activities. Unethical and illegal trade of animals is a major threat to biodiversity. Over-exploitation of fishes, known as overfishing, has reduced some commercial fish stocks by more than 90 per cent. It is really difficult to put a number on overfishing because most of the ocean is still unexplored, but it's estimated that anywhere from 60 to 90 per cent of the ocean has been overfished and reaching to a state of collapse. Commercial hunting and trading is the major destroyer of wildlife. Illegal trade of endangered species of plants and animals is now a business of billion dollars. Rhinoceros, tiger, leopard, mahogany trees are some of the animals and plants which are under the threat of illegal trade.

11.3.4 Environmental Degradation and Climate Change

Changes in the climate can occur naturally over millions of years. But the present day climate change has been attributed to the human interventions and the anthropogenic causes. It is happening so quickly that the species of plants and animals are not adapting to this faster rates of change and are slowly becoming vulnerable to the process of dying out and extinction. Due to the changes in the environmental and climatic conditions, temperature is rising, seas are warming up and sea level is increasing, frequency of extreme events and disasters had increased and many other impacts are now clearly visible. There are alterations to the local climate, rivers and watersheds are drying up, and consequently, there is increased erosion of top soil. Furthermore, the increasing deforestation causes increase in levels of greenhouse gases such as CO_2. According to Myers (1989), over the period

of 1979-1989, there was a 41 per cent increase in the release of carbon as a result of deforestation. Further, climate changes have led to visible changes in timing of agricultural practices, flowering seasons, migration patterns and so on. These changes have the capacity to change food chains and food webs in the ecosystems. Because of all these reasons, many species are affected. There are critical data for decline of birds. Over 1200 bird species are likely to become extinct and about 128 species have vanished over the last 500 years and 103 since 1800 Since 2006, it is estimated that millions of honeybees have been dying known as 'Colony Collapse', which are causing a great concern. Mass deaths of whales at various places are also attributed to the fact of climate change.

11.3.5 Invasive Species

In some areas, exotic species of plants, animals and other organisms are accidently or intentionally introduced to get benefits. Outside the natural geographical areas, these introduced invasive species often damage the native species. They can compete for food, sometime eating native species, helps in spreading diseases and sometimes bringing genetic change due to inter-breeding process. All these processes have the capability to disturb the local ecosystem and the overall physical environment. Species introduced in an area where they have no natural predators can destroy the whole ecosystem. An example of this is the pythons in the Florida Everglades, and Lionfish in the Gulf of Mexico. Most of these invasive species are linked directly to human intentions.

11.3.6 Forest Fires

Frequent fires in the forest areas are caused by higher temperature during summer and dry season. In tropical forests, fires occur in every dry season. These wildfires cause the displacement of territorial birds and mammals, which affect the local balance. Ultimate result of this is in the form of wildlife loss, since displaced individuals have nowhere to go. For example, in the severe fires of 1998 in Russian Federation led to increased water temperatures and high carbon dioxide levels in lakes and water ways. This has adversely affected salmon spawning in the area. In 2019, the fires rage across Australia for several days have brought global attention to wildfires in forest management. Since few years India is also facing wild fires causing extensive damage, for example the fire at Bandipur Tiger Reserve in Karnataka (2018). According to the India State of Forest Report 2019, over 30,000 incidents of forest fires were reported in India in 2019.

11.3.7 Volcanic Eruption

Volcanic eruption also has led to the damage to the habitats of biodiversity in its surrounding areas. The impact of eruption is so vast that it clears all the flora and fauna in the nearby areas. For example, volcanic eruption of Mount St. Helens which is located in the state of Washington (United States) is a good example of it. In May 1980, a major volcanic eruption occurred from mount St. Helens and thick ash accumulation downwind of the volcano damaged many agricultural crops such as wheat, apples, potatoes and alfalfa to a large extent. This has also led to the killing of as many as 1,500 elk and

5,000 deer, and an estimated 12 million salmon were also killed. Therefore, volcanic eruption can do huge loss to the biodiversity of the particular area.

11.3.8 Recreation and Hunting

Human beings are always thrilled by recreational activities. Hunting while travelling to forest is one of them. Recently, hunting for money-making is another interest of human beings. Collections of skin, tusk, meat, fur taken for monetary or aesthetic value or hunting with no purpose are killing the animals and creating the situation of extinction for some particular species. For example, in the last decade, over one-third of African elephants have been killed by hunters and poachers to fuel the ivory trade in African continent. It is found that, in the semi-arid rural area of Southern Cochabamba (Bolivia) 132 inventoried plants are used by the local people for traditional medicinal purposes. Out of the total, at present 10 plants are now under threat because of their excessive collection.

11.3.9 Traditional Knowledge-Based Medicinal Demand

Traditional knowledge about medicines from specific plants and animals are worldwide known. These medicines are in significant demand for which animals and plant material are compromised. These are collected and obtained by killing animals. For example, Rhino horn is highly priced in the culture of Asian countries for its claimed medicinal properties. Therefore, Rhino poaching is now pushing Rhino populations to the brink of extinction.

Another example of aesthetic medicinal plant i.e. red sandal wood, in which centre part of the trunk is used for treating digestive track problems, cough and blood purification. It is also used as a flavouring in alcoholic beverages. It is one of the threatened species recognized by **International Union for Conservation of Nature (**IUCN). Red sandal wood majorly grows in forest tracts or Eastern Ghats of Andhra Pradesh state in India. Since it is a lucrative business, some people try to smuggle these trees illegally to other countries for making goods and medicinal purpose.

Thus, in this section, you learnt major factors causing biodiversity loss. You must have also understood that how various natural and human made factors affected the loss of various types of flora and fauna under different conditions.

SAQ 2

a) List out any three factors which affect the biodiversity loss.

b) Match the following:

1. Plants and Animals Intentionally Introduced in an Area	A. Rhinoceros
2. Dying Honeybees	B. African Elephant
3. Illegal Trade	C. Colony Collapse
4. Endangered species killed by Hunters and Poachers to Fuel the Ivory Trade	D. Invasive Species

11.4 IMPACT OF BIODIVERSITY LOSS

The factors causing biodiversity loss have a huge impact on the natural ecosystem functioning as well as on various human activities. Some of the major impacts are discussed in this section.

11.4.1 Food Chain and Ecosystem Functioning

Biodiversity is the important part of life and any reductions in their quantity can disturb the food chain of ecosystem. Some species appear to be the most important part in supporting the entire ecosystems. When these species disappear, the whole network of life gets disturb and the mutual benefits are lost. Further, the disappearance also leads to the poor functioning of the ecosystems.

11.4.2 Ecosystem Services

Biodiversity are the source of various ecosystem services. For example, forest provide fresh air, humus content to soil, helps in bringing rain, provide shelters to various birds and animals, hold water and soil which are invaluable. If the process of deforestation continue, all these services will be no longer available. Further, it has been said that a square kilometre of coastal ecosystem like mangrove forest can store up to five times more carbon than the equivalent area of mature rainforest. Bacteria break down organic material and helps in building and fertilising the soil. Wetlands filter pollutants from drinking water. Insects pollinate many of our crop species. If humankind has to artificially duplicate these services, the cost would total trillions of dollars annually, and very likely surpass the value of all the world's economies combined.

11.4.3 Human Health

The health of human beings depends especially upon ecosystem products and outputs such as availability of food, freshwater and energy sources. Traditional medicine continues to play an important role in health sector, especially in primary health care. Medicinal plants like neem have immense medicinal value. Many communities rely on natural products collected from ecosystems for medicinal and cultural purposes along with food.

11.4.4 Agriculture

Biodiversity plays a crucial role in human nutrition. Micro-organisms in the soil provide basic nutrient for different crops. Nutritional composition between varieties of the same food can differ dramatically which can affect micronutrient availability in the diet. Healthy diet with adequate average levels of nutrients intake maintains high biodiversity levels.

11.4.5 Religious and Cultural Attributes

Most indigenous population in various countries are closely linked with the biodiversity resources of their areas. Biodiversity of an area shows a very positive link with the cultural heritage of the areas. Various plants and flowers

form the significant part of day-to-day religious activities in Hindu religion. The other religions are also spiritually and culturally associated with biodiversity.

11.4.6 Commercial Activities

Many business and industrial activities are based on various biodiversity products, for example, timber, rubber and variety of forest produce etc. The economy of some of the countries also totally depends on timber like Malaysia. Therefore, biodiversity loss has the capability to affect the economy of a country in the long run.

11.4.7 Tourism

Ecotourism is a large and pollution-free business. It is estimated that the Great Barrier Reef, on the eastern coast of Australia is estimated to contribute nearly $6 billion to the country's economy due to its tourism-related potential and other recreational activities. Besides, various natural scenery, bird sanctuaries, forest areas are the special destinations for nature lovers. If this natural scenery is lost, there will be huge impact on the economic front as well as the maintenance of the ecological balance of the surroundings.

All these impacts of biodiversity loss, sooner or later, will affect the sustainability of the Earth's surface. There will be depletion of natural resource which will lead to the loss of biodiversity and put the survival of humankind at stake.

SAQ 3

Describe the impact of biodiversity loss on human health.

11.5 BIODIVERSITY HOTSPOTS

The concept of biodiversity hotspot was first developed by the British ecologist *Norman Myers* in 1988. There are large areas in the world which are characterised with endangered species of animals and plants. These areas of the world are rich in biodiversity with a large number of endemic species. When these habitats are threatened by habitat loss or any other factors of biodiversity loss, discussed in previous section, are called **biodiversity hotspots**. In other words, it is an area which is prone to extirpation due to habitat loss through encroachments in the forest area. The term **'Endemism'** explains that the state of being unique in a particular area or geographic location, for example a specific habitat type etc.

According to Conservation International, there are two basic criteria for declaration of an area as a biodiversity hotspot:

1. It must have an area of at least 1500 vascular plants or a high percentage of plant life as endemics. Therefore, it can be said that hotspot is irreplaceable.

2. The area must have 30 per cent or less of its original natural vegetation. Therefore, it must be threatened.

Most of the endangered species are located in either biodiversity hotspots or the areas near to them. In the world 36 biodiversity hotspots have been identified which are based on the species richness, endemism, and threat level (Table 11.1). If you observe Figure 11.1, there are eight hotspots in the African continent which holds a diversity of plant and animal life, many of them are not found anywhere on the Earth. The Asia-Pacific region composed of large land areas as well as islands, scattered in the Pacific seas. In this region 13 hotspots represent important biodiversity. In Europe and Central Asia, four hotspots are unique in their diversity, located from the Mediterranean Basin to the Central Asia. North and Central America acts as habitat to thousands of acres of land and include six hotspot locations. South America, from Brazil's Corrido to the Tropical Andes, has some of the richest and most diverse life forms of the Earth in the form of four hotspot regions.

All these hotspots are vulnerable to biodiversity loss. They are threatened by increasing population and various developmental activities in their biodiversity hotspot regions. Therefore, it is needed that policies should be framed to monitor the causes for biodiversity loss in hotspot areas. Developmental activities need to be re-evaluated and employed only after estimation of biodiversity loss in such areas after proposed activity.

Table 11.1: Global Biodiversity Hotspots.

S. No.	Biodiversity Hotspots	Location
1	Cape Floristic Region (South Africa)	Africa
2	Coastal Forests of East Africa (Somalia, Kenya, Tanzania, Mozambique, Zanzibar)	
3	Eastern Afro-montane (Saudi Arabia to Zimbabwe)	
4	Guinean Forests of West Africa (Guinea to Cameroon)	
5	Horn of Africa (Somalia to Sudan)	
6	Madagascar and the Indian Oceans Islands	
7	Maputaland-Pondoland- Albany (Mozambique, Swaziland, South Africa)	
8	Succulent Karoo (South Africa and Namibia)	
9	East Melanesian Islands (Islands of the Pacific Ocean)	Asia-Pacific
10	Himalaya	
11	Indo-Burma (Tropical Asia)	
12	Japan	
13	Mountains of the Southwest China (China)	
14	New Caledonia (Island in the South Pacific)	
15	New Zealand	
16	Philippines	
17	Polynesia-Micronesia (Pacific Oceans)	
18	Southwest Australia	
19	Sunland (Western half of the Indo-Malayan archipelago: Thailand, Malaysia, Singapore, Indonesia, and India's Nicobar islands)	
20	Wallacea (Indonesia)	
21	Western Ghats and Sri Lanka (India, Sri Lanka)	

22	Caucasus Region	Europe and Central Asia
23	Irano-Anatolian	
24	Mediterranean Basin	
25	Mountains of Central Asia	
26	California Floristic Province (US)	North and Central Asia
27	Caribbean Islands	
28	Madrean Pine-Oak Woodlands (Mexico, US)	
29	Mesoamerica	
3031	North American Coastal Plain (US)	
32	Atlantic forest	South America
33	Cerrado (Brazil)	
34	Chilean Winter Rainfall-Valdivian Forests (Chile)	
35	Tropical Andes	
36	Tumbes-Choco-Magdalena	

(Source: Rajagopalan (2016); **www.conservation.org; www.cepf.net)**
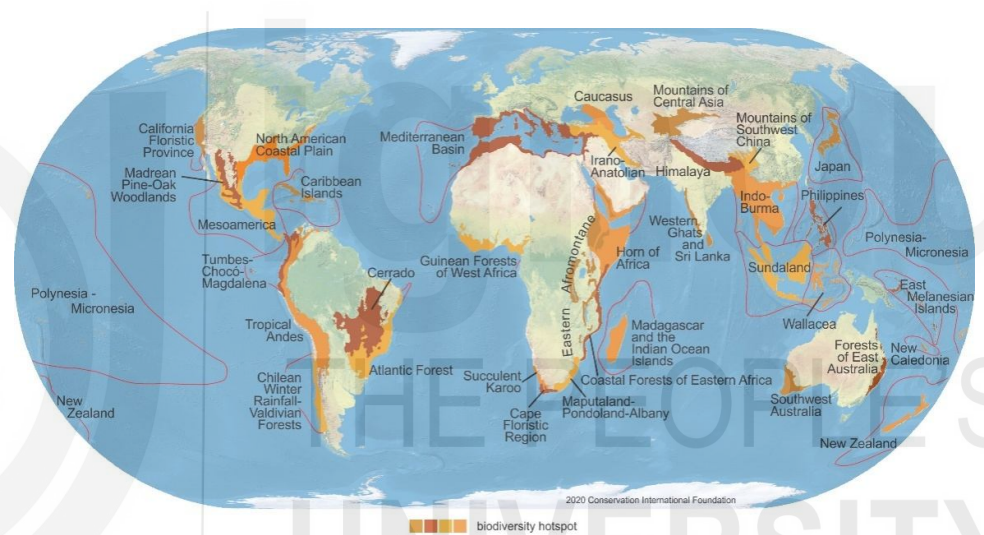
Figure 11.1: Spatial Distribution of Biodiversity Hotspots in World.
*(Source:***http://www.conservation.org***&***https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined***)*

SAQ 4

Fill in the blanks

1. _____ are the home of flora and fauna.

2. The concept of biodiversity hotspot was first developed by _____.

3. An example of invasive species in Florida is _____.

4. There are _____ biodiversity hotspots in African continent.

11.6 MANAGEMENT OF BIODIVERSITY LOSS

Till now, you have been studied the concept of biodiversity, biodiversity loss, the important factors affecting the loss of biodiversity, and the biodiversity hotspots in the world. You now know the management of biodiversity loss

which deals with the methods of protecting and conserving biodiversity. It ranges from protecting an individual species to conserving a large ecosystem.

11.6.1 Methods of Managing Biodiversity Loss

Most of the methods in various literatures suggested two ways of biodiversity management. These are: in-situ and ex-situ management of biodiversity. These are discussed below:

a) In-situ Management
In-situ management of biodiversity includes the protection of species in the areas where they are. It means conservation in their natural habitat only. Therefore, it is also known as on-site management of biodiversity. In-situ conservation is quite relevant as it conserves the biodiversity in their natural habitat. It is also helpful in restoring and renewal of degrading environment. However, it is difficult also due to increasing population pressure and associated impacts.

In-situ management of biodiversity includes the identification of areas with rich biodiversity levels, and declaring and managing them as protected areas. A protected area is a dedicated area for the conservation for flora and fauna and associated ecosystem services. These areas are the mainstay of biodiversity and also contribute in the livelihood security of people who lives around these areas. These protected areas are not only the habitat of biodiversity but also save human beings from natural disasters and play an important role in climate change mitigation.

In recent times, these protected areas are facing lots of problems. The size of the protected areas is too small and, therefore, unable to accommodate large number of species. They are poorly protected due to lack of adequate funds and skilled people. These protected areas are also suffering from land grabbers, poachers, miners and loggers.

b) Ex-situ Management
In the ex-situ management, the biodiversity species are tried to protect in the areas which are away from their natural habitat. It means, some more habitats are developed for their protection. This method is also known as off-site management of biodiversity. Some of the ways adopted in this approach are zoo, development of botanical gardens, seed banks etc.

Biodiversity conservation at zoos*: Zoos are the place where many animals are kept and preserved. In some cases critically endangered species are also maintained with special attention. Zoo requires large space and lots of money. Sometimes, public also support the saving of the popular species like elephant, tiger etc. Zoos also act as protected and breeding grounds for endangered species.

Setting up botanical gardens: Botanical gardens are important sites where different types of plants are preserved. They have enormous value for students, academicians and researchers. The largest botanical garden in the world is located in England that is the Kew Gardens. It has around 25,000 species. It is said that when Britain was the imperial power, large numbers of plant species were taken from the colonies to the Kew Gardens.

Conservation of seed banks: Seed Banks are the storage centre of seeds for food crops and other plant species. They keep and protect the plant species against their extinction due to natural factors. In these banks, seeds are dried up to suitable temperature and stored safely. Seed Banks also keep the details of everything related to the seeds identity, their number, origin etc. The largest seed bank in the world is Svalbard Global Seed Vault opened by Norwegian Government in 2008. The Seed Vault has the capacity to store more than 4 million varieties of seeds.

11.6.2 Global Efforts for Biodiversity Conservation

At the world level, various efforts have been taken for the conservation of biodiversity. There are following international conventions which have been ratified by most countries:

• Convention on Biological Diversity (CBD),

• Convention on International Trade for Endangered Species (CITES),

• Ramsar Convention on Wetlands, and

• Convention on Conservation of Migratory Species of Wild Animals (CMS).

Convention on Biological Diversity

This convention was opened for signing at The United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro, Brazil in 1992. It has since been approved by more than 180 countries. It addresses two major issues: first is the conservation of biodiversity and, second, its use by biotechnology. The two issues have a north-south dimension which is clear in the stated objectives and principles. Under the convention, parties are required to: prepare national biodiversity conservation plans; integrate biodiversity conservation plans into national decision-making, encourage in-situ plans; identify biodiversity important for its conservation and sustainable use and to monitor such; establish protected areas and conserve biodiversity in situ; control and prevent the influx of alien species that threaten ecosystems; and introduce appropriate procedures for impact assessment.

Convention on International Trade in Endangered Species (CITES)

CITES of wild fauna and flora was signed in 1963, and currently, it has been ratified by 168 parties. The main aim of the convention is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. There are also other important conventions and protocols as the **Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979) and the Ramsar Wetland Convention (1991),** both have facilitated biodiversity conservation efforts worldwide.

There is a view that instead of protecting wildlife from any form of conservation it is better to allow sustainable exploitation because that will then provide a basis for conservation; that is, unexploited wildlife is a non-resource and, therefore, valueless (Spellerberg, 1992).

SAQ 5

True or False

1. Ex-situ management of biodiversity includes the protection of species in the areas where they are.

2. Hotspot areas are vulnerable for biodiversity.

3. Process of urban growth is known as urban sprawl.

4. The Kew Garden is located in Switzerland.

11.7 SUMMARY

In this unit, you have studied so far:

- The concept of biodiversity and biodiversity loss.

- What are the factors creating the problem of biodiversity loss? It is known fact that impacts of biodiversity loss are immense.

- Many biodiversity rich areas are now facing the problems of extinction of species. It is affecting the ecosystem services provided by biodiversity.

- The numbers of biodiversity hotspots are on the path of increase.

- Therefore, their management is necessary which can be in the form of in-situ or ex-situ. Their management will bring stability in the functioning of ecosystems and healthy environment around human beings.

11.8 TERMINAL QUESTIONS

1. How climate change and forest fire affects biodiversity loss? Discuss with suitable examples.

2. Write a detailed note on biodiversity hotspots?

3. Differentiate between in-situ and ex-situ management strategies for the biodiversity conservation.

11.9 ANSWERS

Self Assessment Questions (SAQ)

1. a) Biodiversity loss includes everything from the smallest single-cell organism to the greatest predator which forms the biodiversity of a given area.

   b) The death of the last surviving individual of a species or group. It can be attributed majorly by human interventions.

2. a) The factors affecting the loss of biodiversity are pollution, forest fires, environmental Degradation and climate Change, and so on.

b) 1 - D   2 – C   3 - A   4 –B

3. The loss of biodiversity can affect the availability of food, freshwater and energy sources.

4. 1. Habitats   2. Norman Myers   3. Pythons   4. Eight

5. 1. False   2. True   3. True   4. False

Terminal Questions

1. Changing climatic patterns have led to visible changes in timing of agricultural practices, flowering seasons, and migration, etc. Forest fires are caused by higher temperature during summer and dry season. In tropical forests, fires occur in every dry season. Refer to Section 11.3.

2. There are areas of the world having unique biodiversity with a number of endemic species. These biodiversity hotspots are very important in the global environment. Refer to Section 11.5 for information.

3. In-situ management of biodiversity cover with the protection of species in the areas where they are. In the ex-situ management, the biodiversity species are tried to protect in the areas which are away from their natural habitat. Refer to Sub-Section 11.6.1.

11.10 REFERENCES/SUGGESTED FURTHER READING

- Heywood, V.H. (ed) (1995) *Global Biodiversity Assessmen.* Cambridge: Cambridge University Press.

- Lomolino, M.V., Riddle, B.R., and Brown, J.H. (2010) *Biogeography.* Massachusetts: Sinauer Associates Inc.

- Rai, S.C. (2012) *Ecotourism and Biodiversity Conservation*,.New York: Nova Science Publishers, Inc.

- Rajagopalan, R. (2016) *Environment and Ecology: A Complete Guide.* Gurugram: LexisNexis.

- Sachs, J.D. (2015) *The Age of Sustainable Development*, New York: Columbia University Press.

- Spellerberg, I.F. (1992) *Evaluation and Assessment for Conservation: Ecological Guidelines for Determining priorities for Nature Conservation, London*: Chapman & Hall.

- Anil, M.N.V., Kumari, K. and Wate, S.R. (2014) Loss of Biodiversity and Conservation Strategies: An Outlook of Indian Scenario, *Asian Journal of Conservation Biology*, 3 (2): 105–114.

- Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L. and Geschke, A. (2012). International Trade Drives Biodiversity Threats in Developing Nations, *Nature,* 486: 109-112.

- Pandit, M.K., Sodhi, N.S., Koh, L.P., Bhaskar, A., and Brook, B.W. (2007). Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya, Biodiversity Conservation, 16:153-163.

- Kellee Koenig. (2016, June 15). Biodiversity Hotspots Map (English labels) (Version 2016.1). Zenodo. http://doi.org/10.5281/zenodo.4311850 accessed on 5 April 2021. https://www.conservation.org/

- https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined

GLOSSARY

Air pollution : The contamination of air in its physical, chemical or biological modifications in the atmosphere can be called as air pollution. It includes both indoor and outdoor pollution.

Biodegradable waste : These wastes are those leftover materials of organic matter include paper, textiles, wood, food wastes, fruit and vegetable peels, etc.

Biomedical waste : Wastes from hospitals, clinical labs, experimental labs, etc. are classified as biomedical wastes.

CPCB : Central Pollution Control Board is a national organization working under the Ministry of Environment and Forests provides details of environmental standards, programmes, projects, etc.

Endemism : The state of being unique in a particular area or geographic location, for example, a specific habitat type etc.

Extinction : It is a situation arising from the death of the last surviving individual of a species or a group globally or locally.

Fossil fuels : These occur naturally in underground reservoirs formed from the fossilized, buried remains of plants and animals over the course of millions of years. For example, crude oil, coal, petroleum, natural gas, etc.

Gaseous waste : These include wastes in gaseous form produced by in the result of various human activities from manufacturing industries, chemical factories, etc. For example, the gases comprise of methane (CH_4), carbon dioxide (CO_2), chlorofluorocarbons (CFCs) etc.

Liquid waste : These are liquid portions of the wastes which include urban waste water, sewage, effluents, leaching of agricultural chemicals, etc.

Natural pollutants : The pollutants release into the atmosphere as a result of natural phenomena are referred to as natural pollutants.

Noise pollution : The trouble of human or animal life by unbearable sounds from loud music, machines, transportation systems, vehicles, trains and aircrafts, etc. is called noise pollution.

Non-biodegradable wastes : These wastes include inorganic and to a certain extent recyclable waste products. It includes plastic wastes, glass wastes, cans, metals, etc.

Particulate matter : These are fine or tiny particles of solid or liquid suspended in a gas or air.

Pastoralists : These human groups depend mainly on herding

domesticated livestock.

Pollutant : It introduces the harmful toxic substances in to the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases.

Pollution : is an entry of unwanted elements in the form of solid, liquid and gaseous in to the environment that adversely affect the human and their environment.

Predator : These are the animals whose life is dependent on preying of other animals.

Primary pollutants : Pollutant enters directly into the atmosphere as a result of natural and other activities. For example, sulphur and nitrogen compounds, carbon monoxide and carbon dioxide, volatile organic compounds and particulate matter, etc.

Secondary pollutants : These are formed by the subsequent reactions of primary air pollutants. For example, sulphur dioxide reacts with oxygen in the atmosphere to form sulphur trioxide.

Soil pollution : The presence of human induced chemicals like fertilizers, insecticides and pesticides, and mining, agriculture, deforestation, etc. are led to modifications in the soil that cause to pollute the soils.

Solid wastes : Non-soluble wastes or solid portion of rejected materials from plastics, glass-made items, food wastes, metals and mining residue, etc. Most of the solid wastes are not recyclable.

Threatened species : Any species that is likely to become extinct within the foreseeable future throughout all or part of its range and whose survival is unlikely if the factors causing numerical decline or habitat degradation continue to operate.

Urban sprawl : It is the process of urban growth generally characterized by the outward expansion and concentration of urban activities and land uses into the surrounding countryside.

Vascular plant : A vascular plant has a well-developed system of tissue to transport water, mineral, salts, and sugars. Some of the examples of vascular plants are trees, grasses, flowers etc.

Waste : Refers to any materialistic item or thing which is no more useful.

Water pollution : The excessive chemicals in the water leads to poor quality and are harmful to humans and other living things referred to as water pollution. Water pollution affects rivers, lakes, oceans and quality of drinking water all over the world.