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BEVAE -181
Ability Enhancement
Compulsory Course (AECC) on
Environmental Studies

Environmental Studies

Indira Gandhi National
Open University
School of Sciences

BEVAE-181
ABILITY ENHANCEMENT COMPULSORY COURSE ON ENVIRONMENTAL STUDIES

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COURSE INTRODUCTION

Earth is the only known planet in the solar system that supports life. Despite the vastness of the Earth, life exists only in a very thin layer of the Earth called biosphere. For a long period of time, there has been a symbiotic relationship between human being and nature. Due to excessive human interference and unsustainable practices, millions of people's life and livelihoods are at risk. Therefore, there has been a growing need to create awareness amongst all the stakeholders. Keeping this in view, Environmental Studies is being introduced as a compulsory course for all the learners at under-Graduate level. This course has four blocks.

Block 1 An Introduction to Environment and Environmental Studies: Today, human society is standing at a cross road and searching for the better alternatives for sustainable future earth. That is why there is a necessity that every individual should have awareness and knowledge about the earth's environmental resources, human-environment relationship and issues emerging out of human-environment relationship. This block has made an attempt to establish the importance of symbiotic relationship and the need for sustainable development. This block consists of three units. Unit 1 introduces concept of environment and nature and importance of environmental studies. Unit 2 discusses about the concept, features, types and functions of ecosystem and Unit 3 describes about major ecosystems on the earth.

Block 2 Natural Resources: This block discusses about natural resources that provide the base for human sustenance and development by providing ecosystem services. There has been substantial decline and degradation of natural resources over the years. As a result of which, there has been a negative impact on ecosystem services. Therefore, there is a need for sustainable natural resource management. This block consists of four units. Unit 4 deals with land and water resources while Unit 5 discuses about forest resources. Biodiversity: Values and services are discussed in Unit 6 and energy resources were explained in Unit 7. In all these units, resources are discussed in terms of distribution, availability, utilisation, causes of degradation and need for and methods of conservation.

Block 3 Environmental Issues and Concerns: This block consists of four units related to various environmental issues confronted by humans at different levels - local to global. Unit 8 titled Biodiversity: Threats and Concerns focused on causes of bio-diversity loss and measures for biodiversity conservation. Unit 9 ''Environmental Pollution and Hazards'' discussed about the phenomenon of pollution in air, water and soil, their sources and their effects. Apart from these, noise, radiations and thermal pollution have also been discussed. Unit 10 titled Waste Management discussed about the waste and various ways of waste disposal system which have minimum harm to the environment. Unit 11 titled Global Environmental Issues discussed the causes and effects of phenomena namely, global warming, acid rain, ozone depletion and some of the measures taken to deal with these issues.

Block 4 Protecting Our Environment: Policies and Practices: This block being the last block of the course has attempted to address the policies, beliefs and practices associated with environment. This block consists of three units. Unit 12 deals with environmental legislation whereas environmental ethics are discussed in Unit 14. Unit 13 covers issues related to human communities and environment.

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Block

1

AN INTRODUCTION TO ENVIRONMENT AND ENVIRONMENTAL STUDIES

BLOCK 1: INTRODUCTION

Earth is the only known planet in the solar system that supports life. Despite the vastness of earth, life exists only in a very thin layer enveloping the earth called biosphere. Sun is the only source of energy which enables continuous interaction among various life forms. For a long period of time, there has been a symbiotic relationship between human being and nature but it is changing. Due to excessive human interference and unsustainable practices, millions of people's life and livelihoods are at risk. Therefore, there has been a growing need to create awareness amongst all the stakeholders. Keeping this in view, Environmental Study is being introduced as a compulsory course for all the learners at under-Graduate level. This block consists of three units. Unit 1 introduces concept of environment and environmental studies. Unit 2 discusses about the concept of ecosystem and Unit 3 describes about major ecosystems.

Unit 1 Our Environment: This unit, being the first in the course, brings out the holistic meaning of the word 'environment'. This unit will also focus on how we as living beings interact with other living and non-living components of the ecosystem. For centuries humans have considered the earth and environment as an unlimited resource but subtle and gradual changes have altered our environment in many different ways. The concept of sustainable development provides an alternative model of development that could balance between environment and development. This unit will also discuss the multidiscipilinary nature and scope of environmental studies.

Unit 2 Ecosystems: This unit deals with the structure and properties of ecosystem, basic concepts of ecosystem functioning, and the factors controlling it. It also deals with the development of ecosystem. The unit will also familiarise you with interactions like competition, parasitism and mutualism that exist between living beings. This unit will also focus on how we as living beings interact with other living and non-living components of the ecosystem and would also become aware that ecosystems are able to maintain homeostasis by active effort, resisting the tendencies toward disorder.

Unit 3 Major Ecosystems: This unit discusses two broad categories namely terrestrial and aquatic ecosystems and their types. Major terrestrial ecosystems include forests, grasslands and deserts while lakes, rivers, oceans, estuaries and wetlands are collectively known as aquatic ecosystems. Besides, you will study about the importance of the forests, grasslands and aquatic ecosystems.

We hope after studying this block, you will acquire an in-depth understanding of the physical components of the environment, the process related to them and their interactions with other components of the environment

These units would enable you to use your intelligence and skills to the best of your advantage for managing our environment and keeping it healthy for future generations.

Our best wishes are with you in this endeavour.

UNIT 1

OUR ENVIRONMENT

Structure

1.1 INTRODUCTION

Earth is the only planet known for supporting life. Despite the vastness of earth, life exists only in a very narrow zone of the earth called biosphere. Sun is the only source of energy which enables continuous interaction among various life forms.This unit, being the first in the course, brings out the holistic meaning of the word 'environment'. In broad terms, environment includes everything external to an organism that affects it, including physical as well as living factors. The action and interactionof the physical and living factors makes a system of relationships called ecosystem. This unit will also focus on how we as living beings interact with other living and non-living components of the ecosystem. The concept of sustainable development came into existence that explains symbiotic relationship between human being and environment.

For centuries humans have considered the earth and environment as virtually unlimited resources but subtle and gradual changes have altered our environment in many different ways.Special mention has been made of human population within the changing scenario over the years, particularly since the industrial revolution. We hope that this unit will give you a better understanding of the environment and its various components. This unit would also enable you to use your intelligence and skills for managing our environment and keeping it healthy for future generations. This unit will further explain the multi-discipilinary nature and scope of environmental studies.

Expected Learning Outcomes

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

- explain the importance of environment in our life and surroundings;
- recognise the importance of the concept of sustainability and sustainable development;
- analyse the multidisciplinary nature of environmental studies; and
- appreciate the importance and scope of environmental studies.

1.2 CONCEPT OF ENVIRONMENT

Each and every living organism has a specific surrounding or medium with which it continuously interacts, derives its sustenance and to which it is fully adapted. This surrounding is the 'natural environment'. The word 'natural environment' brings to mind broad aspects of landscape, such as soil, water, desert or mountains which can be more exactly described in terms of physical or abiotic influences such as differences in moisture, temperature, texture of soil, and air quality. It also includes the biological or biotic influences in the form of microbes and animals. Thus, environment is defined as, **"the sum total of living and non-living components; influences and events surrounding an organism"**.

Let us begin by asking what is environment? Environment is derived from French word *environ* which means to encircle or surround while *ment* means auctioning, i.e., environment is the interaction between organism and the nature. For humans, there are several kinds of environment such as home environment, business environment, political environment and so on. But we are going to discuss only about natural environment: air, water, land, plants, animals and other organisms. Any individual in nature interacts with its environment, influences it and in turn is influenced by it. Thus environment is the sum total of air, water and land interrelationship among themselves and also with the human beings, plants, animals and other organisms. The most significant attribute of the effect of environment on life of an organism is the interaction of environmental elements. These abiotic and biotic factors are dynamic in nature and interact with each other in every moment of life.

No organism can live alone without interacting with other organisms, so each organism has other organisms as a part of its environment. You must be aware that all animals are directly or indirectly dependent upon plants, basically the green plants that manufacture their own food. Plants also depend on animals for a few things such as pollination of flowers and dispersal of fruits and seeds.

Let us try to understand the concept of environment with an example (Refer Fig.1.1.). Can you identify the environment of a carp fish in the pond? Its environment consists of abiotic components such as light, temperature, and water in which nutrients, oxygen, other gases and organic matter are dissolved. The biotic environment consists of microscopic organisms called planktons as well as aquatic plants and animals and decomposers. The plants are of different kinds such as floating, submerged and partly submerged plants, and trees growing around the edge of the pond. The animals consist of insects, worms, molluscs, tadpoles, frogs, birds and various kinds of fishes.The decomposers are the saprotrophs like bacteria and fungi.

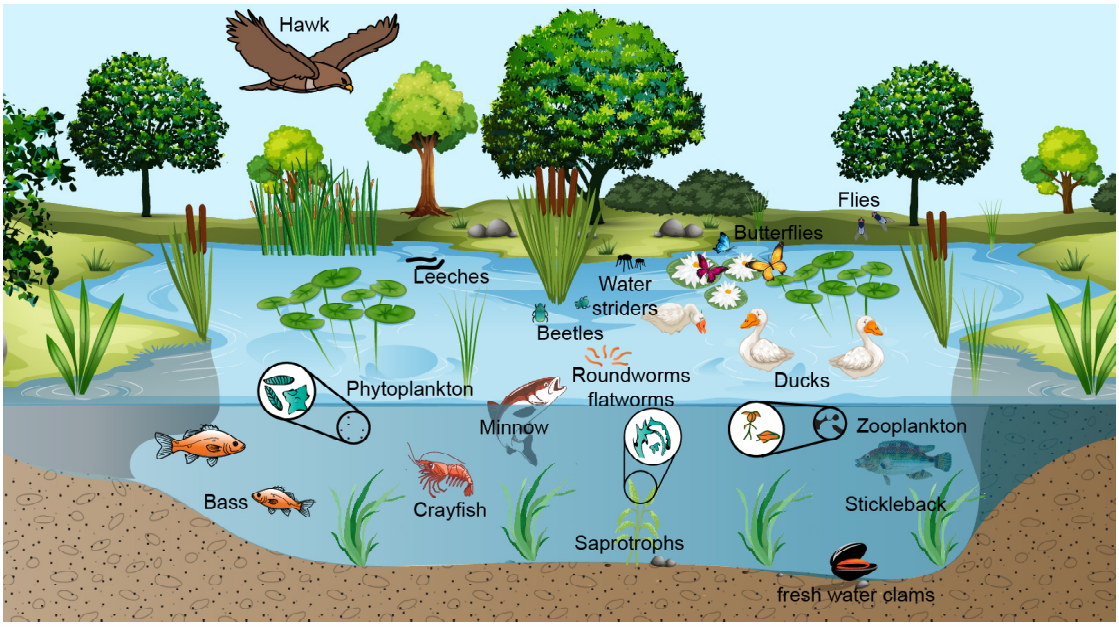

Fig. 1.1: Environment of a Carp in a Pond.

Till now, you might have realised that the environment is not static. The biotic and abiotic factors are in a flux and keep changing continuously. **The organisms can tolerate changes in environment within a certain range called 'range of tolerance'.**

1.3 COMPONENTS AND TYPES OF ENVIRONMENT

After discussing about the concept of environment. In this section, we will discuss about components, types and significance of environment.

1.3.1 Components of Environment

Broadly the environment comprises of abiotic (non-living) and biotic (living) components. Some examples of abiotic and biotic components of environment are listed below in Table 1.1

Table 1.1: Components of Environment

Abiotic Components	Biotic components
Light Precipitation Humidity and Water Temperature Atmospheric gases Seasonal changes Topography	Plants Animals including humans, parasites and micro organisms Decomposers

The physical components set the condition for the survival of the biotic components, which in turn take care of the maintenance of the environment. Linkages among components of the environment are pathways for the flow of energy and cycling of materials. For example, green plants obtain essential resources from the physical realm – water and minerals from the soil, carbon dioxide from the atmosphere and light energy from the sun, and manufacture their food. Animals depend on plants and other animals for their source of

food. We, the human being, in turn harvest the land and the seas for our food; and obtain minerals and fuel from the Earth's crust. We will learn more about these later in this course.

1.3.2 Types of Environment

Recall the definition of the environment, and consider a fish living in a natural pond which we have already discussed in the previous section. Its **external environment** will be the water in the pond which it primarily inhabits. The water would contain nutrients, oxygen and other organisms that the fish requires to sustain its life. As opposed to the external environment, the body cavity within the fish provides an **internal environment** quite separate from the outside environment. The body surface act as an exchange barrier between the internal and the external environment of the fish. The internal environment is relatively stable as compared to the external environment. However, illness and injury or even environment stress can upset it. But when the cause of the disturbance is removed, the internal environment comes back to its original condition.

The pond which the fish inhabits is its **natural environment**. The abiotic factors of the pond, like light, temperature, depth, nutrients, and dissolved gases will provide the life supporting chemical and physical factors for the fish. The other living organisms inhabiting the pond, like bacteria, insects, worms, molluscs, tadpoles, frogs and aquatic vegetation could be food for the fish. Examples of such natural environments on land include forests, grasslands, savannah and deserts. So far we have discussed only the natural environment but there are several components of environment which are created by humans, like crop fields, cities and industrial spaces (Fig. 1.2). These are places made artificially by humans through planned manipulation. For

Natural Environment Oceans, lakes/ponds, rivers, forest, grasslands, deserts etc.	
Human-modified Environment Orchards, plantations, sanctuaries, parks, etc.	
Human-made Environment Industries, cities, towns, crop fields, artificial lakes, dams, etc.	

Fig. 1.2: Examples of Different Types of Environment.

example, let us consider a city. The city environment is totally created by human beings. One of the most important components – water is not taken from streams directly but is first filtered, purified and then used for drinking and other municipal purposes. The metabolic waste and garbage are not disposed off locally but are carried for treatment or dumping to a remote place, away from the city. Food for the people in cities often comes from rural areas. An environment made by humans results in the consumption of excessive amounts of materials and energy, necessitating care, supervision and management.

1.3.3 Significance of the Environment for Life

Whatever type of environment organisms inhabit, they all need life supporting elements for their survival. These include air that they breathe, food and water they take in, and shelter either as natural (like caves and tree holes) or as artificial dwellings (like houses). Environment is the only source that provides these life supporting elements.

We make use of the land for cultivating crops. Soil provides nutrients needed for the growth of plants. The landform determines the soil types found in any one area and soil itself varies from place to place. Some soils are rich in nutrients and other are lacking in them. The soils lacking nutrients need the addition of fertilizers.Climate and short term weather changes are characterized mainly by wind, temperature, pressure and rainfall and are determined by the properties of the atmosphere. Air in the atmosphere provides living organisms with oxygen, without which survival of the most of the living organisms will be threatened.

SAQ 1

Answer the below given question within 30 words.

i) Describe the significance of physical components in an environment.

ii) Explain in brief the significance of the environment for life.

1.4 HUMAN - ENVIRONMENT RELATIONSHIP

As we know from the previous section that all living beings are dependent upon their immediate surroundings for their sustenance and survival. There are two distinct situations observed if we trace the history of human civilization. The first situation is that human being adjusted or adapted to the prevailing environmental conditions. Those who could not adapt or adjust perished. Similar situations can be observed amongst plants and animals also. As human civilization progress, people developed knowledge, skill and technology to subjugate nature. This happened faster after *renaissance* and Industrial revolution. It has improved standard of living as well as made human life comfortable. However, this has leads to irreparable damage of environment and threat to the human society as well as survival of the planet earth. Therefore, it has been realized that there should be a balance between

development and protection of environment. This approach is best expressed as 'sustainable development' which we will discuss in detail in the next section. But now, let us consider the various approaches to human-environment relationship i.e. determinism, possibilism and environmentalism.

Determinism: This concept was developed by German Geographer Friedrich Ratzel, which was further expanded by Ellsworth Huntington. This approach is based on the concept of 'nature controls human' or 'earth made human'. This is also known as environmental determinism. According to this approach, human being is largely influenced by nature. In fact, the determinism states that human being is subordinate to natural environment because all aspects of human life such as physical (health and well-being), social, economic, political, ethical and aesthetic not only depend on but are dominantly controlled by the physical environment.

Possibilism: This term was coined by the French historian, Lucien Febvre. Possibilism approach in the study of human-environment relationship is an offshoot of the criticism of environmental determinism. The evolution of such human-environment relationship was influenced by the advancement of science and technology. Possibilism indicates that the physical environment is passive and human being is the active agent at liberty to choose between wide ranges of environmental possibilities. According to this apporach, the pattern of human activity is the result of the initiative and mobility of human being operating within the natural framework. However, it was agreed upon by the possibilists that humans lack the abilities to fully tame the nature and is not always victorious over it. As a result of the above, some scientists and academics vouched for 'cooperation with nature' or 'mutual interaction' between human being and environment.

Environmentalism or Ecological Approach: This approach is based upon the basic principle of ecology, which is the study of mutual interaction between organisms and physical environment on the one hand, and the interaction among the organisms on the other in a given ecosystem. This approach describes human being as an integral part of nature or environment. Human being as the most skilled and intelligent has a unique role to play in maintaining a natural environment as healthy and productive as it should be. This approach emphasizes on wise and restrained use of natural resources and application of appropriate environmental management programmes, policies and strategies keeping in view certain basic principles of ecology so that already depleted natural resources are replenished, and health and productivity of the nature is restored.

The ecological approach is best reflected in the concept of sustainable development which we will discuss in the following section.

SAQ 2

Fill in the blanks with suitable words:

i) The approach of determinism is based on the concept of .... or ..... .

ii) Possibilism indicates that the physical environment is ..... and human being is the ..... agent at liberty to choose between wide ranges of environmental possibilities.

iii) Environmentalism emphasizes on ..... and .... use of natural resources.

1.5 CONCEPT OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

The concept of Sustainable Development was formally defined in the report titled "Our Common Future". This report was an outcome of deliberation of a group constituted by World Commission on Environment and Development (WCED) and chaired by the then Norwegian Prime Minister Gro Harlem Brundtlandt. Brundtlandt Commission defined sustainable development as the development that involves ***"…meeting the need of present generation without compromising the ability of future generations to meet their own needs."*** This definition of sustainable development initiated a lot of debate. The scientists were of the opinion that the term 'need' and 'development' has not been defined properly in the report. Need can not be generalized universally. It varies from place to place and person to person. Similarly, development was also not properly defined. The report explains development as something people do to improve their lives. Therefore, it becomes amenable to varied interpretations. A more precise definition with clearly spelt-out goals remains elusive.

Herman Daly, an ecological economist, referred to sustainable development as an "**oxymoron**". Do you know what an Oxymoron is? Oxymoron is a figure of speech that combines two usually contradictory terms into a compressed paradox (e.g. bitter sweet, pretty ugly). The definition of '**development'** is not precise enough to make it more in favour of nature conservation than on building roads, factories, infrastructure etc. The Oxford dictionary meaning of development is "**a stage or advancement**".

On the other hand, "**sustainability"** is the capacity to endure. The word "sustainability" is derived from the latin "sustinere" (tenere = to hold; sus= up). Dictionaries provide more than ten meanings for sustain, the main ones being to "maintain", "support", or "endure". Further more, as has been pointed out by Michael Redclift the sustainability discussion has gradually, over the years, moved almost imperceptibly away from "human needs" to "**human rights**". Therefore, **Sustainability** refers to a process which can be continued indefinitely without depleting the resource base on which it depends. Therefore, it is the practical goal towards which our interaction with the natural world should be directed. The guiding principles of sustainability cut across ecological, economic, social and cultural dimensions.

The concept of sustainable development is now well accepted at international, national and local levels. This has been emerging as a strong alternative model of development after a long debate and discussion since Rio Summit in

1992. Sustainable development means different things to different people. There are three important disciplines traditionally concerned with the processes involved in conceptualizing sustainable development. The discipline of economics is mainly concerned with growth, efficiency and the optimum use of resources. On the other hand, sociologists mainly focus on human needs and on concepts like equity, empowerment and social cohesion. Ecologists show their greatest concern for preserving natural systems, for living within the carrying capacity of the environment, and for dealing efficiently with pollution. Today this sectarian approach to development adopted by the above mentioned disciplines have been rejected. Now, it has been argued that sustainable development will be achieved where the concerns of these three groups are addressed in a holistic manner, as shown in Fig. 1.3.

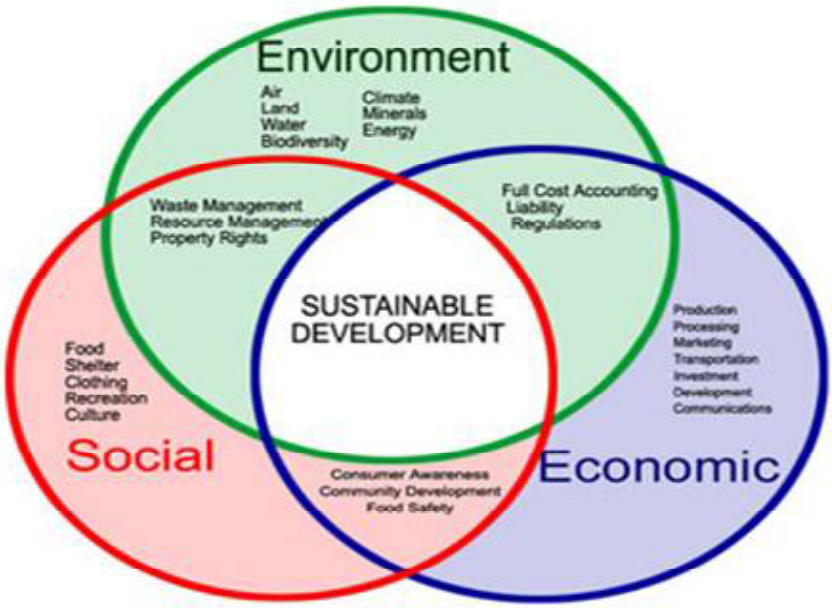

Fig. 1.3: Three Pillars of Sustainable Development.

It has been said that sustainable development is an ideal which no societies today have achieved anything resembling it. Nevertheless, as with justice, equality, and freedom, it is important to uphold sustainable development as an ideal - a goal toward which all human societies need to be moving. For example, policies and actions that reduce infant mortality, increase the availability of family planning, improve the air quality, provide more abundant and pure water, preserve and protect natural ecosystems, reduce soil erosion and reduce the release of toxic chemicals to the environment, all movea society in the right direction – toward a sustainable future.

To achieve this desired goal, societies have to make certain transitions which are very much essential. There is a broad consensus on the following transition to make future societies:

- **A demographic transition**: from a continually growing population to one that is stable.
- **A resource transition** to an economy that is not solely obsessed with growth, rather relies more on nature's income and protects ecosystem capital from depletion.

- **A technological transition** from pollution-intensive economic production to environment friendly processes.
- **A political/sociological transition**
- **A community transition**

Priority Areas for Achieving Sustainable Development

1. **Slow Down Population Growth**: This is essential for addressing all the other priority areas.
2. **Reduce Poverty, Inequality and Third World Debt**: Improving health, longevity and literacy, increasing employment etc. This is important for curbing the loss of species, the extent of land degradation and water pollution.
3. **Make Agriculture Sustainable**: This includes reducing soil erosion and decreasing the use of harmful agricultural practices. This is important for curbing the loss of biodiversity, land degradation and pollution.
4. **Protect Forests and other Habitats**: This includes reforestation and afforestation of wastelands, protection of other living resources, control greenhouse gases and ozone layer depletion. This is important for reducing air pollution, land degradation, depletion of energy and minerals
5. **Make Water and Energy Use Sustainable**: This includes improved energy efficiency, conserving energy and developing renewable energy resources. This is important for reducing air pollution, land degradation, depletion of energy and minerals.
6. **Make Water Use Sustainable**: This includes improving the efficiency of water use and protecting water quality. This is important for curbing water pollution and depletion and land degradation.
7. **Reduce Waste Generation**: This includes improving production processes, waste treatment and recycling processes. This is important for reducing air and water pollution and energy, mineral and water depletion.

SAQ 3

i) Define the term ‘‘Sustainability’’.

ii) Why is it important to uphold sustainable development as an ideal?

1.6 MULTIDISCIPLINARY NATURE OF THE ENVIRONMENTAL STUDIES

Till now, you must have realised that the environment affects us in several ways, for example, the water we consume, the air we breathe, the climatic conditions in which we live, and surrounding where we live all have effects on us. In natural conditions usually living organisms keep a balance with their environment. Humans in many ways have personalized the environment

according to their need with the help of skill and science, but in doing so we have disrupted the fragile intricately woven web of life and life supporting systems. All these interactions with environment as a whole are subjects of environmental studies.Therefore,environmental studies contribute a branch of study of inherent or induced changes in the environment, and their effect on living beings.

Environmental studies cover a large domain of knowledge which deals with every concern that affects an organism. From human angle, this means it is an applied science which seeks all possible answers to make human civilization sustainable on the earth with all its limited resources. It includes not only the study of physical and biological characters of the environment but also economic, social, cultural and even political and legal aspects of the environment. Various issues such as clean and safe drinking water, clean and fresh air, clean living conditions, productive land, good quality foodstuff and sustainable development are dealt with in environmental studies.

The importance of environmental studies cannot be disputed. The need for sustainable development is a key to the future of humankind. Continuing problems of pollution, loss of forest and bio-diversity, solid waste disposal, degradation of environment, issues like global warming and climate change, the depletion of ozone layer and loss of biodiversity have made everyone aware of environmental issues. The United Nations Conference on Environment and Development held in Rio de Janerio in 1992 and World Summit on Sustainable Development at Johannesburg in 2002 have drawn the attention of people around the globe to the deteriorating condition of our environment. This has been again reaffirmed by United Nations by adopting seventeen Sustainable Development Goals in the year 2015. It has been decided that these seventeen goals would be achieved in the next fifteen years i.e. 2016-2030.

Box 1.1: Sustainable Development Goals

1. No Poverty
2. Zero Hunger
3. Good Health and Wellbeing
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13 Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institution
17. Partnership for the Goals.

India is rich in biodiversity which provides various resources for people. Only about 1.7 million living organisms have been described and named globally. Still many more remain to be identified and described. Attempts are made to conserve them in *ex-situ*(outside their natural habitat) and *in-situ*(in their natural habitat situations). You will learn about *in-situ*and *ex-situ* conservation in Unit 8.Destruction of habitats, over-use of energy resources and environmental pollution has been found to be responsible for the loss of a large number of life-forms. It is feared that a large proportion of life on earth may get wiped out in the near future.

These issues are extensively addressed in the next thirteen units of this course both at global as well as national level.

1.7 IMPORTANCE OF ENVIRONMENTAL STUDIES

The environment studies enlighten us, about the importance of protection and conservation of environment. At present, due to our aggressive consumerist lifestyle and carbon intensive industrial development we have created a large number of environment issues both in terms of magnitude, intensity and complexity at local, regional and global level. We shall study about these issues and suggestive measures for mitigation in the Environment Studies. Let us discuss major environmental as issues in the following paragraphs:

1. **Environmental issues are of international importance:** It has now been well recognised that environment issues like global warming, climate change, ozone layer depletion, acid rain, marine pollution and loss of biodiversity are not merely national issues but are global issues and hence must be tackled with international efforts and cooperation.
2. **Emergence of problems in the wake of modernisation and development:** Development in the modern period has given birth to industrialisation, urbanization, modern transportationsystems, Agriculture, Housing etc. When the West developed, it did so perhaps in ignorance of the environmental impact of its activities. Evidently such a path is neither practicable nor desirable. The developing world now faces the challenge of developing without environmental degradation.
3. **Explosive increase in population:** World census reflects that one in every seven persons in this planet lives in India.Evidently with 16 per cent of the world's population and only 2.4 per cent of its land area,there is a heavy pressure on the natural resources including land. This emphasizes on the need for efficient management of natural resources for the benefits of all.
4. **Need for an alternative solution:** It is essential, especially for developing countries to find alternative paths to developmental goal. Such a goal would need to be distinct from the developed world in the manner that would conserve natural resources and avoid wasteful consumption.
5. **Need for wise planning of development:** Resources withdrawal, processing and use of theproducts have all to be synchronised with the

ecological cycles in any plan of development. Our actions should be planned for the sustenance of the environment and development.

SAQ 4

i) Differentiate between *in-situ* and *ex-situ* conservation.

ii) What should be kept in mind while planning for alternative solution in developing countries for the sustenance of environment and development?

1.8 SUMMARY

- Environment is defined as"the sum total of living and non-living components; influences and events surrounding an organism". Broadly the environment comprises of abiotic (non-living) and biotic (living) components.
- Brundtlandt Commission define sustainable development as the development that provides for "…*meeting the need of present generation without compromising the ability of future generation to meet their own needs."*
- It has been said that sustainable development is an ideal which no societies have been able to achieve. Nevertheless, as with justice, equality, and freedom, it is important to uphold sustainable development as an ideal- a goal toward which all human societies need to be moving.
- Sustainability refers to a process which can be continued indefinitely without depleting the resource base on which it depends. Therefore, it is the practical goal towards which our interaction with the natural world should be working. The guiding principles of sustainability cut across ecological, economic, social and cultural dimensions and there are obvious trade-offs.
- The environment studies enlighten us about the importance of protection and conservation of environment. At present, due to our aggressive consumerist lifestyle and carbon intensive industrial development, we have created a large number of environment issues both in terms of magnitude, intensity and complexity at local, regional and global level. As a result, the quality of life and even survival of humankind on earth are threatened. We study about these issues and suggestive measures for mitigation in the Environment Studies.

1.9 TERMINAL QUESTIONS

1. What is environment? Explain various components of environment with suitable examples.

2. Analyse human-environment relationship over time and space.
3. Describe in detail priority areas required for achieving sustainable development.
4. Explain in detail the importance of environmental studies.

1.10 ANSWERS

Self-Assessment Questions

1. i) The physical components set the condition for the survival of the biotic components.

   ii) Environment provides all life supporting elements which include air to breathe, food we eat and water we drink, and shelter either as natural like caves and tree holes or material for the construction of as artificial dwellings.

2 i) nature controls human, earth made human

   ii) Passive, active

   iii) wise, restrained

3. i) Sustainability refers to a process which can be continued indefinitely without depleting the resource base on which it depends.

   ii) A goal toward which all human societies need to be moving.

4. i) *In-situ* refers to conservation in their natural habitat situations. whereas *ex-situ* refers to conservation outside their natural habitat.

   ii) While planning for alternative solution in developing countries for the sustenance of environment and development need to be distinct from the developed world in the manner that would conserve natural resources and avoid wasteful consumption.

Terminal Questions

1. Environment is defined as the sum total of living and non-living components; influences and events surrounding an organism. It has two components i.e. biotic and abiotic. Biotic components include all living organisms whereas abiotic component includes non-living things. Examples of abiotic components are topography, light, precipitation, humidity & water, temperature, atmospheric gases, seasonal changes whereas biotic components include plant, animals including humans, parasites and micro-organisms and decomposers.
2. Human-environment relationship can be grouped under three categories i.e. determinism, possibilism and environmentalism. Determinism states that human being is subordinate to natural environment because all aspects of human life are dominantly controlled by the physical

environment. Possibilism indicates that the physical environment is passive and human being is the active agent at liberty to choose between wide ranges of environmental possibilities.Ecological his approach emphasizes on wise and restrained use of natural resources and application of appropriate environmental management programmes, policies and strategies keeping in view certain basic principles of ecology so that already depleted natural resources are replenished, and health and productivity of the nature is restored.

3. Priority areas required for achieving sustainable development are slow down population growth;reduce poverty, inequalityand Third World debt;make agriculture sustainable;protect forest and other habitats;make water and energy use sustainable;reduce waste generation.

4. Importance of environmental studies are as follows: (i) Environment issues are of international importance; (ii) Emergence of problems in the wake of modernisation and development; (iii) explosive increase in population; (iv) need for an alternative solution; and (v) need for wise planning of development Any four)

1.11 FURTHER READING

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UNIT 2

ECOSYSTEMS

Structure

2.1 INTRODUCTION

Earth is the only planet, revolving around the sun, which is known to support life. Despite the vastness of earth, life exists only in a very thin layer enveloping the earth called biosphere. Sun is the only source of energy which enables continuous interaction among various life forms.

In the previous unit you have already learnt about the word 'environment' and its definition. You have also been familiarised with the external and internal environment of organisms that also include us. Both the external and the internal environment of an organism have an impact on its existence and survival. The components of the external environment of an organism include physical as well as living components. The action and interaction of the physical and living components of an organism make a system of relationship called ecosystem. This unit deals with the structure and properties of ecosystem, basic concepts of ecosystem functioning, and the factors controlling it. It also deals with the development of ecosystem. The unit will familiarise you with interactions like competition, parasitism and mutualism that exist between living beings. This unit will also focus on how we as living beings interact with other living and nonliving components of the ecosystem. You will also

become aware that ecosystems are able to maintain homeostasis by active effort, resisting the tendencies toward disorder.

For centuries humans have considered the earth and the environment as a virtually unlimited resource but subtle and gradual changes have altered our environment in many different ways. We wish that this unit enables you to use your intelligence and skills to the best of your advantage for managing our environment and keeping it healthy for future generations.

Expected Learning Outcomes

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

- define and explain the basic concept of ecosystem, its structure, function, and properties;
- explain the terms biosphere, biome, aquatic zone, landscape and population;
- describe the development, control and stability of the ecosystem in order to act positively towards the environment;
- discuss that the flow of energy and cycling of material are central to ecosystem functioning and indiscriminate intervention would lead to damage and disruption of the environment; and
- explain your duties and obligations towards the environment.

2.2 WHAT IS AN ECOSYSTEM?

You and I, as you know, live in a defined area of the earth where plants and animals, including ourselves, develop relationships with each other for life, food, water, shelter and mates. This discrete unit has both living and non-living environmental components, which are interdependent and interrelated in terms of their structure, components and functioning. Such a discrete unit is called an ecosystem.

2.2.1 Definition of Ecosystem

The word ecosystem, was coined by Prof. Arthur Tamsley in 1935. The prefix 'eco' means environment.

An ecosystem is defined as, "any unit (a biosystem) that includes all the organisms that function together (the biotic community) in a given area, interacting with the physical environment (abiotic component) so that the flow of energy clearly leads to defined biotic structures and cycling of materials between living and nonliving parts".

The ecosystem is thus, a dynamic system which involves the interactions between living and non-living components of an ecosystem and includes the input, transfer, storage and output of energy as well as cycling of essential materials through the ecosystem. All the processes that occur in the ecosystem are energy dependent. Fig. 2.1 illustrates this beautifully. Ecosystems differ greatly in composition, in the number and kinds of species, in the kinds and relative proportions of non-biological constituents and in the degree of variation in time and space.The study of an ecosystem is based on its structure and function.

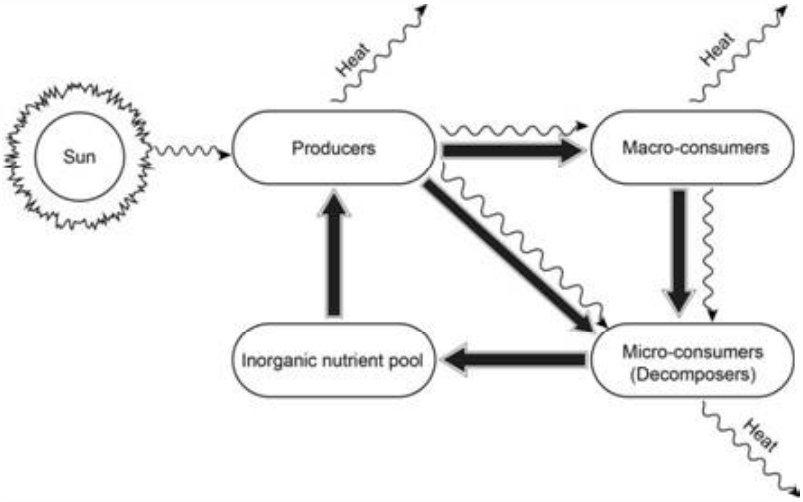


Fig. 2.1: Schematic representation of an ecosystem. The dotted lines represent the boundary of the system. The three major components are the producers, the consumers, and the abiotic elements. The arrows indicate interactions within the system and with the enviroment. Energy does not cycle because all the energy of the ecosystem is derived from the sun and it dissipates as heat.

2.2.2 Ecosystem Features

Ecosystems have both structural and functional features some of which you have studied in Unit 1, and others which you will study in this unit. You will learn about some other aspects in the forthcoming units. The ecosystem features are as follows:

I. Structural Features

The Structural aspect of the ecosystem refers to all the elements that make up an ecosystem – the individuals and communities of plants and animals and the non-living factors present in the ecosystem. The structural components include:

A. Abiotic components (Non-living Components):
   - i) Inorganic compounds – carbon, nitrogen, carbon dioxide, water.
   - ii) Organic compounds – proteins, carbohydrates, lipids, which link the abiotic to biotic components.
   - iii) Climatic regimes – temperature, moisture, light and topography

B. Biotic Components (Living Components):
   - i) Producers – plants
   - ii) Consumers – primary, secondary, tertiary.
   - iii) Decomposers – saprotrophs

II. Functional Features

Functional aspects refer to all the processes and interactions performed by the organisms in an ecosystem and include:

- i) Energy cycles
- ii) Food chains
- iii) Diversity – interlinks between organisms
- iv) Nutrient cycles – biogeochemical cycles
- v) Succession

2.2.3 Size of an Ecosystem

Ecosystems may vary in size from the smallest puddle of water or a terrestrial habitat, to a landscape or large forest, a biome, or even the entire global biosphere or ecosphere (Fig 2.2).

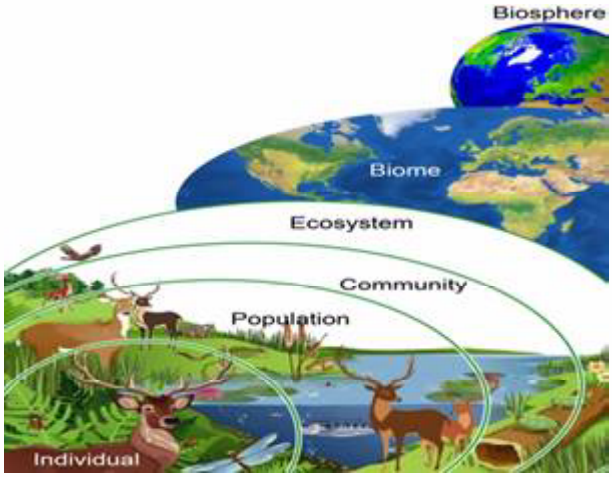


Fig. 2.2 : Size of ecosystem in decreasing order: Biosphere, biome, landscape, ecosystem, community, population, individual.

2.2.4 Largest Ecosystem: Biosphere

Before we explain the functioning of the components of the ecosystem, let us first discuss the largest ecosystem, namely, "the biosphere".

Biosphere is that part of the earth where life can exist. It is a narrow layer around the surface of the earth. If you visualise the earth to be the size of an apple the biosphere would be as thick as its skin.

Biosphere, also called ecosphere, is that part, of the earth, water and atmosphere in which many smaller ecosystems exist and operate. The three main subdivisions of the biosphere are: (1) **lithosphere** (land); (2) **hydrosphere** (water); (3) **atmosphere** (air) or the gaseous envelope of the earth which extends up to a height of 22.5 km. Fig. 2.3 shows the idealised scheme of biosphere in relation to hydrosphere, atmosphere and lithosphere. The area of contact and interaction between these three components is really important for life, as it is here that the entire life is confined and the basic processes of life, like photosynthesis and respiration occur.

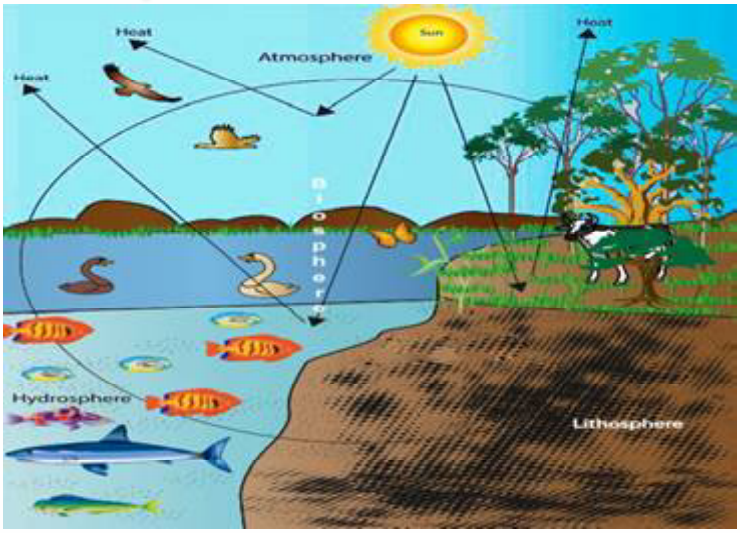


Fig 2.3: Idealised scheme of a biosphere in relation to hydrosphere, atmosphere and lithosphere.

The biosphere extends from the floor of the ocean some 11,000 metres below the surface of the earth to the top of the highest mountains, or about 9,000 metres above the mean sea level. Its most densely populated region is just above and below the sea level. Life in the biosphere is abundant between 200 metres (660 feet) below the surface of the ocean and about 6,000 metres (20,000 feet) above sea level.

Biosphere is absent at extremes of the North and South poles, the highest mountains and the deepest oceans, since existing conditions there do not support life. Occasionally spores of fungi and bacteria do occur at great height beyond 9,000 metres, but they are not metabolically active, and hence represent only dormant life.

Living organisms are not uniformly distributed throughout the biosphere. Only a few organisms live in the polar regions, while the tropical rain forests possess an exceedingly rich diversity of plants and animals. The nutrients necessary for living organisms come from air, water and soil and not from outside. The same nutrients that are present in the biosphere are recycled over and over again for life to continue. The energy required for the life within the biosphere comes from the sun without which the biosphere will collapse.

The terrestrial part of the biosphere is divisible into enormous regions called biomes, which form vast ecosystems and are characterized, by climate, vegetation, animal life and general soil type. The dozen or more biomes of the earth are spread over millions of square kilometres and span entire continents. No two biomes are alike. The climate determines the boundaries of a biome and abundance of plants and animals found in each one of them. The most important climatic factors that determine the boundaries of the biomes are temperature and precipitation (rain or snow).

Aquatic systems are also divided into distinct aquatic life zones, which however are not called biomes but are very similar. The aquatic life zone are regions of relatively distinct plant and animal life. The major difference between the various aquatic zones is due to salinity, levels of dissolved nutrients, water temperature and depth of sunlight penetration. You will learn about the different types of terrestrial ecosystems namely biomes and aquatic life zones on our earth in Unit 3.

SAQ 1

1. a) In the following statements, put a tick (√) mark on the correct ones and a cross (x) on the wrong ones in the given boxes.

   i) An ecosystem is a natural unit of study, consisting of a community of organisms (biotic components) and the non-living environmental factors (abiotic components). ( )

   ii) All ecosystem have well-defined boundaries. ( )

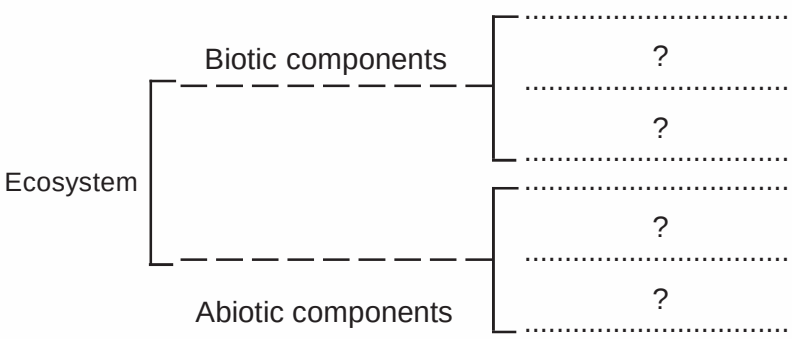
   iii) Ecosystems represent enormous contrast in size and complexity. ( )

   iv) An ecosystem having autotrophs and heterotrophs but no decomposers could be self-contained. ( )

   v) Ecosystems are self-sustaining because they are well insulated from outside influences. ( )

b) Arrange the following sub-components of an ecosystem:

energy, consumers, environment, inorganic elements, decomposers, primary producers and soil.



2.3 COMPONENTS OF THE ECOSYSTEM

Each biome or aquatic zone can be subdivided into smaller units called "ecosystem". An ecosystem is thus, a subdivision of biome and can also be called an ecological system. Recall the definition of an ecosystem from subsection 2.2.1. Any complete definition of an ecosystem includes the biotic as well as the abiotic components and the interaction between the two. For example the desert biome of Rajasthan contains the Thar Desert ecosystem which is characterised by arid conditions, sandy terrain, and succulent plants. Animals found there are lizards and snakes. Similarly, a pond is also an ecosystem of the freshwater aquatic zone and would be characterized by a lentic (standing) fresh water body containing aquatic organisms and plants.

The various kinds of organisms that inhabit an ecosystem form its populations. In ecology, 'a population is a group of potentially interbreeding individuals that occur together in space and time'. The individual comprising a population are members of the same species.

If you look around yourself, you will notice that populations of plants and animals seldom occur by themselves. The reason for this is quite obvious. In order to survive individuals of any one species depend on individuals of different species with which they actively interact in several ways. A population of squirrels would require fruits and nuts for food and trees for shelter. Even plants cannot exist by themselves; for example, they require animals for seed dispersal and pollination, and soil microorganism to facilitate nutrient supply to them through decomposition.

In nature 'an aggregation of populations of different species (plant and/or animals) in an area, living together with mutual tolerance and beneficial interactions amongst themselves and with their environment, form a biotic community.

Communities in most instances are named after the dominant plant form species. A grassland, for example, is dominated by grasses, though it may contain herbs, shrubs, and trees, along with associated animals of different species. Communities may be large or small.

2.3.1 Abiotic Components

You will recall, having read earlier that the physical or abiotic components are the inorganic and non-living parts of the ecosystem. Each of these abiotic factors may be studied individually, however, each of these factor is influenced by and in turn influences all the other factors.

2.3.2 Biotic Components

The biological or biotic components of an ecosystem interact in an abiotic background (Fig. 2.4) and include:

1. Producers/Autotrophs

Chlorophyll bearing green plants, green and purple bacteria and blue green algae are the main biological or biotic members in nature which manufacture their own food from simple inorganic substances by the process of photosynthesis. In this process the chlorophyll bearing organisms in the presence of sunlight take up atmospheric carbon dioxide through their leaves and combine with water to produce organic substances or food.

Food refers to complex organic compounds such as carbohydrates, proteins and fats. Green plants first produce simple carbohydrates like glucose and later various complex carbohydrates.

Chemosynthetic bacteria also synthesise their own food but instead of the sun energy they use simple chemicals released from the interior of the earth to prepare food by the process of chemosynthesis. Organisms that are able to manufacture their own food are called **autotrophs** or **producers**.

2. Consumers/ Heterotrophs

All other organisms that are unable to make their own food but depend on other organisms for food to meet their energy needs for survival are called **heterotrophs or phagotrophs or consumers**.

Among consumers, animals such as goat, cow, deer, rabbit and insects like grasshoppers which eat green plants are called **primary consumers** or herbivores. Organisms which eat a herbivore, like a bird that eats grasshoppers are carnivores as they eat other animals. These carnivores are also called **secondary consumers**. Carnivorous organisms like cats which eat secondary consumers like birds are called **tertiary consumers**. Thus, while the primary consumers are herbivores, the secondary and tertiary consumers are carnivores. Animals like tigers, lions, and vultures which are not killed or eaten by other animals are **top carnivores**.

3. Decomposers or Saprotrophs or Reducers

Both the consumers and producers complete their life cycles and die and new generation of their population develop. You must be wondering what happens to the dead organisms. In the ecosystem there is a continuous breaking up or decomposition of the organic matter of the dead organisms and there is a continuous cycling of materials. Certain bacteria which are micro organisms and some fungi are responsible for the decomposition and recycling of material. The organisms are called **decomposers or saprotrophs or reducers**. Most of the saprotrophs are microscopic and all are heterotrophic in nature. The role of decomposers is very essential and important.

Fragments of decomposing organic matter are called detritus

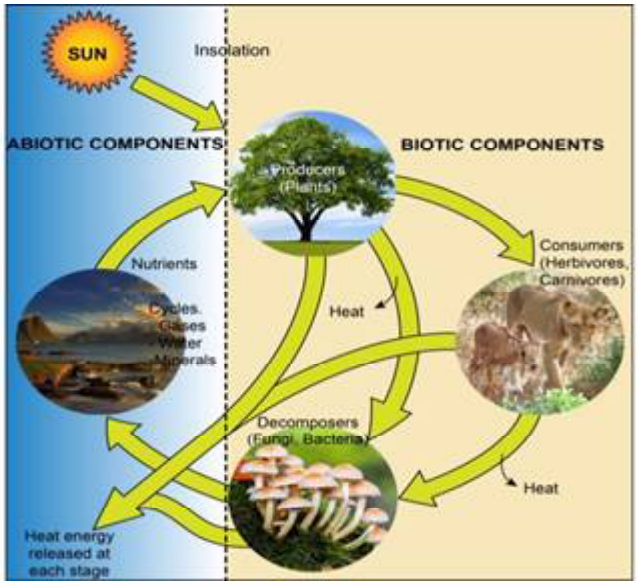


Fig. 2.4: Biotic factors are dependent on abiotic factors. Light and heat energy from the sun are the main key components that biota depend on. Biomass of producers is used by consumers who obtain energy by ingesting food. The assimilated energy is used for various functions of the body like respiration and movements. When the organism dies the energy stored in tissues is used by the decomposers.

2.4 TROPHIC LEVELS

You are now aware that an ecosystem is considered as a discrete unit, where complex natural community obtains food directly or indirectly from plants through one, two, three or four steps and accordingly these steps are known as the first, second, third and fourth trophic (trophe = nourishment) levels or food levels (Fig. 2.5).

A trophic level refers to a position or a level in a food chain or ecological pyramid. It is occupied by a group of organisms that have a similar feeding mode. Trophic levels are numbered according to the number of steps or levels an organism is away from the source of food or energy that is the producer. A food chain would start at trophic level 1. Similarly the base of an ecological pyramid is also at trophic level I. The trophic level 1 is occupied by the primary producers that are referred to as autotrophs. The next trophic level in a food chain or ecological pyramid is trophic level II which consists of organisms that feed on the primary producers and are referred to as primary consumers, or heterotrophs or herbivores .Trophic levels III,IV and V would be occupied be occupied by carnivores. Given below are the probable numbers of trophic levels that can exist in an ecosystem and the types of organism groups that occupy the various trophic levels:

Humans, being omnivores, may belong to more than one trophic level.

Green plants (producers); trophic level I – Autotrophs

- Herbivores (primary consumers); trophic level II – Heterotrophs
- Carnivores (secondary consumers); trophic level III – Heterotrophs
- Carnivores (tertiary consumers); trophic level IV – Heterotrophs
- Top carnivores (quarternary consumers); trophic level V – Heterotrophs

Energy derived from food thus, also flows through the trophic levels: from producers to subsequent trophic levels (Fig. 2.5). This energy always flows from lower (producer) to higher (herbivore, carnivore etc.) trophic levels. It never flows in the reverse direction. Furthermore there is a loss of some energy in the form of unusable heat at each trophic level so that the energy level decreases from the first trophic level upwards. As a result there are usually four or five trophic levels and seldom more than six as beyond that very little energy is left to support any organism.

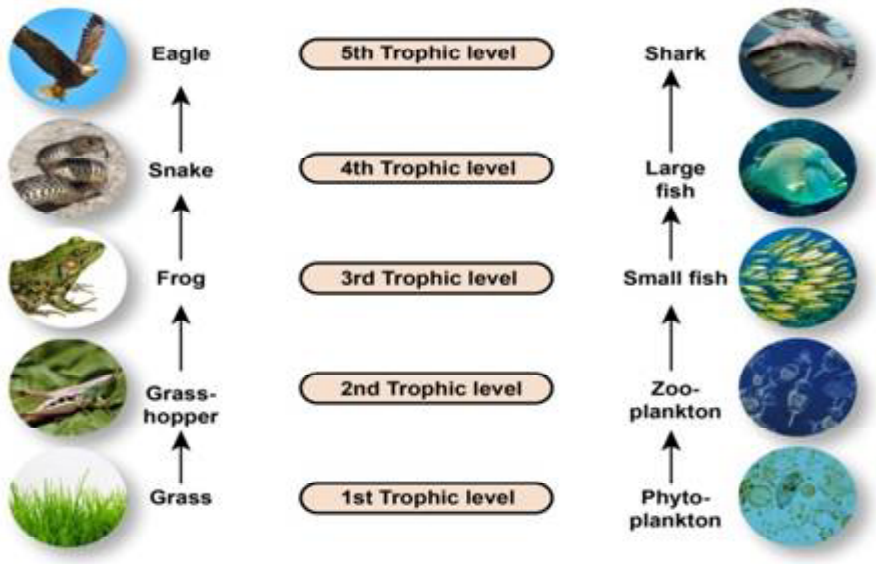


Fig. 2.5: Trophic levels in a food chain in: i) a terrestrial and an ii) aquatic environment.

SAQ 2

a) Give two examples each of organisms that occupy the first, second and third trophic levels.

b) Pick an animal of your choice and show how it can occupy several different trophic levels?

2.4.1 Food Chain

You now know from the previous section that organisms in the ecosystem are related through feeding or trophic levels, that is one organism becomes food for the other. The transfer of food energy from one trophic level to another trophic level in an ecosystem by the repeated process of eating and being eaten is known as food chain. **The food chain can thus be defined as a linear sequence of links of organisms in which an organism becomes food for the next organism** (Fig. 2.6, 2.7and 2.8). The arrows in these three figures denote the direction and movement of nutrients and energy from producer to consumer. Similar to the trophic levels and for the same reasons the links or steps in a food chain are usually upto four or five.

Each link in the food chain can also be called a trophic level.

2.4.2 Types of Food Chains

In nature, three main types of food chains have been distinguished:

i) **Grazing Food Chain:** In this type of food chain the primary consumers, are herbivores and use the plant or plant part as their food. This food chain begins from green plants. An example of such a food chain is given below (Fig. 2.6):

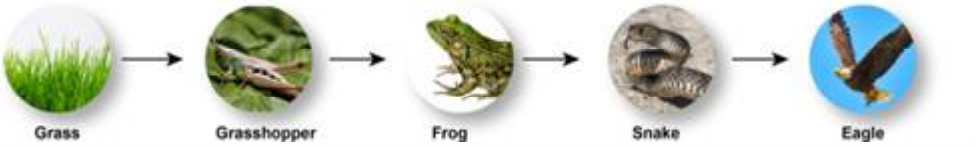


Fig. 2.6: A grazing food chain designated as follows: Grass→ grasshopper → frog → snake→ eagle.

In a community of organisms in a shallow area of the sea, about 30% of the total energy flows via detritus chains. In a forest with a large biomass of plants and a relatively small biomass of animals, even a larger portion of energy flow may be via detritus pathways.

ii) **Detritus Food Chain:** This type of food chain starts from dead organic matter of decaying and metabolic wastes of animals and plant bodies called detritus to the micro-organisms which are primary detritus feeding organism called detrivores or decomposer then to secondary detritus feeders and finally to herbivore and then to predators. The energy contained in detritus, serves as a source of energy in this food chain. An example of such a food chain is given below (Fig. 2.7):

Fig. 2.7: A detritus food chain designated as follows-dead decaying organisms (plants and animals) → earthworm → mole.

iii) **Parasitic Food Chain:** This type of food chain starts with green plants, then goes to the plant or the herbivores on which the parasitic organisms feed. This parasitic food chain ends with parasitic organisms which unlike predators do not kill the host. An example of such a food chain is given below. (Fig. 2.8):

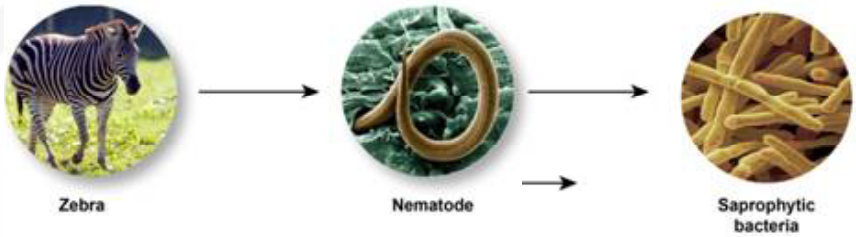


Fig. 2.8: A parasitic food chain designated as follows-zebra→nematode→bacteria.

In nature the food chains are interconnected at various points and together take the form of a food web.

All food webs begin with autotrophs and end will decomposers.

2.5 ECOSYSTEM FUNCTIONING

The processes of matter cycling and transfer and movement of energy are essential for ecosystem function and structure. The processes of cycling of matter and the use of energy in an ecosystem define the fundamental functions of an ecosystem. Energy does not cycle in an ecosystem as the flow of solar energy is unidirectional. As a result the ecosystem needs a continuous inflow of high-quality energy in order to maintain their function and structure. This energy is provided by the solar energy of the sun. For

this reason, ecosystems are “open systems” needing a net inflow of energy from the sun to continue over time. Without the sun, the biosphere of our Earth would shortly run out of energy and collapse. This is because producers which as you are aware are autotrophs use the solar energy of the sun along with nutrients and convert them into food materials which are stored within their bodies. All the food materials or nutrients that we or other animals consume are obtained directly or indirectly from such producers. As a result there is a continuous flow of energy from the sun through various organisms and then to outer space:

The trapping and flow of energy also involves the circulation of nutrients which include basic inorganic elements such as, carbon, hydrogen, oxygen and nitrogen, as well as sodium, calcium, and potassium, which occur in small amounts. In addition, compounds such as; water, carbonates, phosphates and a few others also form part of living organisms. For an ecosystem to function, it is essential that there is a continuous flow of energy and cycling of nutrients.

Sun is the ultimate source of all energy, which caters to the need of our ecosystems. It has been observed that 30% of the total solar radiation entering our atmosphere is reflected by the earth - atmosphere system. The remaining 70% of the radiation is absorbed by the earth’s atmosphere. Of this 19% is absorbed directly by the atmosphere and the rest by the earth.

SAQ 3

1) Explain the statement? ‘‘The ultimate source of energy for our planet is the sun.’’

2.6 NUTRIENT CYCLES

By now, you must be well aware that the living world depends upon the flow of energy and the circulation of nutrients through ecosystem. Both influence the abundance of organisms, the metabolic rate at which they live, and the complexity of the ecosystem. You have already studied that energy is ultimately lost as heat forever in terms of the usefulness of the system. On the other way hand, nutrients of food matter are never lost or used up, instead they can be recycled again and again indefinitely.

Nutrients that are needed by organisms in large amounts are called macronutrients, while those which are needed in minute amount or traces, are called micronutrients Among more than 100 chemicals that occur in nature about 40 are present in living organisms.

Carbon, hydrogen, oxygen, nitrogen and phosphorus in the form of elements and compounds make up 97% of the mass of our bodies and are more than 95% of the mass of all living organisms. In addition to these, 15 to 25 other elements are needed in some form for the survival and good health of plants and animals. These elements or mineral nutrients are always in circulation moving from non-living to living and then back to the non-living components of the ecosystem in more or less a circular fashion. This is known as **biogeochemical** cycling. There are two basic types of cycles, depending on the nature of the reservoir:

A nutrient cycle may also be referred to as **a perfect** or **imperfect cycle**. A perfect nutrient cycle is one in which nutrients are replaced as fast as they are utilised. Most gaseous cycles are generally considered as perfect cycles. In contrast sedimentary cycles are considered relatively imperfect, as some nutrients are lost from the cycle and get locked into sediments and so become unavailable for immediate cycling.

i) **Gaseous Cycle** – where the reservoir is the atmosphere or the hydrosphere and

ii) **Sedimentary Cycle** – where the reservoir is the earth’s crust.

2.6.1 Gaseous Cycles

Let us first study some of the most important gaseous cycles; namely – water, carbon and nitrogen

Water Cycle (Hydrologic) – water is one of the most important substances for life. On an average, water constitutes 70% of the body weight of an organism. It is one of the important ecological factors that determines the structure and function of the ecosystem. Cycling of all other elements is also dependent upon water as it provides a means for their transportation during the various steps, and it also serves as a solvent medium for their uptake by organisms.

Water covers about 75% of the earth's surface, occurring in lakes, rivers and oceans. The oceans alone contain 97% of all the water on earth. Much of the remainder is frozen in the polar ice and glaciers. **Less than 1% water is present in the form of fresh water in rivers, lakes, and aquifers. Yet this relatively negligible portion of the planet's water is crucially important to all forms of terrestrial and aquatic life**. There is also underground supply of water. Soils near the surface also serve as reservoir for enormous quantities of water (see Fig. 2.9).

Water moves in the Earth's hydrologic cycle by connecting ocean, land, and atmosphere. The water from the oceans move to the atmosphere by the process of evaporation. From the atmosphere the water moves to oceans and land by precipitation in the form of rain or snow. From land, the rain and melted snow water are transported either by run off from streams and rivers and subsurface ground water into the oceans, and/or by evaporation from land and transpiration (evaporation of water from plant leaves.) by plants to the atmosphere again. This cycle is driven by solar energy in which about one third of all solar energy is dissipated on cycling is about 10×10^{20} g of water, that is nearly 0.004% of the total. This amount of water is all the time moving in the cycle. The rest of the earth's water as you know is already bound in cold storage (in the form of glaciers and ice).

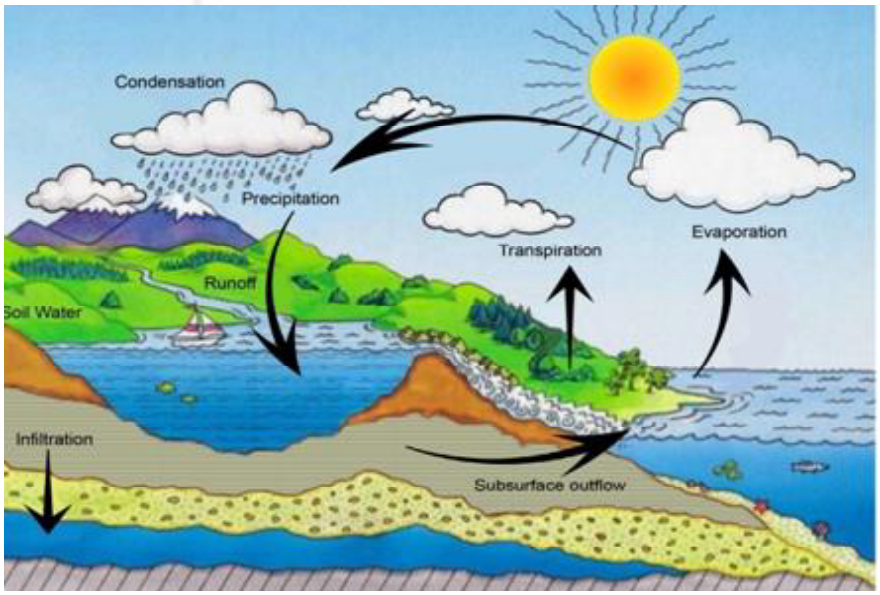


Fig. 2.9: The water or hydrological cycle depicting the major pathway of water movement through the ecosystem.

Life as you know depends on this continuous water cycle but human activities are damaging the environment by polluting the atmosphere to such an extent that the rainfall patterns are getting altered, leading to prolonged drought periods extending over years in countries such as those of Africa, while causing devastating floods in countries such as the US and India.

The Carbon Cycle

Carbon is a minor constituent of the atmosphere as compared to oxygen and nitrogen. However, as you are well aware carbon is the element that anchors all organic substances from coal and oil to DNA (deoxyribonucleic acid: the compound that carries genetic information). Without carbon life could not exist as it is vital for the production of carbohydrates (organic matter) through photosynthesis by plants that use the inorganic carbon dioxide and water in the presence of solar energy and in this process release oxygen in the atmosphere. Carbon is a building block of all living organisms. It is a component of proteins that are the building block of life and lipids that form the plasma membrane of all plants and animals. Carbon is also a part of the ocean, air, and even rocks. Because the Earth is a dynamic place, carbon does not stay still and is on the move.

The carbon in the carbon cycle (Fig. 2.10) may be either 'organic' or 'inorganic'. The majority of the inorganic carbon exists as carbon dioxide, carbonate and hydrogen carbonate. The carbon found in organic compounds is included in both the abiotic and biotic parts of the ecosystem and is found in living or dead organisms, fossil fuels, small deposits in

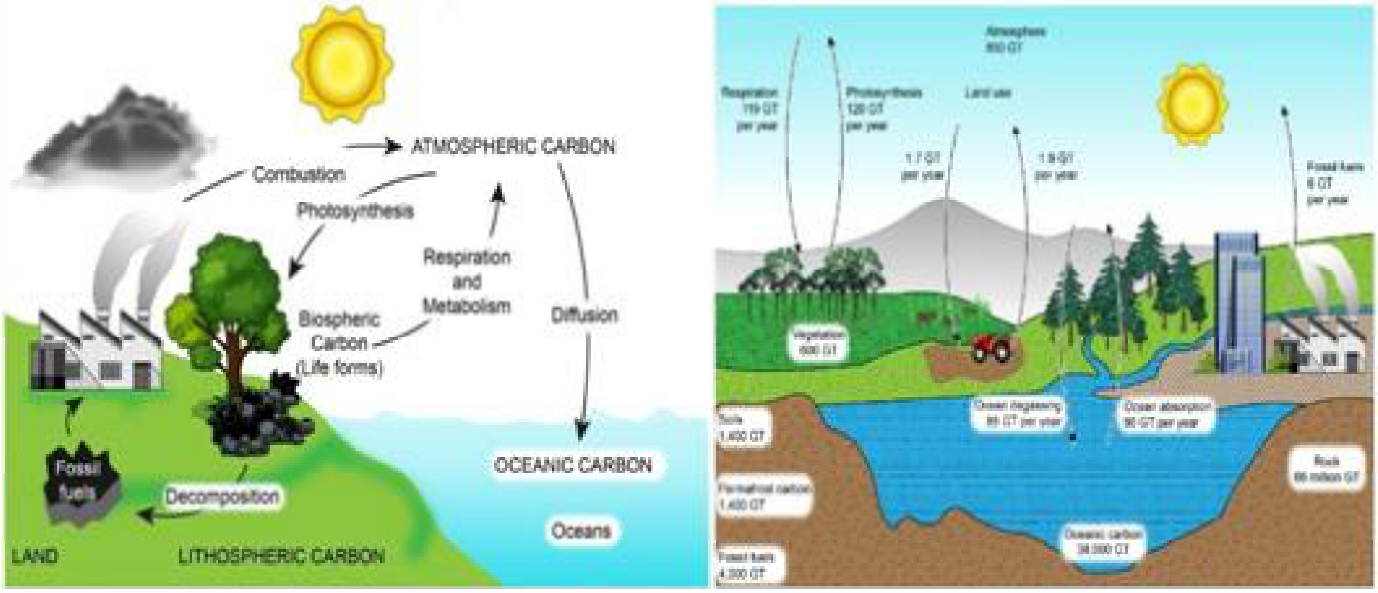


Fig. 2.10: a) Atmospheric carbon is fixed by plants in their biomass and gets transferred plants to the animals feeding on them, and so further moves up the food chain. Respiration, digestion, and metabolism of plants and animals result in some transfer of carbon back to the atmosphere. Some carbon also moves to the lithosphere when these living organism die or when wood and leaves decay or when animals excrete. Some of the living beings buried millons of years ago have been converted into fossil fuel. Mining and burning of fossil fuels cause this carbon to move from the lithosphere to the atmosphere. Some of this atmospheric carbon gets dissolved in the ocean and thus, completes the cyele; b) A generalized global carbon cycle in which estimated volumes are given in Gigatonnes of CO_2 (a gigaton is equal to one billion metric tons).

rocks, dissolved in water or dispersed in the atmosphere. There is a continuous two-way flow of carbon between the organic and inorganic forms whereby there is a continuous exchange of carbon dioxide between the atmosphere and organisms on one hand, and between the atmosphere and the sea, on the other. The carbon cycle is based on carbon dioxide gas (CO_2). In terrestrial ecosystems, CO_2 is removed from the atmosphere, and in aquatic ecosystems CO_2 it is removed from water.

The oceans contain about 50 times more CO_2 than the atmosphere and act as a major carbon-storage sink and so play a crucial role in the global carbon cycle. Marine species remove some carbon dioxide during photosynthesis.

Carbon from the atmospheric pool moves to green plants, and then to animals and finally, from them directly to the atmosphere by process of respiration at various trophic levels in the food chain, or to bacteria, fungi and other micro-organisms that return it to atmosphere through decomposition of excretory wastes and bodies of organisms when they die. Carbon cycle regulates atmospheric CO_2 level to 0.032% despite photosynthetic uptake. In the normal course carbon is returned to the environment about as fast as it is removed. The carbon cycle ensures that the CO_2in the atmosphere is present at acceptable levels. This in turn moderates the temperature for life to exist. If the carbon cycle removes too much carbon, the atmosphere will become cool and if too much carbon is added to the atmosphere, the atmosphere will get warmer.

Global Carbon Cycle

Some carbon however enters a long term cycle referred to as **"Global Carbon cycle"** in which carbon accumulates in the form of organic matter in the peaty layers of bogs and moorlands or as insoluble carbonates (for example the insoluble calcium carbonate (($CaCO_3$) of various sea shells) in bottom sediments of aquatic systems. This sedimentary carbon eventually turns into sedimentary rocks such as lime stone and dolomite. In deep oceans such carbon can remain buried for millions of years till geological movement may lift these rocks above sea level. These rocks may be exposed to erosion, releasing their carbon dioxide, carbonates and bicarbonates into streams and rivers. Hard water has usually flowed through lime stone at some point, picking up carbonates which they accumulate as 'fur' in kettles when the water is boiled. Fossil fuels such as coal, petroleum and natural gas are also part of the carbon cycle which may release their carbon compounds after several years. These fossil fuels are organic compounds that were buried before they could be decomposed and were subsequently transformed by time and geological processes into solid or liquid hydrocarbon fuels. When fossil fuels are burned the carbon stored in them is released back into the atmosphere as CO_2 (2.10 b). The current global cycle shows an increased concentration of CO_2 in the atmosphere. The resulting climate change phenomenon is at the forefront of the environmental problems faced by the world at present.

The Nitrogen Cycle

Nitrogen is an essential constituent of protein which is a building block of all living tissue. **It constitutes nearly 16% by weight of all the proteins**. There is an inexhaustible supply of nitrogen in the atmosphere but the elemental form cannot be used directly by most of the living organisms. Nitrogen needs to be **'fixed'**, that is, converted to ammonia, nitrites or nitrates, before it can be taken up by plants. Nitrogen fixation on earth is accomplished in three different ways: (i) by certain free-living bacteria and bluegreen algae (e.g. *Anabaena*, *Spirulina*), and symbiotic bacteria (e.g. *Rhizobium*); (ii) by human being using industrial processes (fertilizer factories) and (iii) to a limited extent by atmospheric phenomena such as thunder and lighting.

As you can see from Fig. 2.11, nitrogen at any time is tied up in different 'compartments' or 'pools' — the atmosphere, soil and water, and living organisms. The periodic thunderstorms convert the gaseous nitrogen in the atmosphere to ammonia and nitrates which eventually reach the earth's surface through precipitation and then into the soil to be utilized by plants. More important, however, are certain microorganisms capable of fixing atmospheric nitrogen into ammonium ions (NH_4^+). These include free living nitrifying bacteria (e.g. aerobic *Azotobacter* and anaerobic *Clostridium*) and symbiotic nitrifying bacteria living in association with root nodules present in leguminous plants (e.g. *Rhizobium*) as well as blue green algae (eg. *Anabaena, Spirulina*). Ammonium ions can be directly taken up as a source of nitrogen by some plants, or are oxidized to nitrites or nitrates by two groups of specialised bacteria: *Nitrosomonas* bacteria which promotes transformation of ammonia into nitrite. Nitrite is then further transformed into nitrate by the bacteria *Nitrobacter*.

Volcanoes are also important sources of nitrogen. They have been emitting small quantities of nitrogen for centuries and contribute significantly to the nitrogen reservoir of the atmosphere.

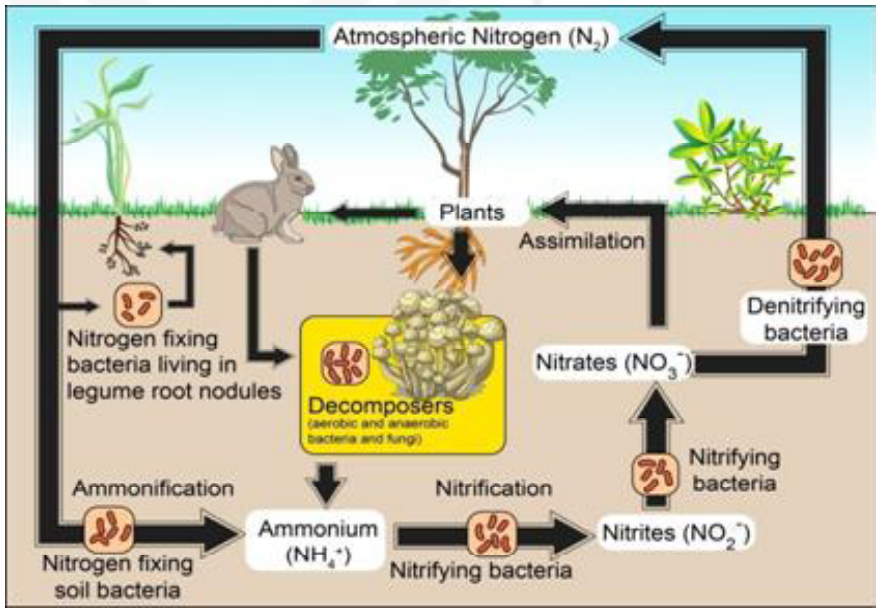


Fig. 2.11: A schematic nitrogen cycle showing the flow of nitrogen through the land environment. Presence of bacteria is a key elements in the cycle as it provides different forms of nitrogen compounds that can be assimilated by higher organisms.

The symbiotic bacteria capable of fixing atmospheric nitrogen live in the root nodules of leguminous plants like beans, peas, alfalfa etc. In agricultural ecosystem legumes of approximately 200 species are the pre-eminent nitrogen fixers. In non-agricultural systems some 12,000 species ranging from cyanobacteria to nodule-bearing plants, are responsible for nitrogen fixation.

The nitrates synthesised by bacteria in the soil are taken up by plants and converted into amino acids, which are the building blocks of proteins. These then go through higher trophic levels of the ecosystem. During excretion and upon the death of all organisms nitrogen is returned to the soil in the form of ammonia. In the soil as well as oceans there are special denitrifying bacteria (e.g. *Pseudomonas*), which convert the nitrates/nitrites to elemental nitrogen. This nitrogen escapes into the atmosphere, thus completing the cycle.

Nitrogen has become a pollutant (in the form of nitrogen dioxide and nitric oxide) because of human intrusion into the natural cycle and this can disrupt the balance of nitrogen in the air.

2.6.2 Sedimentary Cycles

Phosphorus, calcium and magnesium circulate by means of the sedimentary cycle. Sulphur is to some extent intermediate, since two of its compounds hydrogen sulphide (H_2S) and sulphur dioxide (SO_2), add a gaseous component to its normally sedimentary cycle. The element involved in the sedimentary cycle normally does not cycle through the atmosphere but follows a basic pattern of flow through erosion, sedimentation, mountain building, volcanic activity and biological transport through the excreta of marine birds. The sulphur cycle is a good example for illustrating the linkage between air, water and the earth's crust, and hence, a brief account of this cycle is given.

Sulphur Cycle

The sulphur cycle is mostly sedimentary except for a short gaseous phase. (Fig.2.12.).The large sulphur reservoir, as mentioned before, is in the soil and sediments where it is locked in organic (coal, oil and peat) and inorganic (pyrite rock and sulphur rock) deposits in the form of sulphates, sulphides and organic sulphur. It is released by weathering of rocks, erosional runoff and decomposition by bacteria and fungi of organic matter and is carried to terrestrial and aquatic ecosystems in salt solution. Sulphur is found in gaseous forms like hydrogen sulphide and sulphur dioxide in small quantities in the atmosphere, which is thus a small reservoir. Sulphur enters the atmosphere from several sources like volcanic eruptions, combustion of fossil fuels, from surface of ocean and from gases released by decomposition. Atmospheric hydrogen sulphide also gets oxidised into sulphur dioxide (SO_2). Atmospheric SO_2 is carried back to the earth after being dissolved in rainwater as weak sulphuric acid (H_2SO_4). Uptake of sulphur by plants is in the form of sulphates (SO_4^{-2}) which are incorporated into sulphur bearing amino acids in the proteins of autotroph tissues through a series of metabolic processes. The sulphur then passes into the grazing food chain. Sulphur bound in living organism is carried back to the soil, to the bottom of ponds and lakes and seas through excretion and decomposition of dead organic material. Under aerobic(in presence of oxygen) conditions fungi like *Aspergillus* and *Neurospora* and under anaerobic conditions(without oxygen) bacteria like *Escherichia* and *Proteus* are largely responsible for the decomposition of proteins.

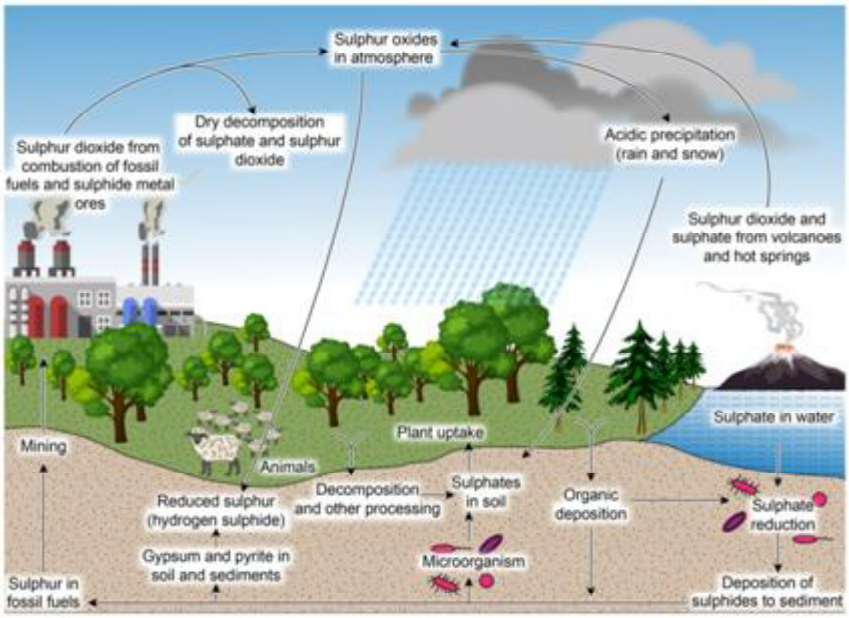


Fig. 2.12: The sulphur cycle, showing the two reservoirs namely, sedimentary and gaseous.

You should bear in mind that the nutrient cycles discussed here are only a few of the many cycles present in the ecosystem. You should also be aware that these cycles usually do not operate in independently but interact with each other at some point or the other.

SAQ 4

1) a) Choose the correct answer.

Which of the following contribute to the carbon cycling?

i) Respiration

ii) Photosynthesis

iii) Fossil fuel combustion

iv) All of the above

b) Tick mark the correct answer.

The main reservoir of nitrogen in the biosphere is the

i) atmosphere

ii) rocks

iii) oceans

iv) organisms

c) Which of the following statements are true and which are false? Write (T) for true and (F) for false:

i) The water cycle is driven by solar energy. [ ]

ii) The carbon in the carbon cycle may be either organic or inorganic. [ ]

iii) The oceans contain about 50 time less carbon dioxide than the atmosphere. [ ]

iv) Sulphur, phosphorus and calcium cycles are completely sedimentary. [ ]

v) Plants take up sulphur in the form of sulphur dioxide. [ ]

2.7 ECOLOGICAL SUCCESSION

A community is also called a biotic community. **"A biotic community is defined as a group of interacting populations living in a given area".** A biotic community represents the living part of an ecosystem and functions as a dynamic unit with trophic levels and energy flow and nutrient cycling system as described earlier.

Biotic communities exhibit progressive change as part of their normal development. The orderly process of change or replacement of some inhabitants or species of the community in an area, through time is known as community development or more traditionally as ecological succession. The time scale for ecological succession can be decades (for example, after a wildfire), or even millions of years after a mass extinction.

2.7.1 Types of Ecological Succession

Ecological changes are fairly predictable and orderly. Within an ecological community, the species composition will change over time as some species become more prominent while others may fade out of existence. As the community develops over time, vegetation grows taller, and the community becomes more established. This final stage of succession is quite stable and the community in this is called the climax community.

Ecological succession includes (1) primary and (2) secondary succession

2.7.2 Primary Succession

Primary succession is initiated when a new area that has never previously supported an ecological community is colonized by plants and animals. This could be on newly exposed rock surfaces from landslides or lava flows. Primary succession thus, occurs where no community exists before, such as rocky outcropping, newly formed deltas, sand dunes, emerging volcanic islands and lava flows. An example, which can be used as a model showing development of primary succession, is the invasion and colonisation of bare rock as on a recently created volcanic island.

Primary succession first begins by the entry of lichens which can invade and colonise bare rocks, once they enter by various methods of dispersal. Lichens get a foot hold on the bare rocks by means of their tenacious, water-seeking fungal component and form the first community, very appropriately often called the pioneer community. (Fig. 2.13). Lichens are soil builders, producing weak acids that very gradually erode the rock surface. As organic products and sand particle accumulate in tiny fissures of the rocks, mosses, larger plants, such

Although succession ends with the establishment of a climax community, this does not mean that a climax community is static. It does change though slowly, even when the climate is constant. It will change rapidly however, if the community is disturbed in some way.

as grasses also get an opportunity to establish themselves and begin a new seral stage. In time lichens that made the penetration of plant roots possible are no longer able to compete for light, water and minerals and are succeeded by larger and more nutrient demanding plants such as shrubs and finally trees. (Fig. 2.13)

Seral stage (Sere) or seral community is the intermediate community stage in succession in an ecosystem which is progressing towards its climax community.

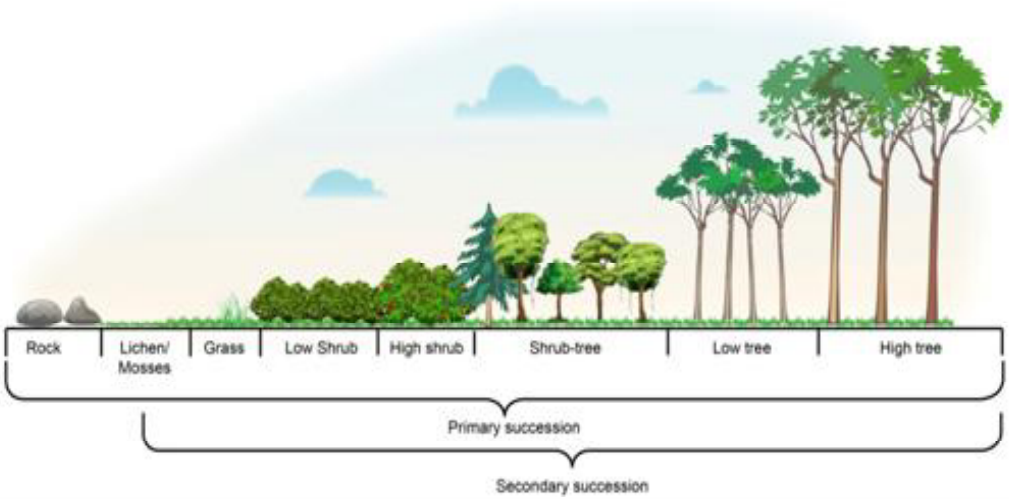


Fig. 2.13: Stages of primary succession in a terrestrial community. The orderly series of species replacement during succession can be seen in this sequence — from a bare exposed rock to a fir-birch-spruce community. Pioneer species of lichens and mosses begin the soil-building process, followed by the invasion of increasingly larger plants until a more stable long-lived, climax forest community forms.

2.7.3 Secondary Succession

Secondary succession occurs when a community in an area is drastically disturbed leading to its destruction which results in a new community moving into that area. Secondary succession is more common than primary succession and is often the result of natural disasters such as fires, floods, and winds, as well as human interference such as logging and tree-cutting.

In secondary succession the basic features are similar to those of primary succession, but the seres occur at a more rapid pace. This is because the soil is already formed and available. Secondary succession is said to occur when the surface is completely or largely denuded of vegetation but has already been influenced by living organisms and has an organic component. In such areas seeds, spores and plant propagates, such as rhizomes may be present in the ground and thus influence the succession.

Secondary succession in grassland communities is much faster, taking 20 to 40 years to develop while on the other hand, fragile disturbed tundra may require many hundreds of years to recover, if it ever does.

2.8 ECOSYSTEM AND HUMAN INTERVENTION

As you are aware, humans can and do change natural communities. We are often guilty of accidentally or deliberately altering the complex and myriad factors that maintain the delicate equilibrium of ecosystems. Today, approximately 40 per cent of the earth's photosynthetic productivity is used or

influenced by human activities. Often in order to correct the wrongs of the past intervention we tend to undertake well-intended but uninformed measures. However, our efforts falter or fail because of lack of basic information. All this shows that we have still not learnt to live in harmony with the ecosystems of which we are a part. Our technology has far outpaced our basic knowledge and understanding of the environment. As we turn to the scientific community for answers and solutions, ecologists will play an increasingly important role in changing the ways in which we interact with the natural world. Each of us will also have to be aware about the consequences of disturbing the delicate balances of ecosystems and should make efforts not to be a contributor to damaging or degrading the ecosystems.

SAQ 4

In the following statements choose the appropriate word from the alternatives given in the parenthesis.

i) In an ecosystem succession that occurs after a fire is (primary/secondary) succession.

ii) The first plants to grow in a new ecosystem is termed as (new/pioneer) species.

iii) Lichens contribute to primary succession by (decomposing organic matter from animals and plants/breaking down the rock to form soil).

iv) Natural disasters such as hurricanes and volcanic emissions are linked to (primary/secondary) succession.

2.9 SUMMARY

- Environment is the sum total of living and non-living components that surround and influence an organism. Living components are called biotic components while non-living components are called abiotic components.
- The biosphere is that region of water, earth and atmosphere where life systems exist. Within the biosphere there are several major regions containing specific types of ecosystems. The major terrestrial regions are called biomes, which are characterised by their dominant vegetation. The other portion of the biosphere is the aquatic zone.
- An ecosystem is the simplest entity that can sustain life. At its most basic, an ecosystem is formed of a variety of individual organisms, micro organisms, plants and animals which interact with each other and with their physical environment. It sustains two processes, the cycling of chemical elements and flow of energy. It is a self-regulatory system based on feedback information given by its living and non-living components.
- Ecosystems are considered functional units of nature having no specific size or limits.

- The abiotic components of the ecosystem consist of physical factors such as light, temperature, rainfall, water and nutrients. The biotic component of the ecosystem consists of autotrophs or producers, and heterotrophs or consumers, and decomposers. These organisms belong to different trophic levels. Trophic levels tell us how far the organism is removed from the producers in its level of nourishment and which organisms share the same general source of nutrition.
- Three main types of food chain can be distinguished namely grazing, parasitic and detritus food chains. Several intersecting food chains form a food web, which depicts the pattern of food consumption in an ecosystem.
- The nutrients in an ecosystem are continuously cycled and recycled. Nutrients essential to organisms are distributed in various chemical forms in air (atmosphere), soil or rock (lithosphere), water (hydrosphere) and living beings. Over time, elements move from one sphere to another by means of biogeochemical cycles. Key cycles described in the unit are water, carbon, nitrogen and sulphur. Soil microorganisms and organisms present in the roots of leguminous plants play a key role in cycling of elements, particularly nitrogen and sulphur.
- Ecosystem succession occurs when a series of communities (each community is called a seres) replace one another. Each community changes the environment to make conditions favourable for a subsequent community and unfavourable for itself till the climax community is established.
- Ecological succession includes (1) primary and (2) secondary succession
- Primary succession is initiated when a new area that has never previously supported an ecological community is colonized by plants and animals called the pioneer community.
- Secondary succession occurs when a community in an area is drastically disturbed leading to its destruction which results in a new community moving into that area.
- The final stage of succession is quite stable and is called the climax community.

2.10 TERMINAL QUESTIONS

1. Give one to two words for the definitions given below:
   i) The basic, functional, self sustaining unit of biosphere, consisting of all living and non living components of a particular area that interact and exchange materials with each other.
   ii) The entire region of the surface of the earth comprising of atmosphere, lithosphere and hydrosphere where organisms can live.
   iii) Non-living components like air, water, soil, light, organic and inorganic compounds in the ecosystem.

iv) The sequential process of eating and being eaten in an ecosystem which also involves with this the transfer of energy from one trophic level to another.

v) The process of change in the species structure of an ecological community over time in which the time scale can be in decades.

2. In your food chain give three for each of the following:

i) Who are the producer? .....

ii) Who are the consumers? .....

iii) Who are the herbivore ?.....

iv) Who are the carnivores? .....

v) Who are the decomposers? .....

vi) Who are the autotroph? .....

vii) Who are the heterotrophs? .....

viii) Who are the predators? .....

3. Tick the correct answer from the following:

a) A producer is :

I. at the start of a food chain

II. at the bottom of the ecological pyramid

III. an autotroph

IV. all of these

b) A detritus food chain begins:

I. always in the ocean

II. with a producer

III. with decaying organic matter

IV. with air pollution

c) Natural disasters such as hurricanes and floods are linked to:

i) old field succession

ii) primary succession

iii) secondary succession

iv) climax succession

d) Top consumers for obtaining energy eat

I. herbivores

II. carnivores

III. omnivores

IV. all of the above

4. What are the two types of biogeochemical cycles and what are their distinguishing features?

5. Describe three pathways whereby atmospheric nitrogen is converted into fixed forms that are usable by plants, and two pathways whereby fixed nitrogen is returned to the atmosphere.

2.11 ANSWERS

Self-Assessment Questions

1. a) (i)

   (ii) X

   (iii)

   (iv) X

   (v) X

   b) (i) biotic components-primary producers, consumers, decomposers.

   (ii) abiotic components-energy, environment, inorganic elements and soil.

2. a) wheat, corn (first trophic level)

   goat, rat (second trophic level)

   lion, cat (third trophic level)

   b) Hint: e.g., Grizzly bear,1

   Second trophic level (herbivore) like squirrel as it eats tubers and various other plant products; third trophic level (carnivore) like bear as it eats animals like squirrel which is a herbivore; fourth trophic level (top carnivore) like mountain lions as it eats animals like grizzly bear which are carnivores.

3. In an ecosystem the producers utilise solar energy and store it in the food they prepare which are mainly carbohydrates. The plant tissues that have the stored solar energy in them serve as a source of energy for the herbivores. And the herbivores pass on the energy to the carnivores and so on and so forth. Thus the ultimate source of energy for our planet on the whole can be considered to be the sun.

4. a) (iv)

   b) (i)

   c) (i) T; (ii) T; (iii) F; (iv) F; (v) F.

5. (i) secondary succession;

   (ii) pioneer;

   (iii) breaking down the rock to form soil;

(iv) secondary succession.

Terminal Questions

1. i) Ecosystem
   ii) Biosphere
   iii) Abiotic factors components
   iv) Food chain
   v) Ecological succession.
2. You can give your own answers.
3. a) (iv); b) (iii); c) (ii); d) (iv)
4. a) Gaseous cycles where the primary reservoir is the atmosphere as far as living organisms are concerned, examples carbon and nitrogen.
   b) Sedimentary cycles where the principle reservoir lies in the earth's crust and is released into the ecosystem by, weathering, mining and erosion. Examples are phosphorus and sulphur.
5. Atmospheric nitrogen is fixed (i) into ammonium by biological fixation through nitrogen fixing bacteria and blue green algae, (ii) by lightning as photochemical fixation into nitrates, (iii) by industrial fixation in the form of nitrate and ammonium fertilisers.

   Nitrogen is returned to the atmosphere through the process of denitrification of nitrates and as oxides of nitrogen in automobile exhaust and industrial combustion.

2.12 FURTHER READING

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UNIT 3

MAJOR ECOSYSTEMS

Structure

3.1 INTRODUCTION

In the previous units you have studied about ecosystem and its structure. As you know the world itself is very vast, and it represents a big ecosystem called biosphere. The word ecosystem is made up of “eco” and “system”. Eco means the habitat, and system means a complex set of interconnected components, both living and non-living. Here system also indicates a functional property and hence an ecosystem can be considered as a functional unit of nature.

Ecosystems can be broadly divided into two main categories: terrestrial and aquatic. Major terrestrial ecosystems include forests, grasslands and deserts while lakes, rivers, oceans, estuaries and wetlands are collectively known as aquatic ecosystems. In this unit we will discuss various types of terrestrial and aquatic ecosystems. Besides, you will also study about the importance of the forests, grasslands and aquatic ecosystems.

Expected Learning Outcomes

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

- differentiate between the major types of terrestrial ecosystems such as grasslands, forests and deserts;
- describe general features and biota of grasslands, forests and deserts;
- describe importance of forests to human welfare;
- describe aquatic ecosystems and distinguish between freshwater ecosystems, marine ecosystems and estuaries; and
- explain the difference between the biota of lakes, rivers and marine ecosystem.

3.2 FOREST ECOSYSTEM

Now let us see as to what a forest is. The word forest is derived from the Latin word 'foris' meaning outside, the reference being to village boundary fence that must have included all uncultivated and uninhabited land. Today a forest is any land managed for the diverse purpose of forestry, whether covered with trees, shrubs and climbers or not. The forest ecosystem includes a complex assemblage of different kinds of biotic communities. The nature of soil, climate and local topography determine the distribution of trees and their abundance in the forest vegetation. Characteristics of different types of forests (Fig. 3.1) are described below:

The term taiga is applied to the northern range of coniferous forests.

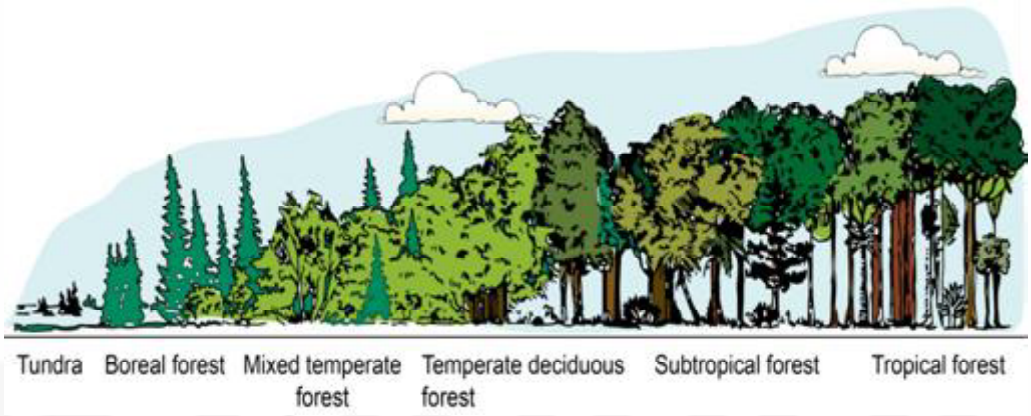

Fig. 3.1: Types of forests

i) **Coniferous forest:** Cold regions with high rainfall and strongly seasonal climates with long winters and fairly short summers are characterised by boreal coniferous forest which is transcontinental. These forests are characterised by evergreen plant species such as spruce. (*Picea glauca*), fir (*Abies balsamea*) and pine trees (*Pinus roxburghii / Pinus strobes*) and by animals such as the lynx, wolf, bear, red fox, porcupine, squirrel, and amphibians like tree frogs and pond frogs.

The litter resultant from conifer needles is broken down very slowly and is not particularly rich in nutrients. These soils are acidic and are mineral deficient. The productivity and community stability of boreal forests are lower than those of any other ecosystem.

ii) **Temperate deciduous forest:** The temperate forests are characterised by a moderate climate and broad-leafed deciduous trees, which shed their leaves in winter and grow new foliage in the spring. These forests are characteristic of North America, Europe, Eastern Asia (including China and Japan), Chile and part of Australia with a cold winter and an annual rainfall of 75-150 cm. The precipitation may be fairly uniform throughout year.

Trees are quite tall about 40-50 m in height and their leaves are thin and broad. The predominant genera of this biome are maple (*Acer*), beech (*Fagus*), oak (*Quercus*), hickory (*Carya*), basswood (*Tilia*), chestnut (*Castanea*), and cottonwood (*Populus*). In Himalayas, the temperate vegetation includes pines, cedars (*Cedrus*), fir and juniper trees along with rhododendrons and willow (*Salix*).

The common animals are deers, bears, squirrels, gray foxes, bobcats, wild turkey and woodpeckers. Common invertebrates include earthworms, snails, millipedes, coleoptera and orthoptera. Vertebrates include amphibians such as toad, salamander, cricket and frog, reptiles such as turtle, lizard and snake, mammals such as racoon, opossum, pig and mountain lion, and birds like horned owl and hawks.

The flora of tropical rain forest is highly diversified: a sq. km area may contain 300 different species of trees - a diversity unparallel in any other ecosystem. The extremely dense vegetation of the tropical rain forests is vertically stratified with tall trees often covered with vines, creepers, lianas, epiphytic orchids and bromeliads. Under the tall trees there is a continuous evergreen carpet, the canopy layer, some 25 to 35 metres tall. The lowest layer is an understory of trees, shrubs, herbs, ferns and palms, all of which become dense where there is a break in the canopy.

iii) **Temperate evergreen forest:** Many parts of the world have a mediterranian type of climate which is characterised by warm, dry summers and cool, moist winters. These are commonly inhabited by low evergreen trees having needle-like or broad leaves. These include hemlock, yew and maple .Shrubs may range up to 3-4m in height. The characteristic animals of temperate evergreen woodland chaparral are mule, deer, brush rabbit, wood rat, chipmunk and lizard.

iv) **Temperate rain forest:** The temperate rain forests are colder than any other rainforest and exhibit a marked seasonality with regard to temperature and rainfall. Rainfall is high, but fog may be very heavy which may actually represent a more important source of water than rainfall itself. The diversity of plant and animals is much low as compared to their warmer counterparts.

v) **Tropical rain forest:** Tropical rain forests occur near the equator, and are among the most diverse communities on the earth. Both temperature and humidity remain high and more or less uniform. The annual rainfall exceeds 200 cm and is generally distributed throughout the year.

The common vertebrates of tropical rain forests are the arboreal amphibian *Rhacophorus malabaricus*, aquatic reptiles, chameleons, agamids, geckos, many species of snakes and birds, and a variety of mammal such as leopard, jungle cats, ant-eaters, giant flying squirrels, monkeys and sloths.

vi) **Tropical seasonal forest:** Tropical seasonal forests occur in regions where total annual rainfall is very high but segregated into pronounced wet and dry periods. In exceedingly wet tropical seasonal forests, commonly known as monsoon forests, the annual precipitation may be several times that of the tropical rainforests. Teak is often a major large tree in the best known tropical seasonal forests of India (central India) and South East Asia. Bamboo is also an important climax shrub in these areas.

vii) **Subtropical rain forest:** In regions of fairly high rainfall but less temperature difference between winter and summer, broad-leaved evergreen subtropical forest is found. The vegetation includes mahogany, palms, oaks, magnolias and tamarind, all laden with epiphytes (of Pineapple and orchid families), ferns, vines and strangler fig. (*Ficus aureus*). Animal life of subtropical forest is very similar to that of tropical rainforests.

Importance of Forest

For humans, forests have been a source of multiple products, services and recreation, and basis of the development of culture and civilisation. Apart from

the source of fuel wood, they provide raw materials to various wood industries like pulp and paper, composite wood, rayon and other man-made fibres, matches, furnitures, shuttles and sport goods. Indian forests also provide many other minor products such as essential oils, medicinal plants, resins and turpentines , lac and shellac, katha and catechu, bidi wrappers and tasser silk. Forests have great biological importance as reservoirs of genetic diversity apart from playing an important role in regulating earth's climate.

Forests provide habitat, and food as well as protection to wildlife species. Forests enhance local precipitation and improve water holding capacity of soil, regulate water cycle and maintain soil fertility by returning the nutrients to the soil through litter. Forests check soil-erosion, landslides and reduce intensity of flood and droughts. Forests, being home of wildlife are important assets of aesthetic, touristic and cultural value to the society.

Forest Conservation

Urbanization, expansion of agriculture and extraction of timber pose serious threats to forest worldwide. Certain forest conservation and management processes have to be employed in the forests to maintain them. To get the desired quality of timber or pulp for paper industry, monoculture forests of fast growing trees such as poplars, certain conifers and eucalyptus have been cultivated by human. Existing forests are strongly manipulated in order to increase their yield of desired benefits. It includes weeding (the elimination of species which might compete with the seedlings of the desired species), thinning (eradication of individuals of the same species) and brashing (removal of leafless lower branches especially in conifers). Forest Management also includes the controlling of forest fire. Silviculture is a branch of forestry which is concerned with the establishment, development, care and reproduction of monocultures of valuable timber trees such as teak, sal, sheesham and kel.

We will discuss in detail about all the above and issues related to forest in Unit 5 titled Forest Resources.

SAQ 1

a) Fill in the blanks and complete the following statements :

   i) The forest biomes comprise a complex assemblage of different kinds of ……..

   ii) Forests may be evergreen or ……..

   iii) Tropical rain forests occur near the ……..

b) What are the direct and indirect services provided by forest to us?

c) Write the major difference between temperate deciduous forest and temperate evergreen forest.

3.3 GRASSLAND ECOSYSTEM

The grassland ecosystem is found where rainfall is about 25-75 cm per year, not enough to support a forest, but more than that of a true desert. Typical grasslands are vegetation formations that are generally found in temperate climates. The grass layer is sparse and consists mainly of annual grass species.

The major difference between steppes and savannas is that all the forage in the steppe is provided only during the brief wet season whereas in the savannas forage is largely from grasses that not only grow during the wet season but also have a smaller amount of regrowth in the dry season.

In arid to semi-arid tracts, active growth of vegetation is triggered each year by the advent of the monsoon during June or early July. The biomass increases to its peak value around September to October. Fruiting is completed by November and subsequently the plants dry up. In subtropical parts of India which receive winter rains, there is usually a second flux of growth in December and January.

In the central and eastern parts of Rajasthan, where the rainfall is about 500 mm per year and the dry season is of six to eight months, dry savanna grazing ecosystems have developed. The light shade cast by the sparse population of trees like *Prosopis cineraria* favours the growth of the grasses which in the best-watered areas can reach up to a height of 100 to 120 cm.

Economic Importance

India with just 2.4 per cent of the total land area of the world supports more than half of the buffaloes, 15 per cent of cattle, 15 per cent of goats and 4 percent of sheep. The livestock wealth plays a crucial, role in Indian life. It is a major source of fuel, draught power, nutrition and raw material for village industries

Grassland ecosystems are important to maintain many domesticated and wild herbivores such as horse, mule, ass, cow, pig, sheep, goat, buffalo, camel, deer and zebra which provide food, milk, wool, hide or transportation to humans.

Overgrazing has harmful ecological effects. The mulch cover of the soil is reduced, microclimate becomes drier and the place is readily invaded by xerophytic plants. Due to absence of humus cover, mineral soil surface is heavily trampled when wetness produces puddling of the surface layer, which in turn reduces the infiltration of water into the soil and accelerates its run off.

Thus, you can realise the importance of the grassland and now after having read about this ecosystem you would like to know what desert biome is and where it occurs? But before that you try SAQ.

SAQ 2

a) Discuss the importance of grassland ecosystem.

b) What are the harmful effects of overgrazing on the area?

3.4 DESERT ECOSYSTEM

Deserts are formed in regions with less than 25 cm of annual rainfall, or sometimes in hot regions where there is more rainfall, but unevenly distributed

in the annual cycle (Fig. 3.2). Deserts in temperate regions often lie in "rain shadows", that is, where high mountains block off moisture from the sea. These areas thus receive meagre rainfall and along with low rainfall there are fluctuations in temperature.

Deserts are found in Australia, Arabia, Turkestan and Argentina. Thar desert in Western India and Pakistan, Gobi desert of Mongolia, and Sinai desert of Egypt are also well known deserts

Fig. 3.2: Desert Ecosystem

The perennial plant species like creosote bush (*Larrea*), organ pipe cactus, ferrocactus and spurges (*Euphorbia*) are scattered throughout the desert ecosystem. In shallow depressed areas with salt deposits sarcobatus, geesewood, seepwood and salt grasses are common. The annuals, wherever present, germinate, bloom and reproduce only during the short rainy season, and not in summer and winter. This is an adaption to desert condition.

Animals such as reptiles and some insects are adapted to deserts, because their impervious integuments and dry excretions enable them to get along on the small amount of water. A few species of nocturnal rodents, for example, excrete very concentrated urine and do not use water for temperature regulation, and can live in the desert without drinking water. Other animals such as camel must drink periodically but are physiologically adapted to withstand tissue dehydration for appreciably long periods of time.

Because water is the dominant limiting factor, the productivity of any desert is almost directly dependent on the rainfall. Where soils are suitable, irrigation can convert deserts into some of our most productive agricultural land. Whether productivity is continuous or is only a temporary 'bloom' depends on how well human is able to stabilise biogeochemical cycles and energy flow at the increased irrigation rates.

Among reptiles there occur two species of testudines (*Loricata*), 18 species of lizards, and 18 species of snakes. Of the lizards, some species like *Calotes versicolor* and *Uromastyx hardwickii* are predatory on the desert locust inhabiting localised areas in Thar desert. Among predominant predatory birds are two species of vultures,namely, White-rumped vulture (*Gyps bengalensis*) and the White scavenger vulture, *(Neophron percnopterus*).

The mammalian fauna of Indian deserts (Box 3.1) includes many species, some of which are rat-tailed bat, longer hedgehog, Indian hairy-footed gerbil, wild boar, jungle cat and panthers.

Box 3.1: Case study: Indian Desert

The Indian desert is one of the most heavily populated desert regions of the world. According to 2011 census, population densities vary from 361 in Jhunjhunu to 17 persons/km^2 in Jaisalmer district. The settlement patterns are entirely compact or entirely spread.Villages are both with compact settlements and spread homesteads (dhanis). Rural people live in hamlets, small villages and dhanis or homesteads. The desert society has multitude of caste and sub-castes. By and large villages where some powerful local chieftains resided and constructed fortresses, developed into towns, which became local trade centres. The settled population in villages is mostly agro-pastoral. About three-fourth of total workers in desert are engaged in cultivation and as agricultural labour. Animal husbandry is followed as supplementary occupation.

Total livestock population recorded an increase of 9.8 million during 1956 to 1981. During 1972-1983 livestock population increased by more than 42 per cent. The enormous increase in human and livestock population has been depleting the natural resources at rapid rate.

SAQ 3

Tick mark the correct answer in the following statements.

a) Which animal drinks water periodically and is physiologically adapted to withstand tissue dehydration for long period?

   i) Lion

   ii) Tiger

   iii) Camel

   iv) Elephant

b) Which biome experiences intense heat and strong wind with a great desiccating action during April to June?

   i) Tundra biome

   ii) Desert biome

   iii) Forest biome

   iv) Grassland biome

c) On which animal *Calotes* and *Uromastyx* are predatory in Thar desert

   i) desert locust

   ii) desert gerbil

   iii) desert dragon flies

   iv) desert snakes

3.5 AQUATIC ECOSYSTEM

Global waters cover about three-quarters of the earth's surface, either as fresh water where salt content is less than 0.5 per cent or as saline water where the salt content is more than 3.5 per cent, or as brackish water where salt content is intermediate between fresh water and saline water. Because of their salt content estuaries and oceans bear different kinds of organisms .It is on this basis, that aquatic ecosystems are categorised into: (i) **Fresh water ecosystems**- lakes, ponds, swamps, pools, springs, streams, and rivers;(ii) **Marine ecosystems** - shallow seas and open ocean; (iii) **Brackish water ecosystems-** estuaries, salt marshes, mangrove swamps and forests.

3.5.1 Aquatic Organisms

The organisms in the aquatic ecosystem are unevenly distributed but can be classified on the basis of their life form or location into five groups as shown in Fig. 3.3.The five groups are given as under:

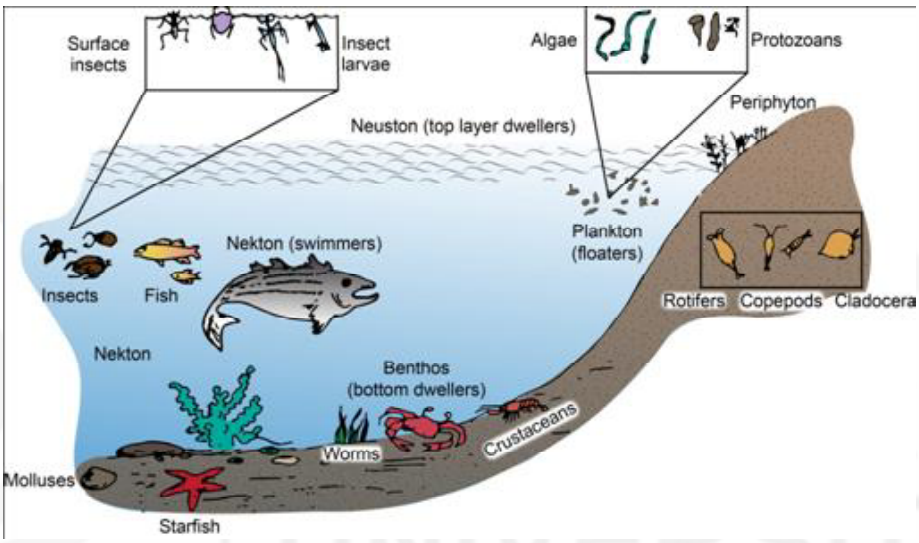

Fig 3.3: Life Styles of Aquatic Organisms

i) **Neuston:** These are unattached organisms which live at the air-water interface such as floating plants and several types of animals (see Fig. 3.3). Some spend most of their lives on top of the air-water interface, such as water striders, while other spend most of their time just beneath the air-water interface and obtain most of their food within the water, e.g., beetles and back-swimmers.

ii) **Periphyton:** These are organisms which remain attached or clinging to stems and leaves of rooted plants or substances emerging above the bottom mud (Fig.3.3). Usually sessile algae and their associated group of animals fall in this group.

iii) **Plankton:** This group includes both microscopic plants, chiefly algae (phytoplanktons) and animals, primarily crustaceans and protozoans (zooplanktons) found in all aquatic ecosystems, except certain swift moving water. The locomotory power of the planktons is limited so that their distribution is controlled largely by currents in the aquatic ecosystems. Most phytoplanktons and zooplanktons are capable,

however, of at least some movement.

iv) **Nekton:** This group contains animals which are swimmers. The nektons are relatively large and powerful as they have to overcome the water currents (see Fig. 3.3). The animals range in size from the swimming insects, which may be only about 2 mm long, to the largest animals that have lived on earth, namely the blue whale.

v) **Benthos:** The benthos or the benthic organisms are those found living in or on the bottom or benthic region of the water mass (Fig. 3.3).They exhibit a variety of adaptations to the environment since the bottom is a more heterogeneous habitat than either the open water or the surface. Benthos includes crabs, lobsters and sponges.

SAQ 4

Match the terms used for defining groups of aquatic organisms given in column A with their definitions given in column B.

Column A		Column B	
i)	Neuston	a)	The group of plants and animals which are found living in or on the bottom of an aquatic ecosystem.
ii)	Nekton	b)	Plants or animals that cling to rooted water plants above the bottom mud.
iii)	Benthos	c)	Animals and plants of minute size which float in the aquatic ecosystems, seas, rivers, ponds and lakes. These organisms are incapable of independent movement and depend on water currents for movement.
iv)	Plankton	d)	Aquatic animals that swim strongly and are able to overcome water currents.
v)	Periphyton	e)	Organisms associated with the surface film of water.

3.5.2 Freshwater Ecosystem

Fresh water ecosystem depends on the terrestrial ecosystems for large quantities of organic and inorganic matter which are constantly added into them by the communities growing on nearby land.

The fresh water ecosystems can be conveniently divided into two main divisions:

i) Lentic (from 'lenis', calm) or standing or basin series ecosystems. Examples of this division are lakes, pools, ponds, swamps and marshes.

The largest lake in the world, the lake Superior in North America has a surface area of 83,000 km^2 and a maximum depth of 307 metres. The deepest lake, in the world, Lake Baikal in Siberia is nearly half the area of Lake Superior, i.e., 31,500 km^2. It has, however, more than twice its depth (706 metres).

Some lakes are formed in crater depressions of extinct volcanoes and are called crater lakes. Lakes may also arise by landslides blocking off streams and valley. Lakes are not evenly distributed on the earth but are grouped in certain regions called 'lake districts'

ii) Lotic (from 'lotus', washed) or running or channel series ecosystems. Examples of this division are rivers, streams and springs.

These two fresh water ecosystems have been described in the following sections.

Lakes are inland, depressions containing standing water. They vary considerably in area and depth.

Fresh water lakes of this earth hold $125 \times 10^3 m^3$ of water and have inflow as well as outflow. In addition they have various patterns of circulation within their boundaries and so their water is not totally static. However, they do lack the constant linear or turbulent flow characteristic of the rivers.

Lakes, Impoundments and Wetlands

Lentic ecosystems include all those systems which have a static body of water. Lakes (Fig. 3.4) (Box 3.2), impoundments and wetlands are all lentic ecosystems. Let us see how they differ from each other.

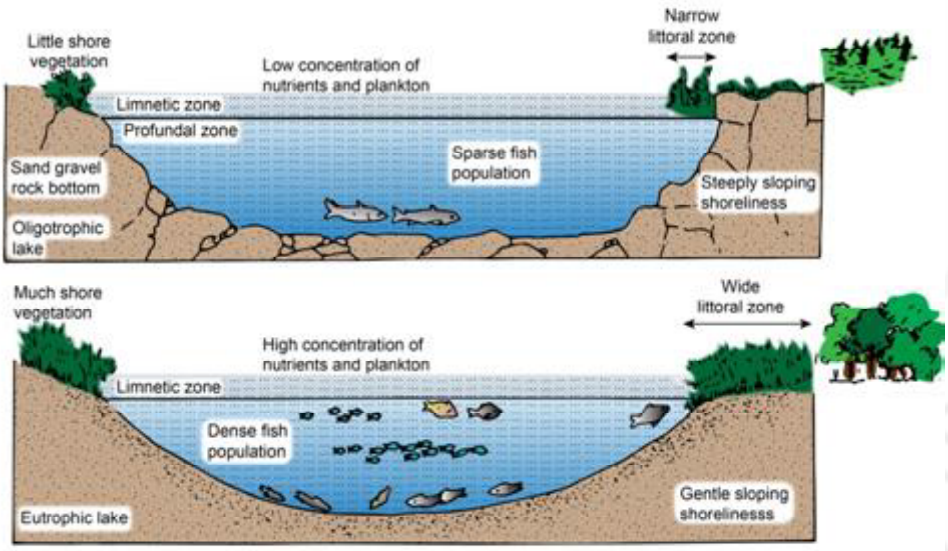

Fig. 3.4: Lake and its biota.

Lakes: Most lakes occur in regions which have recently been subjected to geological changes, say within the past 20,000 years. However, a few lakes, such as lake Baikal in Russia and Lake Tanganyanitia in Africa are ancient and are estimated to have originated twenty million years ago.

Box 3.2: Case Study: Loktak Lake

Loktak Lake (Fig 3.5) is situated 38 km south of Imphal city, the capital of Manipur State. The lake covers an area of about 286 sq. km .Main water body of the lake is surrounded by shallow water, which stagnates over a marsh/swamp land.

The characteristic feature of the Loktak Lake is the presence of floating islands known as Phumdis. These are heterogeneous masses of soil vegetation and organic matter, which occur in all sizes from a few centimeters to about 2.5 m. They occupy about two-third of the surface area of the lake.

Free-floating plants, such as water hyacinth and partly decomposed roots and rhizomes contribute greatly to its development. The largest single mass of phumdis occupying an area of 40 sq. km constitutes Keibul Lamjao National Park.

Fig.3.5: Loktak Lake with phumdis.

A number of streams originate from the hill ranges immediately to the west of the lake and these streams flow directly into Loktak Lake. The indirect catchment area covers catchments of five important rivers i.e. Imphal, Iril, Thoubal, Sekmai and Khuga and is spread over an area of 7157 sq. km.The Lake has been the source of water for generation of hydroelectric power, irrigation and water supply. A large population living around the lake depends upon the lake resources for sustenance. The staple food of Manipur is directly linked to Loktak Lake. The lake is rich in biodiversity and was designated as a wetland of international importance under Ramsar Convention in 1990. The Keibul Lamjao National Park, in the southern part of the lake, is home to the endangered Manipur brow, antlered deer (*Cervus eldi eldi*), locally called Sangai. The lake has been also the breeding ground of a number of riverine fishes and continues to be a vital fisheries resource. It supports a significant population of migratory and resident waterfowl.

Impoundments: They may be called offstem or onstem depending on how these have been created. Onstem reservoirs – these are located in upland areas and are formed by damming a stretch of river or stream in a suitable river valley. In India only these types of impoundments are found. Offstem reservoirs are built in low land areas by pumping water some distance from a river or from an underground source.

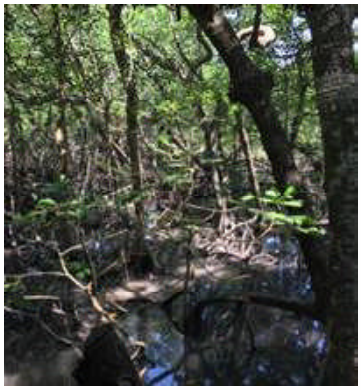

Fig. 3.6: Wetland.

Wetlands: Wetlands are permanently or periodically water covered areas (Fig. 3.6, Box 3.3). They can be defined as submerged or saturated lands either artificially created or natural, and either periodically or permanently covered up to a depth of six metres by water which may be fresh, brackish or saline.

The wetlands may be classified into two categories:

I. Inland wetlands occur when inland is surrounded by land and contain fresh water, e.g. bogs and swamps.

II. Coastal wetlands occur near the coast and contain saline or brackish waters, e.g. mangrove swamps, mangrove forests.

Box 3.3: Case Study: Threats to wetlands in Assam

Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Center (ARSAC), Guwahati, and the Space Applications Centre, Ahmedabad has revealed that 1367 out of 3513 wetlands in Assam are under severe threat due to the invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the state in terms of fisheries and tourism. Though the wetlands of Assam have the capacity of producing 5,000 t/ha/yr of fish, around 20,000 t of fish has to be imported to meet local demand. This is primarily due to poor wetland management.

3.5.3 Lotic Ecosystems – Rivers

The lotic or flowing water habitats include rivers, streams and brooks. The most outstanding features of such habitat is the continuously flowing water which moulds the characteristics of the water bed and influences the distribution of organisms within.

The two most important features are:

1) Rivers are open or heterotrophic systems, whereas lakes are closed or self contained systems except for some gains or losses from inflowing or outflowing streams;

2) Nutrients in a lake may be used several times, whereas in rivers, at any point, plants and animals must avail of temporarily available nutrients.

Biota of Rivers

The biota of both the rapidly flowing and the slowly flowing sections of the river are very distinct. Let us study the biota characteristic of river.

a) **Animals:** In the exposed rock surface habitats only those organisms are found which have efficient mechanisms for staying in one place. These include fresh water limpet, larvae or water penny (riffle beetles), fresh water sponges and caddis flies.

The microhabitat formed in the spaces between rock fragments is slightly sheltered. Here stone fly and dragonfly both of which are flattened and have behavioural adaptations to hold them in place (i.e. clinging by instinct to hard surface and orienting themselves along the current) are found

In the microhabitat beneath rocks, where current is a weak, animal such as annelids, flatworms, clams, some snail species and other insect larvae are found.

In the rapidly flowing habitat, nekton occurs only in areas where current is not too strong and include cold water fish species such as trout or salmon. In areas where the current is very strong nekton are absent and in such cases, the benthos may be many and varied and may form the entire community.

b) **Plants:** Among the plants only small, well attached forms, such as sessile algae can survive here. Thus, due to the presence of only a few plants, the nutrient base for animals here is organic detritus washed into the river from the drainage area.

3.5.4 Marine Ecosystems

A marine ecosystem is the largest and most stable system on the earth and is of great ecological significance. The sea water is salty with an average 3.5%. Sodium chloride (NaCl) is 27% of the salt while rest other important minerals are calcium, potassium and magnesium. An important factor in limiting the production and distribution of marine life is light. Temperature remains almost constant in ocean ranging from 2°C in polar region to 32°C or more in tropics.

The marine habitat is distinguishable into two different zones:(1) Benthic zone – which forms the basin or floor of the ocean, regardless of depth; (2) Pelagic zone – which represents the free water zone, filling the basin (see Fig. 3.7).

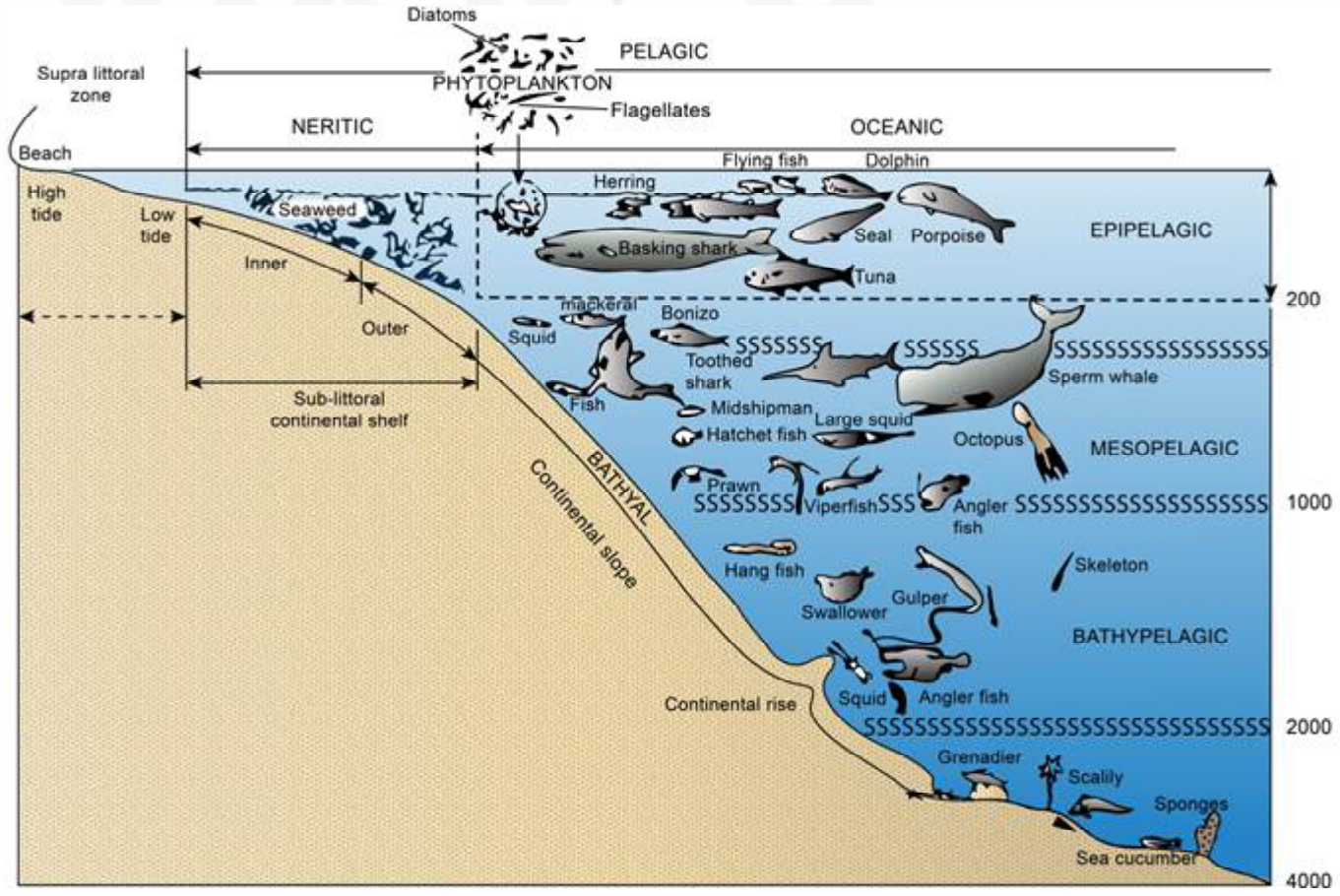

Fig 3.7: Major regions of the ocean.

Biota of Oceans

Life in the sea is not particularly abundant, though the diversity of organisms is high. Almost every major group of animals and every major group of algae occur somewhere in the oceans, with the exception of vascular plants and insects. On the basis of depth-wise differences in life forms, the expanse of marine ecosystems has been divided into littoral, neritic, pelagic and benthic zones. Let us now read about biota of each one of these.

i) **Biota of Littoral Zone:** This zone is the shore region of the marine ecosystems and is subject to violence of waves and tides, fluctuation of water level and variability of temperature, light, salinity and moisture. In common language supra littoral zone is termed as a beach. There are few species of plants present in this zone.

Common animals found here are snails, clams, barnacles, crustaceans, annelids, sea anemones and sea urchin. The animals here exhibit zonation with respect to tides. Animals more resistant to desiccation usually occurring at higher levels than those that are less resistant.

ii) **Biota of the Neritic Oceanic Zone:** This relatively shallow, coastal zone is rich in species and high in productivity owing to factors such as penetration of light to considerable depths and high concentrations of nutrients.

The most productive phytoplanktons are the dinoflagellates and diatoms, though red, brown and green algae attached to the bottom in the shallow regions may be significant. The zooplanktons are usually similar to those of the pelagic zone though some purely open-sea species are replaced by neritic species.

Almost all commercial species of fish as well as whales, seals, sea-otters, sea snakes and large squids are found here. Fishes are numerous and include several shark species as well as sea trout and salmon.

A wide variety of animals among which are clams, shrimps, snails, lobsters, crabs, sea cucumber, starfish, brittle stars, anemones, sponges, bryozoa, annelids and foraminifera and exhibits more diversity than those of the deeper waters.

iii) **Biota of Pelagic Zone:** Pelagic region constitutes 90 per cent of the total ocean surface and is less rich in species and numbers of organisms than the two regions discussed before.

The most abundant pelagic phytoplanktons are still the dinoflagellates and diatoms which are the chief photosynthetic feeders, others are carnivores. Sea cucumbers and sea urchins crawl on the floor eating detritus and bacteria and serve as food for the carnivorous brittle stars and crabs.

iv) **Biota of Benthic Zone :** It forms the floor of the ocean. Organisms here are hetrotrophic Rooted animals are sea lilies, sea fan, sponges etc. Snails and clams remain embedded in mud while starfish, sea cucumbers and sea urchins move on its surface.

3.5.5 Estuaries

All the rivers and lakes ultimately drain into the sea. However, many rivers develop a highly specialized zone before joining the proper sea. This zone is called estuary. An estuary is a transitional zone between rivers and sea representing unique ecological features and biotic communities. Estuaries are the most productive ecosystems of the world. An estuary is semi-enclosed part of the coastal ocean containing brackish water that has free connection with the sea on one side and on the other side it is connected with a river mouth and receives fresh water. In India, estuaries can be seen in plenty along the coast of Kerala or in Sunderbans.

Eustuary is a very important food source and almost all the major marine fisheries of the world are totally dependent on the estuaries for their continuance, because the adult fishes often resort to estuaries for laying eggs, i.e., spawning.

Features of Estuaries

The most dominant feature of the estuarine environment is the fluctuation in salinity. Though salinity gradient exists sometime in an estuary but the pattern of gradient varies seasonally, with the topography, with the tides and with the amount of fresh water.

Biota of Estuaries

The estuarine community is a mixture of three components: Marine, Fresh water and Brackish water, but overall estuarine diversity is still lower than that of the river or marine community. This is because of tremendous variation in the estuary's physical environment. Thus, the great productivity of estuaries is built on a narrow base.

The plants of the estuary are of four basic types: (i) Phytoplankton; (ii) marginal marsh vegetation; (iii) mud-flat algae; (iv) epiphytic plants growing on the marginal marsh vegetation. Diatoms and filamentous blue-green algae found in high number are the sites of intense photosynthesis. Oysters, crabs and some sea shrimps are also found.

SAQ 5

State whether the following statements are true or false :

a) The estuaries are characterised by high salt content in their substratum.

b) The estuaries do not support large organisms.

c) The estuaries are the most productive ecosystem of the biosphere.

d) Estuaries are a nursery ground for a large number of fishes.

3.6 SUMMARY

- Forests occupy approximately 40% of the land. The forest biomes can be classified as coniferous forest, temperate deciduous forest, temperate evergreen forest, temperate rain forest, tropical rain forest, tropical seasonal forest, sub-tropical forest etc.
- Grassland ecosystems are found where rainfall is about 25-75 cm every year. Grassland ecosystems are important to maintain the crop of many

domesticated and wild herbivores such as horses, buffaloes, camels, deers, zebras which provide food, milk, wool, leather, transportation to man.

- Desert ecosystems are found in the regions where rainfall of less than 25 cm.
- Ecosystems consisting of water as the main habitat are known as aquatic ecosystems. There are three kinds of aquatic ecosystems – fresh water, saline and brackish water ecosystems.
- Fresh waters are again of two types. The static water ecosystems are called as lentic systems and are exemplified by various lakes impoundments and wetlands. The lotic systems are characterised by flowing water and are exemplified by rivers.
- Rivers are main channels which supply surplus rainwater from land to sea. Each river has a slow moving and a fast moving zone. In slow moving one main factor limiting the growth of organisms is the availability of dissolved oxygen. In the fast moving waters the speed of water current is the main factor limiting the growth.
- Saline ecosystems comprise all the oceans of the world and contain a major portion of the total biomass of the earth. Oceans are also the main reservoir of air and water vapour in the atmosphere.
- Estuaries are examples of brackish water ecosystems. Their salt content varies seasonally. They are the most productive ecosystems of the world. They are also the most delicately balanced ecological systems, because the factors governing the functions of estuarine ecosystems are intricately dependent upon each other. One should be careful before deciding to dump garbage, sewage or industrial wastes into such ecosystems.

3.7 TERMINAL QUESTIONS

1. Describe the importance of forests in our life.
2. Describe how desert plants and animals adapt themselves to the conditions present in desert.
3. Discuss the economic importance of grassland ecosystem.
4. Discuss which is the most dynamic ecosystem in your view and why.
5. Give a brief account of marine and estuarine ecosystem.

3.8 ANSWERS

Self-Assessment Questions

1. a) i) Biotic communities, ii) Deciduous, iii) Equator

   b) See Section 3.2 Importance of forest.

   c) See Section 3.2. types of forest

2. a) See Section3.3 Grassland Ecosystem
   b) See Section 3.3 Grassland Ecosystem - Economic importance
3. c, 2. b, 3. a
4. i) e, ii) d, iii) a, iv) c, v) b
5. a) T, b) F, c) T, d) T

Terminal Questions

1. See Section 3.2 Importance of forest.
2. See Section 3.4 Desert ecosystem.
3. See Section 3.3 Grassland ecosystem.
4. Describe the ecosystem which you find is most dynamic in your view and support your answer
5. See Section 3.5.4 Marine ecosystem.

3.9 FURTHER READING

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Acknowledgement of Figures

1. Fig. 3.2 : Desert Ecosystem https://en.wikipedia.org/wiki/Desert_ecology #/media/File:Algeria_Sahara_Desert_Photo_From_Drone_5.jpg
2. Fig. 3.5 : Loktak Lake: www.flamingotravels.com/image/loktak_big.jpg

Indira Gandhi National
Open University
School of Sciences

BEVAE-181
ABILITY ENHANCEMENT COMPULSORY COURSE ON ENVIRONMENTAL STUDIES

Block

2

NATURAL RESOURCES

BLOCK 2 : NATURAL RESOURCES

This Block discusses about the natural resources, their distribution, significance, utilisation and problems arising out of their utilisation. Natural resources include land, water, mineral, plant and animal etc. Nature has given us these resources which are essential for survival and development of all the life forms. It is our prime responsibility to use our natural treasures wisely and judiciously. Our demand on natural resources is rapidly increasing and it is believed that the resources are being used indiscriminately. This is partly because of the tremendous increase in human population, rate of consumption and partly due to lack of realisation on our part that these resources are limited and will be exhausted one day. Therefore, there is a need for sustainable natural resource management

Unit 4 Land and Water Resource: In this unit we shall discuss the two vital natural resources namely land and water which are essential for survival and development of all the life forms. It is our prime responsibility to use our natural treasures wisely and judiciously despite of our increasing demand. Intensive and unregulated use of land surface for cultivation, grazing or exploitation of plant material has adversely affected the plant communities and their composition as well as regeneration capacity. Likewise, one of the most pronounced and long lasting effects of mining and pollution is both quantitative and qualitative deterioration of water resources. Industries add toxic wastes to the water bodies making them unusable. Demand for natural resources is increasing progressively, hence we need to use them more efficiently and also look for alternative sources or their substitutes.

Unit 5 Forest Resources: This unit will describe economic, ecological and socio-cultural significance of forest as a resource. It will also provide explanation for various causes and consequences of deforestation. The final section deals with methods of conservation and management of forest resources.

Unit 6 Biodiversity: Values and Services: This unit defines biodiversity and explains different levels of biodiversity namely genetic, species, and ecosystem diversity. It also enumerates and analyses the wild life species that occur in the different biogeographic zones of India. The unit also explains the value of diversity in terms of direct vs. indirect use, extractive vs. non-extractive use and resource vs. non-resource use.

Unit 7 Energy Resources: In this unit, we begin our discussion about energy as resource with an understanding of the multi-faceted role of energy in economic development. We will examine the energy resource base at our disposal and the various energy options available to us. Finally, we will analyse the carrying capacity of the Earth in relation to our energy demand with a view of switching over to renewable energy sources.

UNIT 4

LAND AND WATER RESOURCES

Structure

4.1 INTRODUCTION

In the previous units you have studied what constitutes your environment and how ecosystem supports myriad living forms including human beings. You have also understood the importance of environment and how energy moves from one form to another form, from sun to producers (trees, algae, etc.) and thereafter to herbivores and then to various life consumers like carnivores. In the present unit, we shall discuss the resources or the wealth, nature has given to us as these are essential for survival and development of all the life forms. It is our prime concern to use our natural treasures wisely and judiciously. Our demand on natural resources is rapidly increasing. However, it is believed that the resources are being used indiscriminately. This is partly because of the tremendous increase in human population and partly due to lack of realisation on our part that these resources are limited and will be exhausted one day.

Intensive and unregulated use of land surface for cultivation, grazing or exploitation of plant material has adversely affected the plant communities and their composition as well as regeneration capacity. Likewise, one of the most pronounced and long lasting effects of mining and pollution is both quantitative and qualitative deterioration of water resources. Industries add toxic wastes to the water bodies making them unusable.

There is another reason to conserve and safeguard our land and water resources as their supply is not unlimited. Demand for natural resources is increasing progressively, hence we

need to use them more efficiently and also look for alternative sources or their substitutes. It will be only possible when we understand about their availability and limitations.

Expected Learning Outcomes

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

- define renewable and non-renewable resources;
- explain how various human activities in agriculture and industry have led to degradation of land and water resources;
- describe how environmental degradation has led to conditions of floods and droughts; and
- explain the phenomena of soil erosion and desertification and how with wise and careful planning, various natural resources like land and water can be utilized in a sustainable manner.

4.2 RENEWABLE AND NON-RENEWABLE RESOURCES

Our resources are basically of two kinds viz., renewable and non-renewable. Let us see what this means. A resource may be defined as any useful information, material or service. Broadly we can differentiate between natural resources i.e., goods and services supplied by the environment and human-made resources i.e., cities, buildings, institutions and other artefacts and human resources which include wisdom, experience, skill and enterprise.

Natural resources are of two kinds. Some of the resources of the earth are replaced from time to time by natural multiplication such as vegetation. In other words these resources are regenerated and are, therefore, called **renewable resources**. Forests, pastures, wild life and aquatic life are examples of renewable resources. Water is also a renewable resource because it gets recycled. There are some other resources such as minerals and fossil fuels which once used are lost for ever. They cannot be regenerated. Mineral deposits were formed slowly in millions of years. Once a deposit is used it cannot be regenerated. For example, fossil fuels (petrol, coal) get burnt up and cannot be recovered. These are known as **non-renewable resources**. Similarly, the formation of soil is a very slow process and formation of a layer of top soil can take thousands of years. Hence, it is also a non-renewable resource. Let us examine water and land as the renewable and non-renewable resources individually.

4.3 RENEWABLE WATER RESOURCE

Water is one of the most essential components of life. Our water resources are limited though apparently water is available in an abundant quantity. There is scarcity of usable quantity of water in large parts of the world.

Human survival since ages has depended on the relationship societies had with land and water resources. This relationship has been evolving ever since riverbanks and river valleys influenced the early human settlements. Many early civilizations have flourished on the riverbanks, and perished in the river floods – some probably due to the faulty watershed/river basin management. However, eventually human beings had come to understand the cyclical relationship of water with land. This understanding led to the creation of tanks using highly developed engineering techniques.

Freshwater is one of the most important substances for sustaining human life. Considered as one the important one in the five elements – earth, fire, air, space and water – it was revered and worshiped and treated by all with respect.

This is because a mere one percent of all water on the planet is readily accessible to us for use. Of this amount, about 73 per cent goes to agriculture, 20 per cent to industry and the rest is used for domestic and recreational needs such as drinking and other non-potable uses.

The global distribution of water resources reveals that less than 3% of the total quantity is fresh water. A break up of the total fresh water among various resources and its availability is shown in Table 4.1

Table 4.1: Global distribution of fresh water

Types of Fresh Water	% of Fresh Water	% Available
1) Frozen	80.00	
2) Liquid	20.00	
Lakes	0.2	1.0
Soil	0.04	0.2
Rivers	0.02	0.1
Atmosphere	0.02	0.1
Biological (Metabolic)	0.001	0.005
Ground water	19.7	98.4

It is evident from the Table 4.1 that only one fifth of the fresh water is available in the liquid form. This limited amount is replenishable and therefore, has been relied upon for recurrent use by human being. More than 90% of this scarce commodity is in the form of ground water, while only 1% is in the lakes and ponds. The soil profile carries only 0.2%, but double the amount is held either by rivers or atmosphere. India, in terms of total annual rainfall is very fortunate. It receives an average rainfall of 400 m ham (million hectare metres) out of which 185 m ham is available as surface water, 50 m ham is stored as underground water and 165 m ham is stored in soil.

The total amount of fresh water is more than enough to meet the present and future needs of human kind. But due to its uneven distribution, wide seasonal as well as yearly fluctuations, water shortage is a chronic problem in many parts of the world.

Thus we can see that the water which is required for various purposes like irrigation, navigation, generation of hydroelectricity and domestic and industrial needs is rather scarce. It is, therefore, necessary that water resources should be utilized judiciously.

4.3.1 Water Cycle (Hydrological Cycle)

The movement of water on the earth is continuous and forms many complex inter-related loops (Fig. 4.1). Cycling of water involves atmosphere, sea, earth and the entire living biota. The circulation of water is highly dynamic and global in extent. However, for the sake of convenience it is divided into different categories:

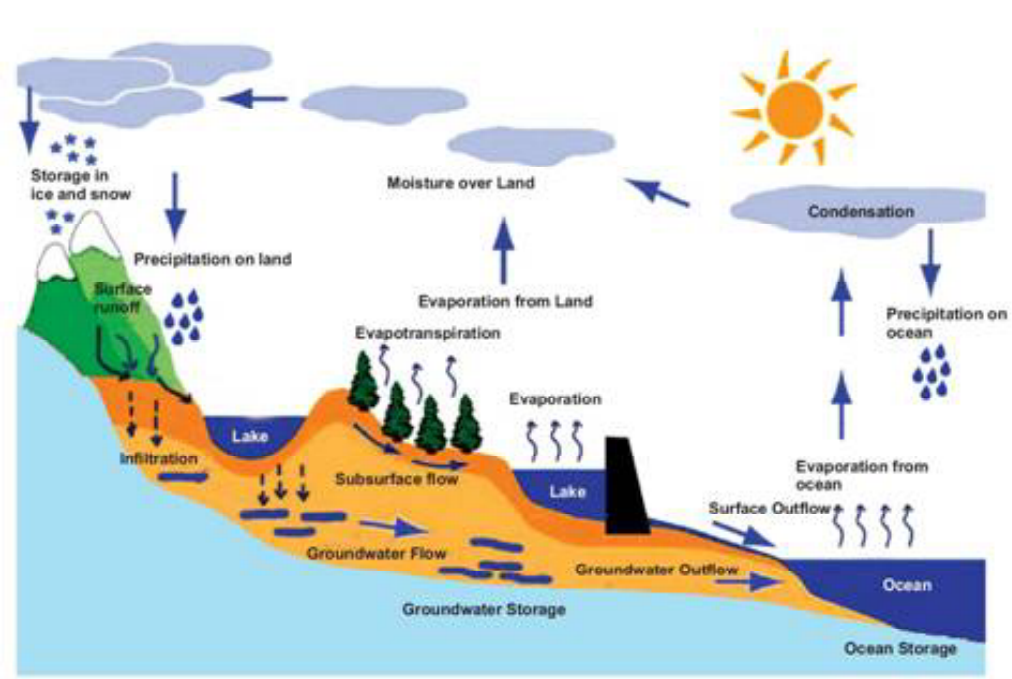

Fig. 4.1: Hydrological cycle.

i) **Precipitation:** Precipitation includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew. The moisture that enters the atmosphere by the vaporisation of water condenses either into liquid (rain) or solid (snow, hail and sleet) before it can fall (Fig. 4.2). Water returns to the land and the sea from the atmosphere by means of condensation, deposition and precipitation. **Condensation** is defined as the process by which water changes from vapour phase to a liquid state (in the form of dew droplets). **Deposition** is the process by which water changes directly from a vapour into a solid (ice crystals) phase. In the atmosphere tiny droplets of water and ice crystals produced through condensation and deposition form clouds. The major amount of water on earth, is received as rainfall.

The water cycle in nature is sustained by energy from the sun. Solar energy evaporates water from the sea and the land. Water vapours condense in the atmosphere to form clouds which are transported to long distance by wind currents. Rainfall and melted snow replenish water in rivers, which carry it back to the sea.

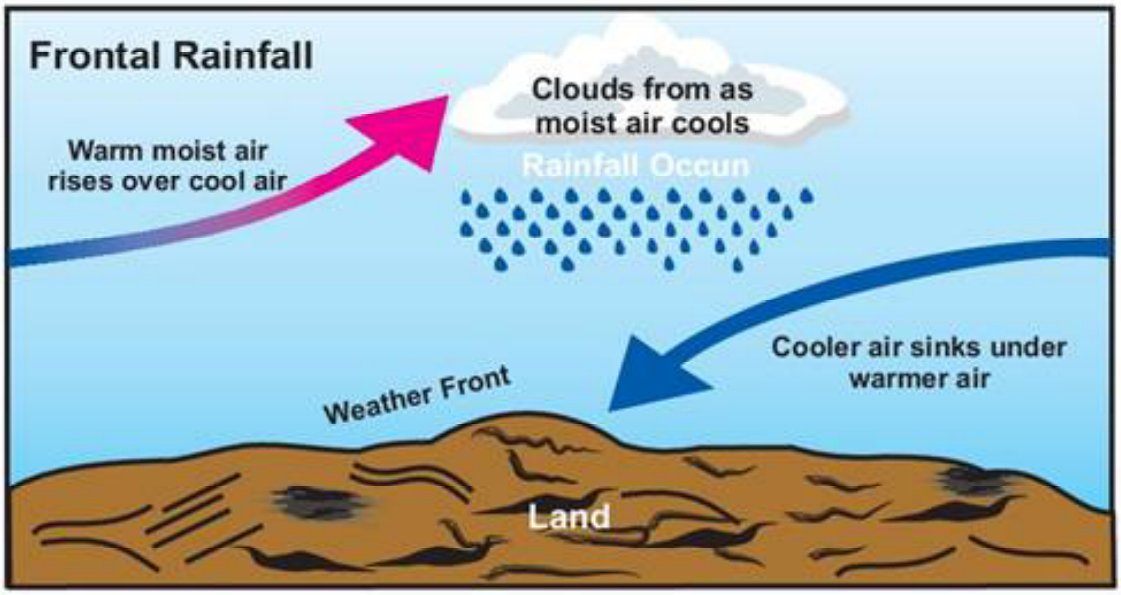

Fig. 4.2: Relative humidity for a given parcel of moisture laden air varies with temperature.

ii) **Run off:** Some of the rainfall is soaked into the soil and excess water flows over the land surface along the natural slope of the area. Run off is the main source of water for lakes and rivers which ultimately drain into the sea. The flowing water acts as an agent of soil erosion and weathering of the underlying rock. Excessive run off during the rainy season causes flood in many parts of our country.

iii) **Sublimation:** It is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase. The gradual disappearance of flakes of ice during the periods when the temperature remains well below freezing is an example of sublimation.

iv) **Evaporation:** It is the process by which liquid water changes into vapour at ambient temperature. Water evaporates from all aquatic bodies as well as from wet surfaces. Evaporation from the ocean surface is by far the largest source of atmospheric water vapour.

v) **Transpiration:** It refers to the loss of water in vapour form from plant leaves. On land, transpiration is considerable. For example, the loss of water through transpiration alone by one hectare (2.5 acres) of corn approximately amounts to 35,000 litres (8800 gallons) of water each day.

After learning the cycling of water in nature you would like to know about the different types of water found on the earth.

4.3.2 Forms of Water

Water exists on land in three forms viz: fresh water,brackish water and marine water.

Fresh Water

Water, a universal solvent, invariably contains many soluble salts. In fresh water the total salt content remains under 1.5 per cent. Different types of

soluble salts released by weathering of rocks, soil erosion and decay of organic matter, readily dissolve in water. Dissolved salts have particular significance for floating aquatic vegetation and phytoplankton.

Brackish Water

The content of dissolved salts in brackish water is higher than the fresh water and ranges between 0.5 and 3.5%. These waters of intermediate salinity range are distinct from fresh or marine waters. In an estuary which represents the tail end of a river, mixing of fresh water with sea water results in brackish water.

Marine Water

The sea water is highly saline. The average salinity of sea water remains almost constant at 35 parts of salt per 1000 parts of water by weight and is written as 3.5%. Some salt lakes may also have salinity levels up to and above 35%. The biotic activity in such habitats is greatly restricted.

4.3.3 Over Exploitation of Surface and Groundwater

Water which falls in the form of precipitation moves down into soil and through rocks and gets accumulated as **ground water.** The layer of rock through which it percolates down is known as **aquifer** and water can be utilised by digging out wells. Ground water can be found in two layers of the soil. The **zone of aeration,** where gaps in the soil are filled both with air and water. Further down there is a **zone of saturation** where in the gaps are filled up completely with water. Water table is the boundary between the saturated zone and unsaturated zone in rock and it rises and drops drown with increase or decrease in the amount of ground water. Ground water provides a constant supply to us for different purposes and this is not likely to dry up under natural conditions.

Box 4.1 : Ground Water Depletion

Ground water is a major source of drinking water. Its usage has been estimated at around 50% but much of its availability is dependent on the rainfall and recharge conditions. While the demand is on the rise, it has also led to water scarcity, and where available it is affected by pollution, depriving millions of people an access to safe drinking water. This kind of crisis is more a human made crisis than a natural one. The extraction levels have gone up and even the farming and industrial sectors are increasingly using the water from wells. The crisis can be attributed to lack of adequate water conservation methods, inefficient use of water, poor ground water recharge and lack of quality in fresh water sources. The water pollution is marked by excess fluoride, arsenic, iron, salt and organic matter.

Source: *http://edugreen.teri.res.in/explore/water/water/ground.html*

The surface water includes the streams, ponds, lakes, human-made reservoirs and canals, and freshwater wetlands. As part of water cycle the surface water bodies are considered renewable resources though they are dependent on other parts of water cycle.

Agriculture is by far the biggest consumer of water. Almost 70% of available water is consumed every year in agricultural production worldwide. In Asia, it accounts for 86% of total annual water withdrawal, compared with 49% in North and Central America and 38% in Europe. The Green Revolution in India ushered in an era of energy and resource intensive agriculture. Water was a critical input to the Green Revolution, through irrigation, flood control, and drainage, and it has contributed most to the growth in wheat and rice production for the past 40 years.

Implications for future agricultural production are to develop water efficient measures giving more productivity per unit of water input. This would require efficient operation of irrigation systems; technologies that reduce water consumption, appropriate soil and water conservation measures, changes in cropping patterns and the ways in which crops are grown, so as to use water more efficiently.

Similar standards would need to be set and enforced for industries to cut down on water use and prevent them for discharging polluting effluents into water bodies.

4.3.4 Degradation of Water Sources

The depletion of water resources and their contamination making them unfit as a source of water for human consumption. It is a major problem today. Most of our water bodies like rivers, lakes, oceans, estuaries and ground water bodies are facing severe pollution due to intensive agriculture, urbanisation, industrialisation and deforestation. Siltation of rivers and lakes due to soil erosion progressively reduces their water holding capacity resulting in ravaging floods year after year. Today we are faced with the paradoxical situation of lack of safe drinking water in above-average rainfall areas and regions having abundant water bodies.

Discharge of sewage and industrial effluents into water bodies not only pollute water but often lead to an increase in the growth of aquatic plants and algal blooms in water bodies, ultimately causing them to disappear. This may also cause the decay and destruction of various organisms in water, e.g., fish.

4.3.5 Floods and Droughts

Floods are the most common of all natural calamities. Floods regularly claim over 20 thousand lives and adversely affect 75 million people annually world wide. Bangladesh alone accounts for about two-third of global loss of life due to floods. India accounts one fifth of global death count and loss of Rs. 600 million every year on an average. More than the loss of life and damage to property, millions of people are displaced every year due to floods in the South Asian countries.

A flood is the discharge of water that exceeds the canal capacity of the river. Floods are caused by different factors that include:

It is possible to reduce the adverse effects of floods by:

- construction of dams and reservoirs at appropriate places;

- strengthening the embankments on rivers and canals;
- improving the carrying capacities of rivers, canals and reservoirs by periodical desilting and deepening operations;
- diversion of flood waters from a river or a channel into other canals and channels;
- introducing flood plain management techniques; and
- preparing ponds, reservoirs, tanks and leading channels by removing obstructions and avoiding constructions.

It is now easy to predict or forecast onset of floods before hand by the advancement in science and technology. The damage to property and loss of life or displacement of people can be reduced if only the concerned agencies coordinate their activities and act in time to address the calamity.

Like flood a **'drought'** can be defined as a prolonged period of unusually dry weather, with little rainfall, in a region where rains are normally expected. As such a drought differs from a dry climate which is usually associated with a region that is normally or seasonally dry. Droughts often last for years. Drought is a creeping calamity because it develops slowly and has a prolonged existence. Droughts are not confined to any particular tectonic or topographic setting and their impact often extends over large areas and regions. The impact of drought affects the developing countries more severely than the developed countries. Crop losses hunger and malnutrition cause immense misery to the poor people.

Box 4.2 : A Case Study of Drought in Rajasthan

Rajasthan, the largest State in India with a land area of 342,239 sq. km and an estimated population of about **54 million** was in the grip of a **severe drought in the year 2000.** Out of the 32 total districts in the State drought was prevalent in 31 districts and among these 25 districts were affected severely. 73.64% villages were under the clutches of drought; affecting nearly 33.04 million people and 39.97 million cattle. The severity of the drought can be judged from the fact that **out of a total of 2647 major water reservoirs only 300 were filled up. Also, nearly 75 to 100% of crops was destroyed due to water scarcity.** All this caused loss of livelihood leading to mass migration in search of employment.

Source: *http://www.un.org.in/UNDMT/states/rajas/dstatus.html*

Though climate is usually the prime trigger of drought, the situation is often made worse by the way people use the water resources. Felling trees for firewood, denuding the forest for agricultural or housing purpose, mining, unscientific farming methods and indiscriminate drawing of ground water cause drought. It is argued that serious droughts in developing countries are more a function of global developmental policies than climatic conditions.

Droughts produce series of direct and indirect impacts that usually extend far beyond the area that is experiencing the actual water shortage. These may be classified as:

- Economic – Loss of crop, dairy, livestock, fishery produce;
- Environmental – Damage to plant and animal species, erosion of soils; and
- Social – Food shortage, damage to health, conflicts between water users.

It is possible to take precautions in drought prone areas by constructing reservoirs, educating people in water conservation, scientific farming and optimal use of ground water resources. Since many parts of India are prone to drought, government agencies maintain a stock of food grain to meet the scarcity to crop failures.

Water Harvesting Measures: One of the effective measures to combat drought and resulting water shortage is to adopt rain water harvesting measures. Water harvesting can be undertaken through variety of ways by:

- capturing runoff from rooftops;
- capturing runoff from catchments;
- capturing seasonal floodwaters from local streams in ponds and reservoirs; and
- conserving water through watershed management.

These techniques can serve the following purpose:

- Provide drinking water
- Provide water for irrigation
- Increase groundwater recharge
- Reduce storm water discharges, urban floods and overloading of sewage treatment plants
- Reduce seawater ingress in coastal areas.

At the **local** level, several water management strategies are in use today, that offer practical and sometimes superior alternatives to the large-scale centralized, capital-intensive approaches to water management. They can also complement wider reaching water management approaches.

Several methods are being used in the traditional system of water harvesting in different regions of the country. For example, *johads*, *talaabs* as surface water bodies and *kunds* (underground tanks) are in vogue in many parts of the country. In the North-eastern Hills bamboo drip irrigation is practiced to conserve water (Fig. 4.3).

In a cold desert area like Spiti in Himachal Pradesh, *kul* irrigation is practiced since ancient times. *Kuls* (see Fig. 4.4) are diversion channels made to carry water from glaciers to villages. The *kuls* often span long distances, some being 10 km long and run down precipitous mountain slopes.

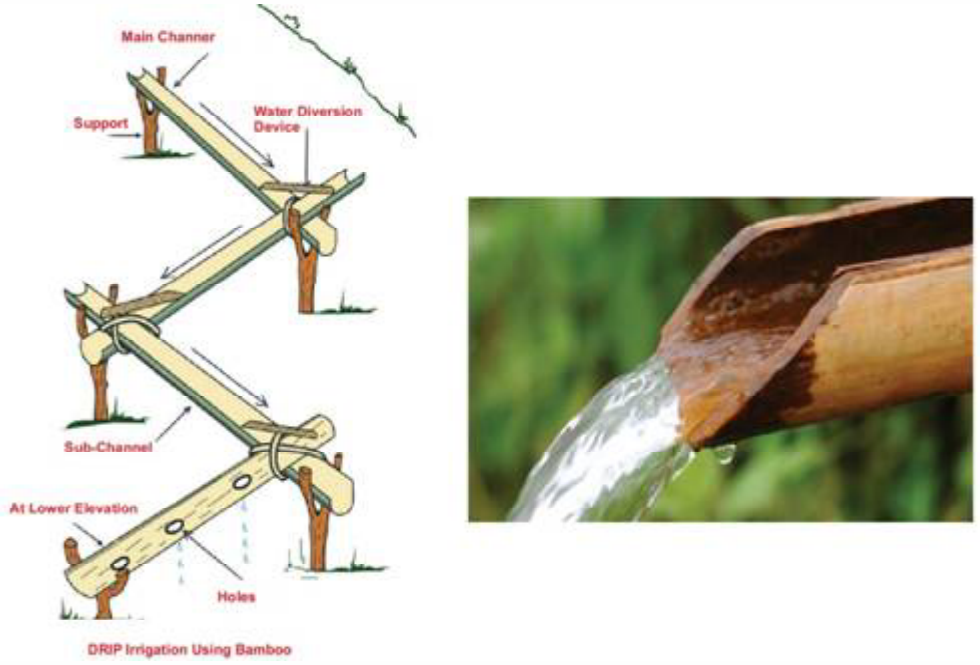

Fig. 4.3: Bamboo drip irrigation.

Fig. 4.4: Kuls in the Spiti area.

Several methods are being followed by individuals, and communities in urban as well as rural areas to harvest rain water. One such scheme is operational in the Rashtrapati Bhavan.

In Rashtrapati Bhavan an underground tank of 1 lakh litre capacity has been constructed to store water for low quality use (see Fig. 4.5). Rainwater from the northern side of roof and paved areas surrounding Rashtrapati Bhavan is diverted to it.

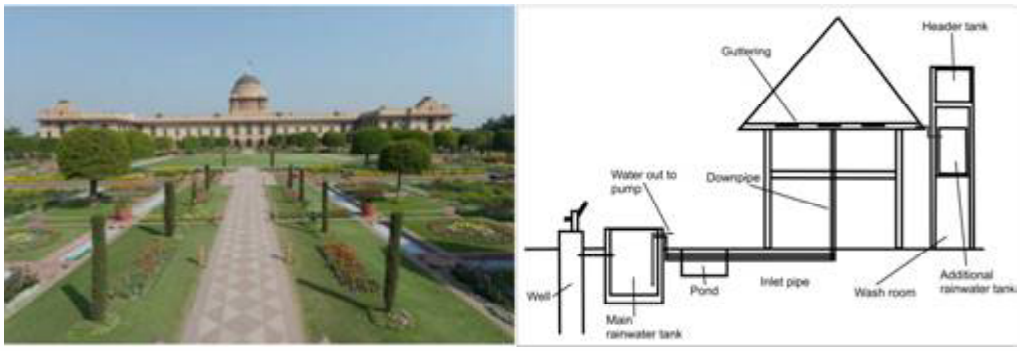

Fig. 4.5: Rainwater harvesting in Rashtrapati Bhawan.

Two dugwells are used to store overflow from the 1 lakh litre rainwater storage tank. Another dry open well is recharged with rainwater from the southern side of the roof and runoff from the staff residential area. A desilting tank is used to remove pollutants from the water passing into the recharge well. (see fig. 4.6)

Fig. 4.6: Rain water harvestig.

Box 4.3 : Water Harvesting measures by Hyderabad Metropolitan Water Supply and Sewerage Board

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) has set up an ambitious plan of taking up several water harvesting measures in twin cities of Hyderabad and Secunderabad and its vicinity through active involvement of people to improve the ground water level. The Water Harvesting measures, under the Neeru-Meeru (Water and You) Programme, include construction of a recharge pits or a mini-treatment units, planting saplings or any other action that would

improve water recharge and green cover which ultimately increase the ground water levels. Different opinion makers like ex servicemen, retired officials, women's groups and NGOs were sensitised on motivational aspects and techniques of various water harvesting structures. The trained groups would in turn reach out to communities and motivate the people highlighting the importance of rainwater harvesting and its benefits. As part of the strategy, the Board has recently created water soldiers, by sensitising ex-servicemen recently. It had also proposed to involve the student community in a big way so that the schools and colleges and other institutions would contribute to the cause of improving ground water table.

Source: http://www.hyderabadwatr.gov.in/RWH_Note.html

4.3.6 Conservation and Management of Water Resources

Water is increasingly becoming a scarce commodity. Its scarcity threatens us all - jeopardizing our livelihoods, and sometimes endangering our lives. For many millions of people, freshwater scarcity is defined as much by *poor quality* as by *insufficient quantity*. As reported in 2001 by the United Nations Population Fund (UNFPA), within the next 25 years, one-third of the world's population will experience severe water scarcity. Right now, more than 1 billion people lack access to safe drinking water and 3 billion people (half of the Earth's population) lack access to basic sewage systems. More than 90 % of all the sewage produced in the developing countries returns untreated to land and water. Unless water resources are managed properly, we will keep facing paradoxical situations like lack of drinking water due to pollution even in above-average rainfall areas.

As populations increase and economic development intensifies, critical policy decisions would need to be taken on a long-term basis for **regenerating, regulating**, **allocating**, and **using** water resources. In future, conflicting demands will increasingly be felt between the needs for safe drinking water and sanitation as well as industrial and agricultural activities.

Management of water resources means a programme to provide an adequate supply of good quality of water for various uses without endangering the life of the source or the reserve of water. In other words, efforts should be made to see that: (i) water of the right quality is available for all kind of uses and (ii) there is no misuse or wastage of this precious resource.

Water management includes recharging the reserves of groundwater and diverting supply from an area of surplus to the region of scarcity.

Recharging of groundwater is the most important aspect of the water management. In the mountains and hills, the watersheds are covered with vegetation. The litter-covered soil of the watershed allows infiltration of rain water, which finds its way to the aquifers.

In urban and rural areas, storm water, used water or domestic drains can be fed into pits, trenches, or any depression, where it can filter underground. Flood water can be injected into aquifers through a series of deep pits or it can be spread on the fields through a network of ditches.

The excess flow of normal as well as flood water can be diverted to areas where there is scarcity of water. This will not only remove the danger of damage caused by floods but will also benefit the regions of scarcity.

By proper treatment of the domestic and municipal waste water, one can obtain a supply fit for many industrial and agricultural purposes. The treatment of waste water involves removal of pollutants, germs, and toxic elements as you have already studied in the previous section.

Desalination of sea water

By use of solar energy, sea water can be distilled, thus fresh water of good quality can be obtained. This method of desalination of sea water is being used in our country at places like Bhavnagar in Gujarat (Fig. 4.7) and Churu in Rajasthan.

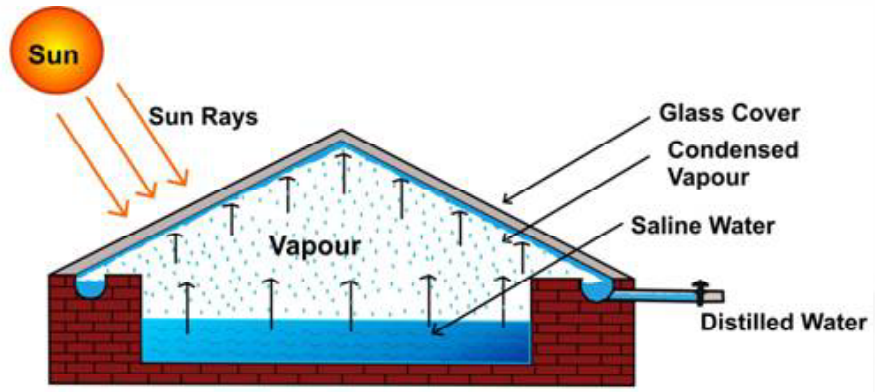

Fig. 4.7: Desalination of sea water by use of solar energy.

Reducing over consumption

Using more water than necessary is an unpardonable waste of the precious and scarce resource. In our country, a lot of water is wasted due to leaking taps and bad plumbing. There is also need for a check on excessive irrigation.

Waste water

Domestic and municipal waste water is rich in organic nutrients. If this kind of water is made free from disease carrying germs and poisonous elements, it can be used for irrigation of farms, gardens and other vegetations (Fig. 4.8).

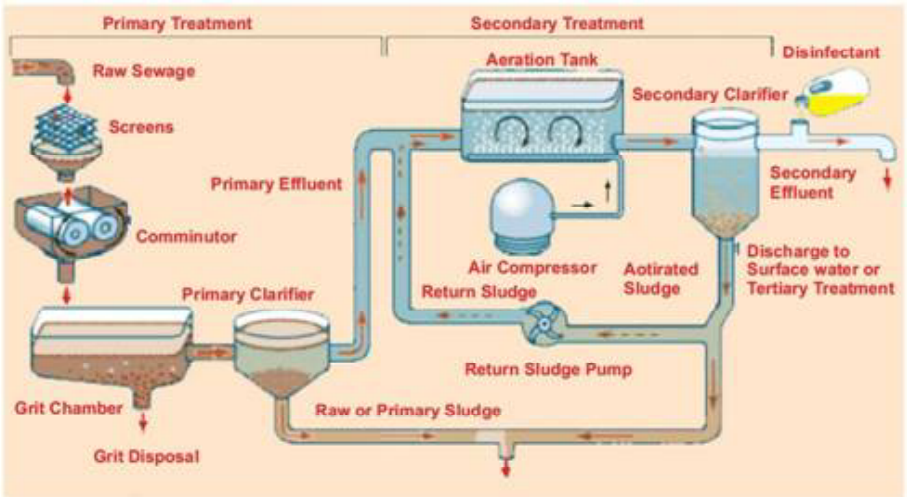

Fig. 4.8: Domestic and municipal waste water treatment.

For the removal of germs and toxic elements, the waste water or sewage is treated in a tank or in ponds for several days. In doing so, the heavy particles settle down to the bottom by themselves, while the finer particles are made to settle down by adding alum and caustic soda. The clear liquid is then allowed to pass through filters or sand or earth and finally air is blown through it. This treatment not only removes carbon dioxide and hydrogen sulphide which is generally dissolved in waste water, but also adds oxygen to the filtered water, thus helping in purification. Treatment of water with appropriate doses of chlorine, known as chlorination, kills all the harmful germs and makes water usable. Growing of algae or water hyacinth, a wild plant that grows in floating masses in rivers and lakes serves a double purpose. It cleans the water of pollutants like phosphates and nitrates that act as nutrients for these plants, and these plants can also be utilised for the production of biogas.

SAQ 1

Fill in the blanks with appropriate words and check your answer given at the end of this unit:

i) ……. is one of the most important substances for sustaining human life.

ii) Movement of water on the ……. is continuous.

iii) Water a universal ……. invariably contains many soluble ……..

iv) Agriculture is by far the biggest ……. of water.

v) A ……. is the discharge of water that exceeds the canal capacity of the …….

vi) The Krishna ……. reached its decision in 1973.

vii) ……. methods are being used in tradition system of water ……

4.4 NON-RENEWABLE LAND RESOURCE

After learning about the renewable resources like water and forests, you would like to know what are our non-renewable resources such as land, mineral oceanic resources. These resources can neither be regenerated nor expanded.

Land resources

Land is a basic resource for us. As you have learnt in the previous section, it is, in fact, the foundation on which the entire ecological system rests and it is the living ground (habitat) for all terrestrial plants and animals. The capability of land to support life and various activities of man and animals is dependent both on its biological productivity, and load bearing capacity of the soil and rocks.

Land is under great pressure due to increase in population. Our land mass which was, in 1901, inhabited by 238 million people, is now shared by more than 1200 million people. Mismanagement of the land resource as a result of

indiscriminate cutting of trees or deforestation has caused considerable damage to the quality of the soil and landscapes.

Soil resources

Soil, which forms the uppermost layer of the land, is the most precious of all resources, because it supports the whole life system, provides food and fodder in the form of vegetation and stores water essential for life. It contains sand, silt and clays, mixed with air and moisture. It possesses rich organic and mineral nutrients.

The type of soil varies from place to place. Those soils which are rich in organic matter are fertile. Fertility is also dependent on the capacity of the soil to retain water and oxygen. The following major types of soil are shown in the outline map of India (Fig. 4.9).

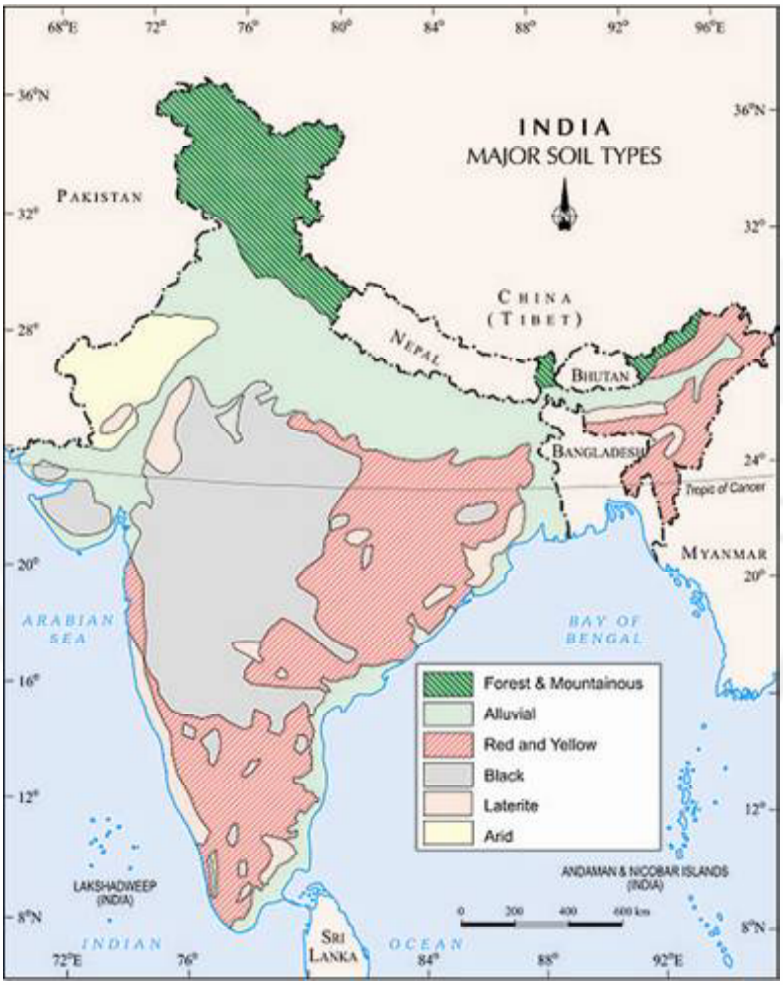

Fig. 4.9: Major Soil types of India.

1. **Red soil** is found on plateaux and lowland areas of eastern Bihar, Madhya Pradesh, Jharkand, Chhatisgarh, Odissha, Kerala, Karnataka and Andhra Pradesh, where rainfall is between 100-300 cm/year and temperature remains above 22°C. The soil supports rain forests and grasslands and is good for cultivation of potatoes, bananas, pineapples and rubber.
2. The type of soil found on the Deccan and Malwa plateaux of western and

central India has a cover of clay and is **loamy and black**. It is very fertile and supports mixed grasslands, forests, crops of sugarcane, groundnut, soyabean, cotton and rice.

3. The **soils of the desert region** of western and north-western India are low in organic matter and generally considered to have low fertility. However, if water is provided they can be made very fertile.
4. Another type of soil forms part of the Indo-Gangetic plains extending in the delta regions on the coasts of Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Gujarat. This soil is characterised by **loamy texture, dry composition** and variability of thickness from place to place. The soil is highly productive and supports crops of all kind.
5. The soil that forms part of the low-lying wetlands or marshy land in the deltas of Ganga, Godavari, Krishna, Kaveri and in the river basins of Kerala, contains rich organic matter such as decomposed farmyard manure (dung) and plant material (wood peat), and as such is very fertile.
6. The soil found on the mountainous Himalayan region, which is ash **grey to pale yellow-brown in colour**, has low fertility and supports oak and coniferous plants such as pines and deodar.

4.4.1 Processes Involved in the Soil Formation

The processes which are involved in the formation of soils can be studied under the following headings:

Weathering of Rocks

The processes involved in the formation of soil are slow, gradual and continuous. The sum total of natural processes resulting in the disintegration of parent rocks is collectively known as 'weathering', and it involves physical, chemical and biological agencies.

Physical Weathering

Mechanical forces acting upon the rocks cause physical weathering. Temperature fluctuations cause expansion and contraction of rock surface resulting in the formation of cracks and fissures. During cold weather, the water present in rock crevices gets frozen and the formation of ice results in its expansion. The force of expansion causes breaking up of rock. Broken rock fragments roll down the slopes and break further into smaller pieces. Hails, rainfall and fast flowing streams are important agents of physical weathering. Wind is another agent of physical weathering particularly when it carries sand particles which causes abrasion of rock surface, due to friction. In the Vindhyan hill forests, it is commonly seen that tree roots often penetrate through the rock crevices and in course of time, with the radial growth of roots, the rocks get disintegrated.

Chemical Weathering

The rocks while getting disintegrated may also undergo chemical change.

Water is an important agent in bringing about chemical changes due to dissolution or reaction of one or more components of rock materials. Presence of dissolved materials and warm temperature favour chemical weathering. Another very important process of chemical weathering is through hydrolysis in which water dissociates (particularly in the presence of carbon dioxide and organic acids) into H^+ and OH^- ions which act on silicates like orthoclase to produce silicate clays. Oxidation and reduction reactions and carbonation are other important means of chemical weathering.

Mineralisation and Humification

As a result of physical weathering, the rocks are broken down into smaller particles. But this is not the true soil, and plants cannot grow well in the disintegrated rock material alone. The weathered material, however, undergoes further changes, that you would study in this section. You might have noticed that during weathering, mostly physical and chemical factors are involved. For the further development of soil, that is mineralisation and humification, mainly the biological agents are involved.

During the early stages of soil formation, organic matter in the soil is not very high, as the vegetation and the soil fauna are not much developed. In such soils, algae, lichens, mosses, and other small form of plants grow and contribute organic matter through their death and decay. In due course of time, various types of plants, animals and microorganisms colonise such soils. They also contribute organic matter to the soil, in the form of wastes or their dead remains. This organic debris then break down into simpler products. This breakdown process, also known as decomposition, is brought about by different kinds of microorganisms such as bacteria and fungi. They break the organic substances into various compounds such as polysaccharides, proteins, fats, lignins, waxes, resins and their derivatives. These compounds are further broken down into simple products such as carbon dioxide, water and minerals. This latter process is called mineralisation. The residual, incompletely decomposed organic matter left after mineralisation is called **humus** and the process of its formation as humification. Humus is an amorphous, colloidal and dark substance that is the source of energy and nutrients for most soil microorganisms. Humus is important, as it gives the soil a loose texture ensuring better aeration. Being colloidal in nature, it has a great capacity for imbibing and retaining water and nutrients. Humus greatly improves the soil fertility.

4.4.2 Changes Caused by Agriculture and Overgrazing

The changes in environment caused by man through his agro-pastoral activities can be divided into two types for the sake of simplicity: (a) changes brought about by traditional agriculture; (b) changes brought about by modern agriculture. The characteristics of traditional agriculture include defacement of land, deforestation coupled with loss of soil structure, soil erosion and depletion of soil nutrients. Overgrazing, is also a bye-product of efforts to exploit the land resources for maximum livestock production. While modern

agriculture continues to share the disruptive effects of traditional agriculture on environment. It also affects certain changes in environment characteristic only of modem agricultural practices. For example, excessive irrigation causes twin problems of salinisation and water logging resulting from rise in water table apart from causing depletion of ground water resources. Similarly, addition of chemical fertilisers increases the rate of depletion of micronutrients from soils and eutrophication of water bodies and nitrosoamenia in children. The use of plant protection chemicals poisons the food products and sometimes kills non-target friendly organisms. Likewise, use of high yielding varieties makes the agriculture market-oriented, encourages monoculture causing eruption of epidemics and depletion of genetic diversity.

4.4.3 Land Degradation

Land degradation refers to the process of deterioration in the quality of land (Fig.4.10). In a general way, it has been defined as a reduction in the capacity of the soil to produce in terms of quality, quantity, goods and services. Human activities which result in land degradation include **deforestation, farming, damming of rivers, industrialisation, mining, developmental works such as human settlements, roads and highways, and networks for transport and communication.**

Fig.4.10: Land degradation due to agricultural mismanagement and deforestation.

Natural disasters, such as droughts, floods, landslides and earthquakes also contribute to land degradation. Land use has undergone tremendous change as human societies evolved through the ages. However, in the pre-industrial era, nature's restorative ability could take care of these changes. In recent times, the over exploitative use of land and soil degradation have assumed alarming proportions. Table 4.2 gives the extent and causes of major land degradation in the world.

Table 4.2: Extent and causes of land degradation of the world

Extent of Degradation	Causes of land degradation
580 million ha	**Deforestation**-Vast reserves of forests have been degraded by large scale logging and clearance for farm and urban use. More than 200 million ha of tropical forests were destroyed during 1975-1990, mainly for food production.
680 million ha	**Overgrazing** – About 20 per cent of the world's pasture and rangelands have been damaged. Recent losses have been most severe in Africa and Asia.
137 million ha	**Fuel wood consumption** – About 1730 million m^3 of fuel wood is harvested annually from fomrests and plantations.
550 million ha	**Agricultural mismanagement** – Loss of soil due to water erosion is estimated at 25,000 million tonnes annually. Soil salinization, water logging, chemical degradation and desertification affect about 40 million ha of land globally.
19.5 million ha	**Industrialization and urbanization** – Urban growth, road construction, mining and industry are major factors in land degradation in different regions. Valuable agricultural land is often lost.

Source: FAO, 1996

Land and Soil

Environmental degradation has not only led to lowering of water tables but also to land degradation, soil erosion, and desertification. Table 4.3 gives the worldwide statistics for land use. Notice that only about 10 per cent of the world's land area is arable (able to be tilled for crops) or under permanent crops such as orchards, plantations or vineyards. The remaining area is too steep, too cold, too hot, too wet, or too dry for cultivation.

Table 4.3: World land use, 1972 and 1987.

Land Use	World Area (1000 ha)	
	1972	1987
Total area	13,389,001	13,389,055
Land area	13,073,849	13,076,536
Arable and permanent crops	1,413,990	1,473,699
arable	1,322,797	1,373,200

Permanent crops	91,193	100,499
Permanent pasture	3,226,013	3,214,352
Forest and woodland	4,195,500	4,068,536
Other land	4,238,344	4,519,949

Source: Food and Agriculture Organization, *Production Yearbook 1989*, vol. 42, Statistics Series 88, Rome.

In India, between 30 and 50 per cent of private and common land is estimated to be ecologically degraded to varying degrees and is generally referred to as "wasteland", that is land not producing its potential of biomass due to ecological degradation, over exploitation or the absence of a clear management system.

Wasteland development involves *regenerating the land through a variety of soil and water management practices, planting appropriate plant species, protecting them and sharing the benefits*.

The following programmes are being implemented currently as part of the national effort towards wasteland development:

- Integrated Wastelands Development Project (IWDP) schemes
- Technology development extension and training scheme
- Support to NGOs/Voluntary agencies (grant-in-aid) scheme
- Investment promotional schemes (IPS)
- Wastelands development task force (WDTF)

The Society of Promotion of Wasteland Development (SPWD) has undertaken Charagah development in Rajasthan as one of its major activities. Charagahs are common lands allotted for cattle grazing in a village. In dry land areas like Rajasthan, the role of common lands is crucial in the maintenance of cattle population. Small farmers depend on Charagahs as fodder availability on their own lands is poor especially in the months when no fodder is available at all. Thus, the development of Charagahs assumes importance. The following experiences reflect a measure of success in development of wasteland through voluntary effort supported by government agencies.

Box 4.4 : The Case of Prayatna Samiti

Prayatna Samiti is an NGO involved in regenerating forestland and panchayat lands in villages of Gudli-Bambora region of Girwa block in Udaipur district, Rajasthan. Its work on Charagah protection was started by constructing cattle proof trenches/stone walls around the common land. Appropriate soil and water conservation measures and plantation were undertaken along with dibbling of seeds (grass and trees). The market value of grass produced in these Charagahs in four years was to the tune of Rs.32.5 lakhs. Apart from making fodder available, these efforts led to regeneration of local species and greatly reduced levels of soil erosion. More information about this effort can be obtained from

Source : http:/www.humanscapeindia.net/humanscape/new/june02/thecostof.html.

Box 4.5: The Case of Hanuman Van Vikas Samiti

The Society for Promotion of Wastelands Development works with Hanuman Van Vikas Samiti in Tonk village of Udaipur district since 1994. Due to soapstone mining in the charagah land by local residents, it was badly degraded. In addition, a major portion of the land was encroached upon by some influential people. Meetings were held with the village community to create awareness, remove encroachment and to stop mining. Self-help groups formed by Hanuman Van Vikas Samiti played a vital role in facilitating community action. A charagah management committee was formed to manage this work. Financial support was provided for the **boundary wall, trench, pit digging, gully plugs/check dam, plantation, dibbling of grass and tree seeds**. The employment generated through these activities was to the tune of around 4,500 human days. In comparison, a similar period of soapstone mining would provide 2000 human days/year. Grass production from the charagah increased from 6 to 44 tonnes. The per family grass availability was 155 kg while the per animal availability was 27 kg during 2000-2001. An investment of Rs.3.77 lakh was made for the development of fifty hectares of land. Hence, the average cost per hectare with local contribution was Rs.7,540. At the prevailing rate of grass, its total value is estimated to be Rs.1.93 lakhs.

More information about this effort can be obtained from:

Source : http:/www.humanscapeindia.net/humanscape/new/june02/thecostof.html.

Soil is literally the material we live on. It is the material that supports what we build, treats our waste, and purifies our water. Use of soil for any purpose changes it - some of these changes may be good, many are not. Some of the severest challenges confronting agriculturists today are soil erosion, soil salinity, soil pollution and maintenance of soil fertility.

Soil Erosion is the process in which the top layers of soil are removed and carried away from one place to another by wind or water. In this process, mineral particles, organic matter, and nutrients from the soil are removed, reducing its thickness and water-holding capacity. Eroded soil may then become a pollutant in streams and reservoirs. The time required to form new soil is so long that from human viewpoint, soil lost through erosion is lost forever. A host of practices such as bunding, mulching and soil moisture conservation needs to be adopted at a large scale to prevent soil erosion.

One way of achieving and maintaining a fertile soil is to apply organic material in the form of green manures, straw or as manure which has already undergone a high degree of fermentation. This improves the cohesiveness of the soil, increases its water retention capacity and promotes a stable aggregate structure.

In arid and semi-arid regions, too much or too little irrigation can lead to an increase in soluble salts, rendering the soil **saline** or **alkaline** and thus

unfavourable for plant growth. As water evaporates from the soil, salts such as chlorides, sulfates, and bicarbonates of sodium, calcisum and magnesium accumulate in it. The most effective treatment of alkaline soils is to apply "gypsum". A good drainage system must also be provided to assist with washing out the sodium from saline soils. Only the most salt-tolerant species can be grown in areas with severe soil salinity.

4.4.4 Land Use Planning and Management

Land is an exhaustible resource and is very sensitive to changes in climate and physical processes. Land should be used according to its suitability and capability. As you have studied in earlier sections, suitability and capability of land is assessed in terms of its load bearing ability and fertility.

Since food for an increasing population requires more land for cultivation, the encroachment of fertile agricultural lands for non-agricultural purposes like construction of roads and buildings should be reduced to the minimum. Extreme care should be taken in selecting sites for development of industries, construction of dams and water reservoirs and mining so that the environment and socio-economic conditions of the people living in that area are not disturbed.

Hill areas, as far as possible, should be put under forest cover because forests serve as a resource for fuel, fodder, and timber, and provide space for animal farming (Fig. 4.11). Besides, forests help in increasing the ground water, since they impede the free surface run-off, thus allowing water to be absorbed by the ground. In this process, soil erosion is minimised and flooding can be avoided.

Fig. 4.11: An ideal land use in the hill region.

Let us see what are the essential components of land management.

Soil Management

As we have said before, soil is a precious resource which takes millions of years to form, and hence proper management of soil is very necessary. The management of the soil is two-fold i.e. (a) to minimise or check soil erosion and (b) restore productivity of the soil.

(a) (b) (c)

Fig. 4.12: a) Drainage system for preventing uncontrolled flow of water; b) & c) Check dams for preventing the flow of running water.

Control of soil erosion

The most significant measures for control of soil erosion are: growth of grasses, shrubs and trees on soils i.e; construction of a drainage system which can prevent free, uncontrolled flow of water (Fig. 4.12a). Water flow causes formation of narrow channels or gullies and leads to development of deep narrow valleys leading to ravine land. The famous Chambal ravines (Fig. 4.13) have been formed as a result of deep soil erosion and the process is still continuing. This can be controlled by constructing a series of check dams which prevent the flow of running water and widening of gullies (Fig. 4.12b & c). Formation of a broad wall of stone along the coasts of Maharashtra, Kerala, Andhra Pradesh and Odisha has proved to be very effective in controlling erosion by sea waves and currents. Movement of sand by gusts of wind in the deserts and sandy coasts can be prevented by putting barriers of trees and shrubs across the path of wind (Fig. 4.14). In the mountain and hilly areas, planting of stems and branches of self propagating trees and shrubs, not only strengthens the slope of the terrace but also provides fuel wood and fodder to the farmers.

Fig. 4.13: Chambal ravines.

Fig. 4.14: Checking movement of sand gust by erecting barriers of trees and shrubs.

On the vulnerable slopes, a cover of vegetation is provided and in the beginning, seeds are covered with coir netting pegged firmly to the ground (as shown in Fig. 4.15). Netting checks erosion, holds the soil material together and adds nutrients. The quick growth of grass stabilises the soil.

Fig. 4.15: Plantation of vegetation cover and brush wood or coir netting on the slopes of mountain.

Treatment of soil sickness

Due to overuse without rest, soil becomes deficient in the requisite nutrients and loses its fertility. Rotation of vegetables, such as peas and beans, helps to remove the deficiency of nutrients. Legume plants such as peas add nitrogen to the soil and thus increase its binding property as well as productivity. The roots and off-shoots of the crops and their remains are left in the field for a certain period of time to protect the soil from erosion.

It is found that excessive irrigation causes complete saturation or water logging of the soil, which consequently loses productivity, partially or

completely. As a result of over irrigation in some areas, salinity and alkalinity of the soil increases, making it "sick". This kind of soil sickness can be controlled by, first of all, sealing off all points of leakage canals, reservoirs, tanks and ponds, and use of only the required amount of water.

SAQ 2

Fill in the blanks with appropriate words and check your answer given in the end of this unit:

i) ……. forms the upper most layer of …….

ii) Mechanical forces acting upon the rocks cause physical …….

iii) ……. is a by-product of efforts to exploit the land resources for maximum ……. production.

iv) Land ……..…. refers to the process of deterioration in the quality of land.

v) ……. are common lands allotted for cattle grazing in a …….

vi) Land should be used according to its ……. and …….

vii) Excessive irrigation course complete ……. or water logging of the …….

4.5 SUMMARY

In this unit we have tried to view the natural resources land and water and principle of their management and conservation.

- Water is renewable resource whereas land is a non-renewable resource.
- Degradation in physical resources such as land and water results mainly due to exploitative activates of humans in the fields of agriculture, industry and urbanisation.
- Conservation in agriculture can be affected by changes in land use pattern, conservation of irrigation water, minimising use of pesticides and fertilisers and implementation of innovative and environmentally sound agricultural techniques.

4.6 TERMINAL QUESTIONS

1. What are renewable and non-renewable resources? Explain with the help of examples.
2. Discuss the various ways of water conservation.
3. Describe the essential components of land management.

4.7 ANSWERS

Self-Assessment Questions

1. i) Fresh water; ii) Earth; iii) Solvent, Salts; iv) Consumer;
   v) Flood, River; vi) Tribunal; vii) Several, Harvesting

2. i) Soil, Land; ii) Weathering; iii) overgrazing, Livestock; iv) Degradation

   v) Charagahs, Village; vi) Suitability, Capability; vii) Saturation, Soil

Terminal Questions

1. Refer to Section 4.2 for its answer.
2. Refer to Sub Section 4.3.6.
3. Refer to Section 4.4.4

4.8 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.
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3. Kaushik, A. 2nd Ed. (2004) *Environmental Studies*, New Delhi: New Age International (P) Limited.
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5. Wright, R. T. (2008) *Environmental Science: Towards a Sustainable Future* New Delhi: PHL Learning Private Ltd.

Acknowledgement

1. Fig. 4.4: Kuls in the Spiti area.

   (Source: <https://image.slidesharecdn.com/ traditionalwaterharvestinginindia1-130531120014-phpapp01/95 /traditional-water-harvesting-in-india-part-1-12-638.jpg?cb=1370002112>;

   Source: http://www.rainwaterharvesting.org/methods/traditional /kul2.jpg)

2. Fig. 4.9: Major Soil types of India.

   (Source: https://upload.wikimedia.org/wikipedia/commons/b/be/ Major_soil_types_in_India.jpg)

3. Fig. 4.10 Land degradation due to agricultural mismanagement and deforestation Source:https://en.wikipedia.org/wiki/Land_degradation#/media/ File:Karst_following_phosphate_mining_on_Nauru.jpg

4. Fig. 4.11: An ideal land use in the hill region.

   (Source: https://upload.wikimedia. org/wikipedia/commons/thumb/7/78/ 080110_zell_mosel.JPG/1200px-080110_zell_mosel.JPG)

5. Fig. 4.12: (a) Drainage system for preventing uncontrolled flow of water, (b) & (c) Check dams for preventing the flow of running water.

   (a) Source: https://pixabay.com/photos/white-water-cascade-flow-stream-983997/

   (b) Source:https://en.wikipedia.org/wiki/Manimuthar_Dam#/media/ File:Manimuthar_Dam_f.jpg

   (c) https://en.wikipedia.org/wiki/Dam#/media/ File:Lake_Parramatta,New_South_Wales.jpg

UNIT 5

FOREST RESOURCES

Structure

5.1 INTRODUCTION

In the previous unit, you have studied about land and water as resources. In the present unit we shall discuss about the forest as a resource. You must have read in your Social Sciences text book about the early humans who were basically wanderers in the forest. They used to derive food, clothing and shelter from the forest. Later on, human being started settled life by clearing forest. But, life was still highly dependent on forests in a symbiotic manner. After industrial revolution in 18th century, humans began to exploit forest in a ruthless manner without considering its negative impact on the earth and its environment.

In this unit, we will describe economic, ecological and socio-cultural significance of forest as a resource in section 5.2. In section 5.3, explanation for various causes and consequences of deforestation are presented followed by some selected case studies in section 5.4 and 5.5. In the final section i.e. Section 5.6, methods of conservation and management of forest resources are being described.

Expected Learning Outcomes

After studying this unit you will be able to:

- describe significance of forest as a resource;
- explain various causes and consequences of deforestation;
- analyse impact of mining, dam building and other developmental activities on environment, forest and biodiversity;
- highlight the impact of mining and dam building and other developmental activities on forested People and their rights through various case studies; and
- describe various methods of conservation and management of forest resources.

5.2 FOREST AS A RESOURCE

Forests are our treasures which provide us a wide variety of commodities such as timber, fuel wood, fodder, fibre, fruits, herbal drugs, cosmetics and many types of raw materials used by the industries. A great variety of mammals and birds which live in the forests, serve as useful living resources (Fig. 5.1). Forests play a great role in soil formation, water conservation and regenerating of oxygen. Trees fix CO_2 in their biomass and through transpiration (loss of moisture to atmosphere) they moderate the climate. Can you imagine what would happen if forest does not exist in the world. As mentioned above, it performs certain functions which can be directly observed. But there are certain functions which cannot be directly observed like purification of air, carbon sink etc.

Fig. 5.1: Forest Supports many Forms of Life. a) A Nilgai Antelope Calf; b) Elephant Feeding on Yellow-bark Acacia Tree.

Broadly, all the above mentioned functions performed by the forest can be categorised under three major headings: economic, ecological and social.

i) Economic Significance

Forest is one of the largest available renewable resources on the planet earth. It provides a wide variety of goods and services which include food, fodder and fuel. Wood is used for making houses, furniture, matches, ploughs, bridges and boats. Forest products such as tannins, gums, spices, waxes, honey, musk, and hides are all provided by the flora and fauna of forests.Fruits, leaves, roots and tubers of plants form the food of forest tribes.Wood and bamboo pulp are used for manufacturing paper and rayon. The flora and fauna of the forest also holds the key to numerous life sustaining products such as pharmaceuticals, insecticides and pesticides. These substances should be harvested sustainably so that it could enhance the long term resource value of the forest.

ii) Ecological Significance:

As mentioned above forest performs certain function like moderation of global climate, supporting natural ecological systems and processes. Let us discuss them in detail:

a) **Moderation of global climate:** Forests stabilise global climate in a significant manner by influencing natural cycles such as hydrological and carbon cycles. You might have read about these cycles when you were in school. As you know, spatial as well as temporal patterns of rainfall are greatly influenced by forest. How much of water is retained in the soil, and how much flows away, sometime causing floods, also depends on tree cover. Similarly forest can also influence the atmospheric carbon dioxide level. Tree biomass holds carbon dioxide in a fixed state. Therefore, forest acts as a major source of carbon sink i.e. ability to absorb carbon dioxide from the atmosphere.In other words, a carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. When wood is burnt CO_2 is released in the atmosphere. This has a direct impact on the extent of greenhouse effect and global warming. In other words, more forests lead to greater removal of atmospheric carbon dioxide during photosynthesis resulting reduction of the greenhouse gases in the atmosphere. Therefore, large-scale afforestation has been adopted as a measure to reduce greenhouse effect.

b) **Protection of biodiversity:**Forests are the greatest repository of biodiversity on the land as they provide ideal conditions for the survival and growth of living organisms. The number of species per unit area is much greater in a forest than in any other terrestrial ecosystem. For example, the tropical rainforest covers less than 7% of the earth's land surface but accounts for more than 50% of all known species. About 62% of all known plants are found in these rainforests. That is why there has been a growing campaign for saving the rain forest in Amazon and Nile basin. The growing awareness about the importance and necessity to conserve biodiversity is helping human being to realise the significance of forest. Do you think this awareness or campaign is sufficient to protect rain forest? Think about it? We will discuss some of the conservation measures in the last section of this unit.

c) **Supporting natural ecological systems and processes:** As mentioned earlier forests perform certain activities which are crucial for supporting ecological systems and processes directly. Some of these functions and processes are as follows:

- Forests check the soil erosion by preventing the action of winds and water thereby preserves the fertile top soil.
- It prevents landslides and reduces the intensity of cyclones and floods.
- By preventing soil erosion, forests reduce silting of water bodies including reservoirs.
- Forest improves air quality by absorbing toxic gases and particulate matter.
- It protect watersheds and ensure perennial supplies of fresh water.

iii) **Socio-cultural significance:** As mentioned in the introduction, forests have been part of our social and cultural ethos since the inception of civilization. We find signs of such cultural bonds even in today's modern and materialistic life. This is largely because forests have significant aesthetic, recreational and spiritual value.

I am sure, till now, you must have realised the importance of forest as a resource. You might be reading in the newspapers or might have watched in the television about clearing of forests for urbanisation, mining, establishing industries, construction of dams, railway lines, roads etc. Do you know rate of deforestation is so high the world over that it has started affecting our life. In the following section we will discuss about extent, causes and consequences of deforestation.

SAQ 1

Answer the below given question within 30 words.

i) How does the forest act as a carbon sink?

ii) State any three socio-cultural significance of forest.

5.3 DEFORESTATION: CAUSES AND CONSEQUENCES

Deforestation refers to the permanent removal or destruction of indigenous forests. Today, it has been roughly estimated that the indigenous forest cover constitutes 21% of the earth's land surface. According to the World Resources Institute, deforestation is regarded as one of the world's most pressing land-use problems. Another major concern is the rate at which deforestation is occurring. Currently, 12 million hectares of forests are cleared annually. Almost all of this deforestation occurs in the moist forests and open woodlands of the tropics. It has been predicted that if deforestation continues at this rate then all the moist tropical forest could be lost by the year 2050, except for isolated areas in the Amazon and the Zaire basin, as well as a few protected areas within reserves and parks.

In India, forests cover 24.39 percent of the total geographical area. However, it is assessed that the country needs 33% of its area under forests to meet the ecological and economic needs.

5.3.1 Causes of Deforestation

Let us discuss some of the major causes of deforestation all ouer the world in general and India In specitic.

i. **Population Explosion:**Increasing human population is one of the major causes of deforestation. It poses a major threat to the environment. Vast areas of forest land are cleared (Fig. 5.2) to reclaim land for expansion of farming land, mining activities, creation of new and expansion of existing

human settlements, and development of infrastructure like roads and railway tracks. Growth of population increases the demand for forest products like timber, firewood, paper and other valuable products of importance, all necessitating felling of trees.

ii. **Forest Fires:** This is also another major cause of deforestation. Forest fires occur either naturally or are human induced. Some of the major causes of forest fires are as follows:

Fig. 5.2: Logging operation in the forest .

- Dry humus and organic matter forming a thick cover over the forest floor provides ideal condition for ground or carelessly surface fires.Throwing burning cigarette stubbs on dried foliage can light a fire.
- Crown fire takes place in densely populated forests where tree tops may catch fire by heat produced by the constant rubbing against each other.

Fire destroys fully grown trees, results in killing and scorching of the seeds, humus, ground flora and animal life.

iii) **Grazing of Animals:** Trampling of the forest soil in the course of overgrazing by livestock has far reaching effects such as loss of porosity of soil, soil erosion and desertification reduced productivity of the previously fertile forest area.

iv) **Pest Attacks:** Pests destroy trees by eating up the leaves, boring into shoots and by spreading diseases.

5.3.2 Consequences of Deforestation

Forests are closely related with climate, biological diversity, wild animals, crops and medicinal plants. Large scale deforestation has far-reaching consequences:

i) Habitat destruction of wild animals. Tree-using animals are deprived of food and shelter.

ii) Increased soil erosion due to reduction of vegetation cover.

iii) Reduction in the oxygen liberated by plants through photosynthesis.

iv) Increase in pollution due to burning of wood and due to reduction in carbon dioxide fixation by plants.

v) Decrease in availability of forest products.

vi) Loss of plant, animal and microbial diversity.

vii) Scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests.

viii) Lowering of the water table due to more run-off, and resultant increased use of the underground water.

ix) Rise in carbon dioxide level in the air due to burning of vegetation has caused global warming resulting in melting of ice caps and glaciers and consequent flooding of coastal areas.

SAQ 2

Fill in the blanks with appropriate words

i) In India, forests cover _____ percentages of the total geographical area but the country needs _____ percentages of its area under forests to meet the ecological and economic needs.

ii) _____ fire takes place in densely populated forests.

iii) Deforestation leads to reduction in the _____ liberated by plants through _____

5.4 IMPACT OF MINING AND DAM BUILDING ON ENVIRONMENT, FOREST AND BIODIVERSITY

Timber extraction, mining and construction of dams are invariably parts of the needs of a developing country like India. Unfortunately forests are located in areas where there are rich mineral resources. Mineral based industries like iron and steel, aluminia refinaries etc. are also located in these areas. Out of the top mineral producing districts in the country, almost half of the districts are predominantly tribal dominated. The average forest cover in these districts

is 28 per cent, much more than the national average of 20.9 per cent (Centre for Science and Environment, 2008). Forests also cover the steep embankments of river valleys, which are ideally suited to develop hydel and irrigation projects. Thus, there is a constant conflict of interest between conservation and development. What needs to be understood is that long-term ecological gains cannot be sacrificed for short-term economic gains that unfortunately lead to deforestation. These forests where development projects are planned can displace thousands of tribal people who lose their homes when these plans are executed.

Floods, droughts and landslides become more prevalent in such areas. Forests are the repositories of invaluable gifts of nature in the form of biodiversity and by destroying them, we are going to lose these species even before knowing their significance as well as benefits. These species could be having marvellous economic or medicinal value and deforestation results in loss of this storehouse of species which have evolved over millions of years in a single stroke.

5.5 EFFECT ON TRIBAL POPULATION AND THEIR RIGHTS

Poverty amidst plenty, nature is bountiful but tribals are poor. This statement explains the conditions of majority of tribal population in our country. Tribal dominated areas of the country have rich forest cover, mineral bearing areas, and significant number of watersheds of key rivers. Forest provides food, medicine and other products needed for tribal people and plays a vital role in the life and economy of tribes living in the forest. As mentioned in the previous section, due to developmental activities like construction of dams, mining, establishment of mineral based industries etc. alienated tribal people from their own land. This alienation deprived them from their livelihoods. Most of them are dependent upon natural resources based informal economy. Their natural resource based informal economy is mostly dependant on agriculture, both settled and jhum and on the other non-timber forest product (NTFP) such as medicinal herbs, edible flowers, leaves and fruits. They also get their small timber and firewood from the forest.

Hence development is bound to affect their agricultural and forest land which is the primary source of their livelihood. The development process pushes them from an informal to a formal economy that is new to them without any preparation. They had depended on agricultural land and forests, both of which they loose to the project. When they receive compensation it is monetary with which most communities living in the informal economy are nor familiar. As mentioned above in most cases the Common Property Resources are not compensated. Therefore, there was a need to address these problems. Government of India passed an act in the Parliament titled ‘The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006’ to address this anomaly (See Box 5.1).

Boc 5.1 : The Scheduled Tribes and Other Traditional Forest Dwellers Act, 2006

An Act to recognize and vest the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been residing in such forests for generations but whose rights could not be recorded; to provide for a framework for recording the forest rights so vested and the nature of evidence required for such recognition and vesting in respect of forest land.

And whereas, the recognised rights of the forest dwelling Scheduled Tribes and other traditional forest dwellers include the responsibilities and authority for sustainable use, conservation of biodiversity and maintenance of ecological balance and thereby strengthening the conservation regime of the forests while ensuring livelihood and food security of the forest dwellings Scheduled Tribes and other traditional forest dwellers;

And whereas, the forest rights on ancestral lands and their habitat were not adequately recognised in the consolidation of state forests during the colonial period as well as in independent India resulting in historical injustice to the forest dwelling Scheduled Tribes and other traditional forest dwellers who are integral to the very survival and sustainability of the forest ecosystem.

And wherea, it has become necessary to address the long standing insecurity of tenurial and access rights of forest dwelling Scheduled Tribes and other traditional forest dwellers including those who were forced to relocate their dwelling due to state development interventions.

Source : https://indiacode.nic.in/bitstrean/123456789/2070/1/A/2007-02.pdf

SAQ 3

Answer the below given question within 30 words.

i) Name any four non-timber based forest product (NTFP).

ii) How do Forest Right Act 2006 enable tribals and other forest dwellers in strengthening the con servation of the forests while ensuring the livelihood and food security?

5.6 CONSERVATION AND MANAGEMENT OF FOREST RESOURCES

As a result of increased exploitation of forests for timber, firewood and other forest products, without putting in adequate efforts to regenerate them, the forests are known to be fast disappearing. This has caused an environmental imbalance. For example, most of the rainwater is lost as runoff which flows over the mountain slopes unchecked often causing floods. The excessive washing away of top soil results in low fertility and reduces crop yields. It is because of these consequences

of deforestation, a strong forest policy has been adopted by our Indian Government to protect forests and to plant more trees. Some of the conservation measures practiced in India and other parts of the world are as follows:

i) **Increase in area of forest plantation:** The Tree plantation can be raised in vacant or unused lands and waste, degraded and marginal lands, especially on road side, along railway tracts, on contours and on land not suited for agricultural production. Planting trees outside forest areas will reduce pressure on forests for timber, fodder and fuel wood. Apart from this, the deforested areas need to be reforested.

ii) **Developing alternative sources and promoting the substitutes:** It has become necessary to find alternative fuels as well as raw materials to manufacture paper, sports goods, packing cases, furniture and beams used in buildings. Research is going on to develop alternate sources; in some cases, plastics and composite materials have been successful in replacing the use of timber.

iii) **Increase the area of forest permanently reserved for timber production:** The most serious impediment to sustainable forest management is the lack of dedicated forests specifically set aside for timber production. If the forest does not have a dedicated long-term tenure for timber production then there is no incentive to care for the long-term interests of the forest. FAO (2001) found that 89 per cent of forests in industrialized countries were under some form of management but only about six per cent were in developing countries. If 20 per cent could be set aside, not only could timber demand be sustainably met but buffer zones could be established to consolidate the protected areas.

iv) **Adoption and promotion of sustainable management of forest:** Achieving ecological sustainability means that the ecological values of the forest must not be degraded and if possible they should be improved. This means that **silviculture** and management should not reduce biodiversity, soil erosion should be controlled, soil fertility should not be lost, water quality on and off site should be maintained and that forest health and vitality should be safeguarded. However, management for environmental services alone is not economically and socially sustainable. It will not happen until or unless the developing nations have reached a stage of development and affluence so that they can accommodate the costs of doing so. There are vast areas of unused land some of which is degraded and of low fertility. Technological advances are being made to bring this land back into production. This should be a major priority since a significant proportion of cleared tropical forest will eventually end up as degraded land of low fertility.

v) **Developing a reliable mechanism of information base and regular monitoring**: Knowledge of how much forest, where it is and what it is comprised of seems to be straightforward. However, surprisingly, this most basic information is not always available. It is not possible to properly manage a forest ecosystem without first understanding it. Remote sensing technologies make it feasible and affordable to identify hotspots of deforestation. The international

community could undertake monitoring efforts that would have immediate payoffs. A priority is to fund and coordinate basic monitoring on the rate, location and causes of global deforestation and forest poverty along with the impacts of project and policy interventions.

vi) Establishing an effective system of fighting forest fires:

vii) Strictly enforcing laws to deal with unauthorized cutting of trees.

viii) **Promoting agro-forestry and social forestry**: Rural people partly meet their needs for fire wood and small timber by growing fast growing trees planted within the limits of their village, along the footpaths, roadsides, alongside railway tracks, side roads or canals and streams, boundaries of fields and empty spaces. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements of local people.

ix) **Participatory forest management and rights:** All stakeholders with an interest in the fate of the forest should be involved in planning, management and benefit sharing. The balance of rights can be tilted strongly toward society in the form of publicly owned strictly protected areas. State ownership and management can be retained but with sustainable timber extraction allowed. As of now much of the world's tropical forest are state owned but community participation in forest ownership and management needs to be encouraged. Land reform is essential in order to address the problem of deforestation. However an enduring shift in favour of the peasants is also needed for such reforms to endure. Moreover the rights of indigenous forest dwellers and others who depend on intact forests must be upheld. Therefore, the recognition of traditional laws of the indigenous peoples as indigenous rights will address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use while ensuring conservation of forest resources. Keeping this in view various state Govenment in India has been implementating Joint Forest Management Programme after successful implementation in West Bengal and Haryana in 1970's.

Box 5.2 : Joint Forest Management

The need to include local communities in Forest Management has become a growing concern. Local people will only support greening an area if they can see some economic benefit from conservation. An informal arrangement between local communities and the Forest Department began in 1972, in Midnapore District of West Bengal. JFM has now evolved into a formal agreement which identifies and respects the local community's rights and benefits that they need from forest resources. Under JFM schemes, Forest Protection Committees from local community members are formed. They participate in restoring green cover and protect the area from being over exploited.

Fig. 5.3: Planting pine trees on the steep slopes of mountains.

SAQ 4

Answer the below given question within 30 words.

i) How can we address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use?

ii) What is the aim of social forestry?

5.7 SUMMARY

- Functions performed by the forest as a resource can be categorised under three major headings: economic, ecological and social. Ecological functions include stabilising global climate, protect biodiversity and support global ecological system and processes. Forest has also socio-cultural significance in terms of providing ethical, spiritual, recreational and tourist value.
- There are various causes responsible for deforestation. Some of the immediate or explicit causes are logging for wood, land use and land cover change, forest fire and pest attack. Indirect or implicit cause is increasing population.
- Large scale deforestation has far-reaching consequences namely habitat destruction of wild animals and deprivation of food and shelter for tree-using animals; Increased soil erosion; reduction in the oxygen liberated by plants through photosynthesis; increase in pollution due to burning of wood and due to reduction in carbon dioxide fixation by plants; decrease in availability of forest products; loss of plant, animal and microbial diversity; scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests; lowering of the water table due to more run-off, and resultant increased use of the underground water and rise in carbon dioxide level in the air due to burning of vegetation has caused global warming resulting in melting of ice caps and glaciers and consequent flooding of coastal areas.

- There is a constant conflict of interest's between conservation and development. What needs to be understood is that long-term ecological gains can not be sacrificed for short-term economic gains that unfortunately lead to deforestation.
- Developing alternative sources and promoting the substitutes, application of scientific methods, monitoring and management of growth of forests, establishing a system for controlling and preventing forest fire and by strictly implementing forest laws we can conserve our forest resources.

5.8 TERMINAL QUESTIONS

1. Describe the three major functions of forest as a resource.
2. Name the four major causes of deforestation.
3. State any five consequences of deforestation.
4. Why is there a constant conflict of inlerest between conservation and development? Explain with suitable examples.
5. Explain any five conservation measures for forest resources in India.

5.9 ANSWERS

Self-Assessment Questions

1. i. A carbon sink is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.
   ii. Aesthetic, recreational and spititual value
2. i. 24, 33 percentages
   ii. Crown
   iii. Oxygen, photosynthesis
3. i. Medicinal herbs, edible flowers, leaves and fruits
   ii. The recognised rights of the forest dewelling Scheduled Tribes and ofther traditional forest dwellers include the responsibilities and authority for sustainable use, conservation of biodiversity and maintenance of ecological balance and thereby strengthening the conservation regime of the forests while ensuring livelihood and for security.
4. i. Recognition of traditional laws of the indigenous peoples as indigenous rights.
   ii. The aim of social forestry is to meet the needs of fuel, fodder, fruits, timber and other requirements.

Terminal Questions

1. The three major functions of forest as a resource are economic, ecological and socio-cultural. Explain the three functions in detail with suitable examples. Refer Section 5.2
2. Four major causes of deforestation are : population explosion, forest fires, grazing of animals and pest attacks. Describe the four major causes in detail with suitable examples. Refer Section 5.3
3. Consequences of deforestation are habitat destruction of wild animals, increased soil erosion, reduction in the oxygen liberated by plants, increase in pollution, decrease in availability of forest products, loss of plant, animal and microbial diversity, scarcity of fuel wood and deterioration in economy and quality of life of people residing near forests, lowering of the water table and rise in carbon-di-oxide level in the air (any five)
4. Timber extraction, mining and construction of dams are invariably parts of the needs of a developing country like India. Unfortunately, forests are located in areas where there are rich mineral resources. Mineral based industries like iron and steel, alumina refineries etc. are also located in these areas. Out of the top 50 mineral producing districts in the country, almost half of the districts are predominantly tribal dominated. Forests also cover the steep embankments of river valleys which are ideally suited to develop hydel and irrigation projects.
5. Conservation measures adopted for forest resources in India are developing alternative sources and promoting the substitutes; Increase in area of forest plantation; increase the area of forest permanently reserved for timber production; adoption and promotion of sustainable management of forest; developing a reliable mechanism of information base and regular monitoring; establishing an effective system of fighting forest fires; strictly enforcing laws to deal with unauthorized cutting of trees; promoting agro forestry and social forestry; and participatory forest management and rights.

5.10 FURTHER READING

1. Bharucha, E. (2005) *Textbook of Environmental Studies for Undergraduate Courses,* Hyderabad: Universities Press (India) Private Limited.
2. Botkin, D. B. & Keler, E. A. 8th Ed. (2011) *Environmental Science: Earth as a Living Planet*, New Delhi: Wiley India Pvt. Ltd.
3. Centre for Science and Environment (2004) Rich Land and Poor People, New Delhi: Centre for Science and Environement.
4. Rajagopalan, R. 3rd Ed. (2015) *Environmental Studies*, New Delhi: Oxford University Press.
5. Wright, R. T. (2008) *Environmental Science: Towards a Sustainable Future,* New Delhi: PHL Learning Private Ltd.

Acknowledgement

Fig. 5.1: Forest supports many forms of life a) A Nilgai antelop calf; b) Elephant feeding on yellow bark Acacia tree

Source :

a) https://thefarmatwalnutcreek.com/deer-elk-nilgai-html

b) https://www.countrylife.co.za/conservation/elephant-survivors-damaraland

Fig. 5.2: Logging operations in the forest

Source: https://en.wikipedia.org/wiki/File:Logging Operation on BLSF.jpg

Fig. 5.3: Planting pine trees on the steep slopes of mountains

Source: https://www.denbow.com/wp-content/uploads/2016/10/steep-slopes-1000.jpg

UNIT 6

BIODIVERSITY: VALUE AND SERVICES

Structure

6.1 INTRODUCTION

The earth's biodiversity has taken more than 3000 million years to evolve, and today, it forms the basis for survival of the human species and other life forms on our planet. When we speak of global biodiversity we speak of the totality of genetic strains, species and ecosystems in the entire world.

Many of these ecosystems coexist in larger units called biogeographic regions. W.A. Rodgers and H.S. Panwar of the Wildlife Institute of India grouped India's natural habitats into 10 major biogeographic zones. The climate and biodiversity of ten zones are discussed in this unit. Endangered and endemic species of these zones are also mentioned.

Global biodiversity hot spots, including those in India, which is a megabiodiverse country are also discussed in this Unit.

One way would be to understand the "resource" or "use" value of various components of biodiversity which are used by humans. Biodiversity has also, however, great "non-resource" or "non-use" value such as maintaining ecosystem functions.

Expected Learning Outcomes

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

- define biodiversity;
- explain different levels of biodiversity i.e. genetic diversity, species diversity, ecosystem diversity;
- enumerate and analyse the wild life species that occur in the different biogeographic zones of India;
- list global biodiversity hot spots and reasons for varied biodiversity in different ecosystems/countries and discuss the criteria for identifying global biodiversity hot spots; and
- explain the value of diversity in terms of direct vs. indirect use, extractive vs. non-extractive use and resource vs. non-resource use.

6.2 DEFINING BIODIVERSITY

Biodiversity is the diversity of and in living nature. Diversity, at its heart, implies the number of different kind of objects, such as species. However, defining biodiversity or measures of biodiversity is not so simple.

The 1992 Earth Summit in Rio de Janeiro defined biodiversity as:

The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

SAQ 1

Define biodiversity.

6.3 LEVELS OF BIODIVERSITY

There are three levels of diversity viz. **genetic**, **species** and **ecosystem** diversity. In effect, these levels cannot be separated. Each is important, interacting with and influencing the others. A change at one level can cause changes at the other levels.

6.3.1 Genetic Diversity

Genetic diversity is the “fundamental currency of diversity” that is responsible for variation. This is the diversity of basic units of hereditary information which are passed down generations found within a species (e.g. different varieties of the same species). Different varieties of mango or rice are examples of genetic diversity within species.

It is genetic diversity that allows a species to adapt to changing environmental conditions such as a lower rainfall, or a higher temperature year round.

6.3.2 Species Diversity

Species diversity means the differences between species (both domesticated and wild). It is the most visible component of biodiversity as implied by the word 'species' which literally means outward or visible form. This is why we often tend to describe biological diversity in terms of the number of species in a particular area or at the global level.

There are different estimates of extant (i.e. currently existing) species on earth which range from about five to 100 million, but a figure of about **12.5 million** is the most widely accepted. Of these, only about **1.7 million species have been described** as yet. In terms of sheer numbers alone, **insects and micro-organisms are the most abundant life forms on earth**. **(Box 6.1)**

Box 6.1: Known species of flora and fauna in the world

	4,500 species of mammals
	10,000 species of birds
	12,000 species of amphibians and reptiles
	22,000 species of fish
	400,000 species of invertebrates (excluding insects)
	960,000 species of insects, approximately 600,000 of which are beetles
	270,000 species of plants
	70,000 species of fungi
	4,000 species of bacteria
	5,000 species of viruses

6.3.3 Ecosystem Diversity

Ecosystem diversity means the variation between different types of ecosystems. Different species of animals, plants and micro-organisms interact with each other and their physical environment (such as water or minerals). Groups of organisms and their nonliving environment, and the interactions between them, form functional dynamic and complex units that are termed ecosystems. These systems help maintain life processes vital for organisms to survive on earth.

Species are not evenly distributed around the globe. Some ecosystems such as tropical rain forests and coral reefs are very complex and host a large number of species. Other ecosystems such as deserts and arctic regions have less biodiversity but are equally important.

It is believed that there is a positive relationship between species diversity and an ecosystem's stability and resilience (i.e. ability to resist disturbances).

An ecosystem having higher diversity means the number of species and interactions between them which constitute the food web, is large (Fig.6.1a). In such a situation, the elimination of one species would have little effect on ecosystem balance. In sharp contrast, the number of species in the food web of a simple ecosystem is small (Fig.6.1b). So loss of any one species has far more serious repercussions for the integrity of the ecosystem itself.

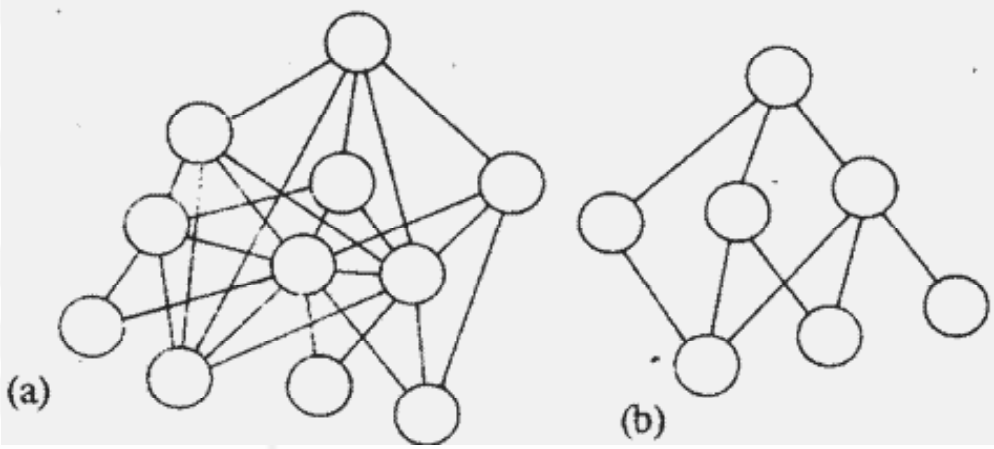


Fig. 6.1: The two illustrations give comparative picture of ecosystems with high: a) and low; b) species diversity. The circles represent. organisms. Note: The complex, linkage in (a) only a few links in (b). The increased numbers of links are believed to confer stability to the ecosystem.

SAQ 2

Differentiate between genetic and species diversity.

6.4 THE BIOGEOGRAPHIC ZONES OF INDIA AND THEIR BIODIVERSITY

The country has been divided into ten biogeographic zones: *Trans-Himalayas, Himalayas, Indian Desert, Semi-Arid, Western Ghats, Deccan Peninsula, Gangetic Plains, North-East India, Islands, and Coasts*. (Fig. 6.2). This

classification was developed at the Wildlife institute of India by Rodgers & Panwar (1988) and it is being largely followed. What are these biogeographic zones? These represent the major species groupings. In addition, each of these ten zones indicates a distinctive set of physical, climatic and historical conditions. The Himalayas and Gangetic Plains are examples of two adjacent but obviously extremely different zones.

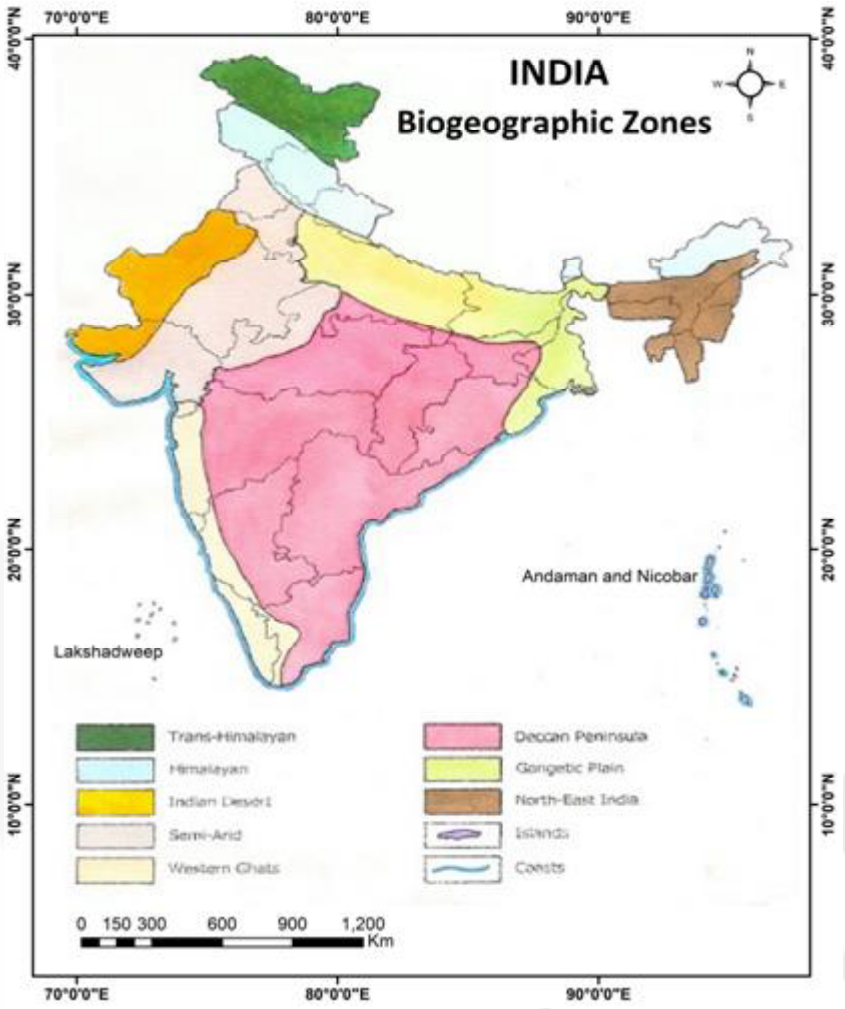


Fig.6.2: The biogeographic zones of India. From: W. A. Rodgers and H.S. Panwar, 1988. Planning a wildlife protected area network in India. Vol. 1, Department of Environment, Forests and Wildlife, Govt. of India.

6.4.1 Zone 1: The Trans-Himalayas

This zone has an area of about 1,86,200 sq. km and it covers mainly Ladakh and Lahul-Spiti. This zone is much more extensive than the area within India. Taking the topography into account, the area comes out to be around 2.6 million sq. km, with altitude between 4,500 and 6,000 m @mean sea level.

The Wildlife of the Trans-Himalayas Zone

This zone represents an extremely fragile ecosystem, because of its harsh climatic conditions and the inhospitable terrain.

The vegetation of Ladakh and Lahul-Spiti is largely a sparse alpine steppe. In addition, several endemic species also occur here. This area within India,

along with Pakistan and Tibet, has the richest wild sheep and goat communities in the whole world. There are eight distinct species and sub-species of sheep (Fig. 6.3 a-d).

The flatter plateaux have a distinct grazing community comprising of Wild Yak, Tibetan Ass, Tibetan Gazelle, Ibex and Tibetan Antelope (see Fig. 6.4 a-e). In addition to these herbivores, there is an equally distinctive set of carnivores including Snow Leopard, Indian Wolf, Pallas's Cat, Fox and smaller animals like Marbled Pole Cat, Pika and Marmot (see Fig. 6.5 a-d). Of these the Pallas's Cat is endemic to this area. The lakes and marshes too, have a distinctive avifauna including the spectacular Black-necked Crane, which is a migratory bird. Avifauna refers to the birds of an area collectively.

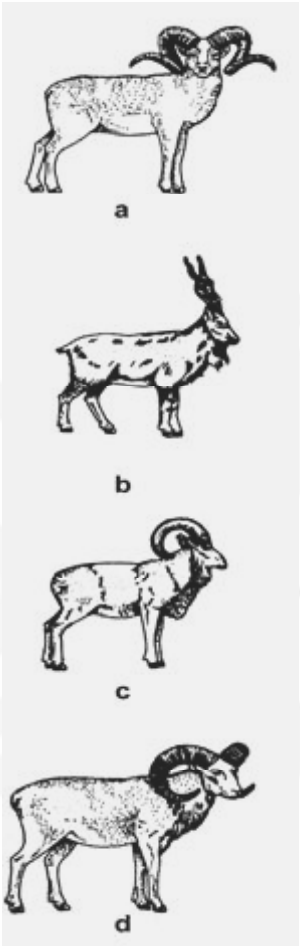


Fig. 6.3: Sheep species found in the Trans-Himalayan zone, a) Urial (*Ovis orientalis*); b) Nayan (*ovis ammon hodgsonii*); c) Marco polo (*Ovis ammon polii*); and d) Markhor (*Capra falconeri*).

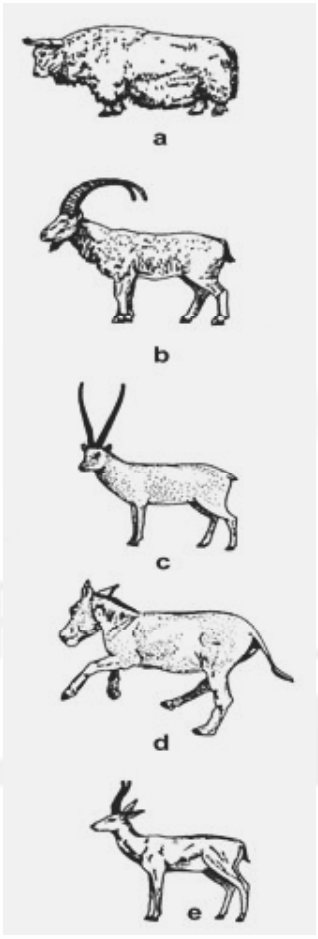


Fig. 6.4: Some herbivores of the trans-himalayan zone, a) Wild yak (*Bos grunniens*); b) Gazelle chinkara (*Gazella gazella*); c) Tibetan ass (*Equus hemionus*); d) Ibex (*Capra ibex*); and e) Tibetan antelope (*Pantholops hedgsoni*).

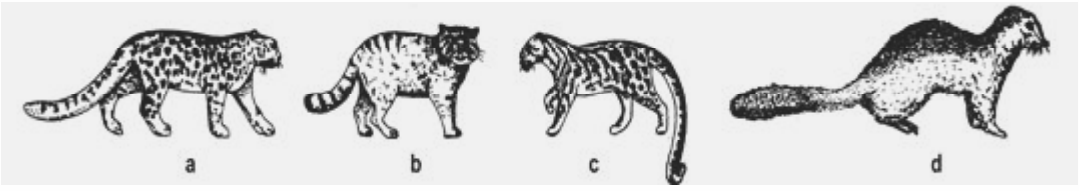


Fig. 6.5: Some carnivores of the trans-himalayan zone, Marmot (*Marmot caudate*).

6.4.2 Zone 2: The Himalayas

The Himalayan mountain ranges in India stretch for over 2,000 km from east to west.

The Wildlife of the Himalayan Zone

The Himalayan zone is one of the richest areas of India in terms of habitat and species diversity.

First let us look at the wildlife within the altitudinal and longitudinal range of Himalayas. These are:

i) The **lower sub-tropical foot-hills**. These have typical mixed deciduous community merging into Chir Pine (Fig. 6.6a) and then Ban Oak.

ii) The **temperate areas**. These lie below 3,500 m. This zone has a complex mixture of vegetation types with forests of Maples (Fig. 6.6b) and Walnuts, Moru and Oak (Fig. 6.6c), and a variety of conifers such as the Blue Pine, Fir and Spruce (Fig. 6.6d-g).

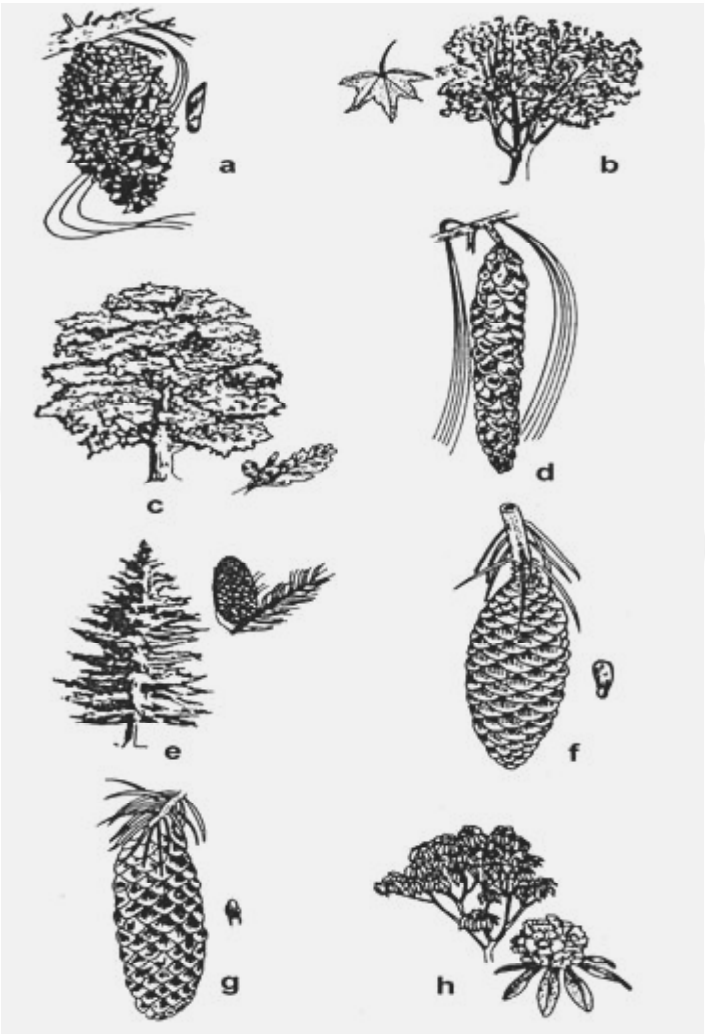


Fig. 6.6: Some representative members of the Himalayan vegetation, a) Chir pine (*Pinus roxburghii*) a cone; b) Maple (*Acer* sp.); c) Oak (*Quercus* sp.); d) Blue pine (*Pinus wallichiana*) a cone; e) Fir (*Abies* sp.). Tree and a cone; f) Spruce (*Pieea smithiana*) found in Western-Himalayas, a cone; g) Spruce (*Pieea spinulosa*) from Eastern Himalayas, a cone; h) Rhododendron (*Rhododendron* sp.)

iii) The **sub-alpine area**. This area has forest and scrub vegetation of Birch and Rhododendrons (Fig. 6.6h) interspersed with grasslands with several kinds of herbs.

iv) **The Western Zone**: This is a comparatively drier area with Deodars (Fig. 6.7) and Blue Pine.

v) **The Central Zone**: There is a poor representation of large herbivores. Ibex, Markhor and Hangul populations have dwindled significantly.

vi) **The Eastern Zone**: Mishmi Takin a herbivore, is found here (Fig. 6.8). This area has a higher tree line, and supports arboreal forest animals at higher altitudes.

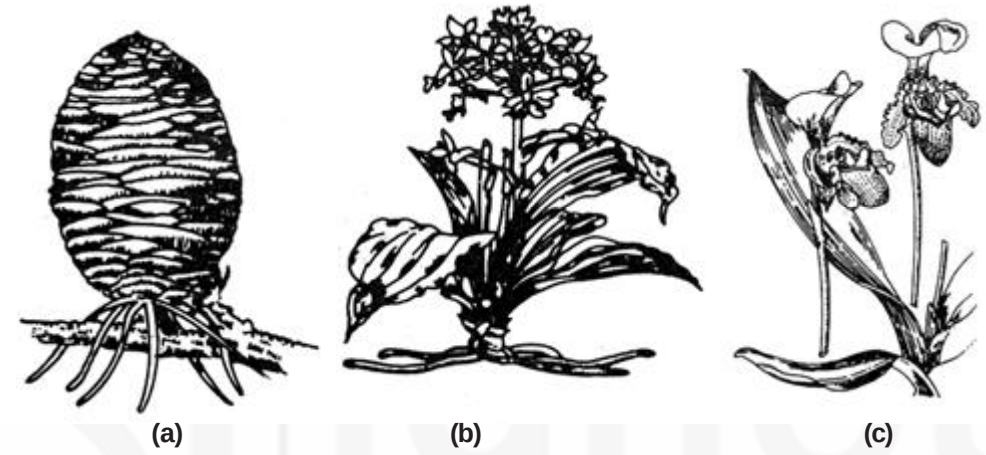


Fig. 6.7: Deodars, *Cedrus deodara* predominates the western zone of Himalayas, b,c) Orchids constitute characteristic vegetation of the Eastern Himalayan zone.

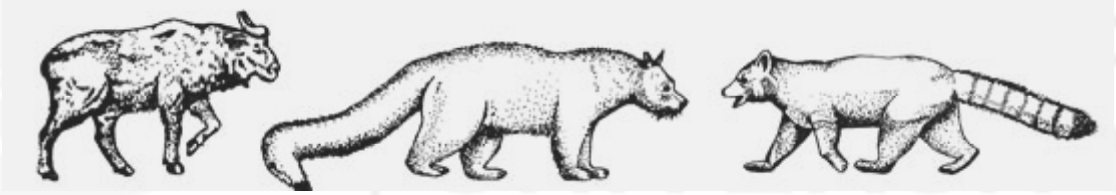


Fig. 6.8: Some animal species of the Eastern Himalaya, Takin (*Budorcas s.p.)*

Endemism is high in nearly all groups of plants and animals found here. In addition to the endemic species there are quite a few endangered species in high altitude region.

6.4.3 Zone 3: The Indian Desert

This zone is located in the western part of the country and is also known as the Thar desert. It covers west Gujarat and west Rajasthan. Parts of Punjab and Haryana were once a part of this desert, but the irrigated cultivation has changed the situation there.

The Wildlife of the Indian Desert

The wildlife of the desert zone is peculiar not because of its great diversity or density, but because of the extraordinary ecological adaptations to the desert

conditions. Several of the species are endemic to Thar Desert. Desert Fox, Desert Cat (Fig. 6.9a), Houbara Bustard and some Sand Grouse species are restricted only to the Thar area. *Prosopis cineraria, Salvadora oleoides* are common trees of Indian desert.

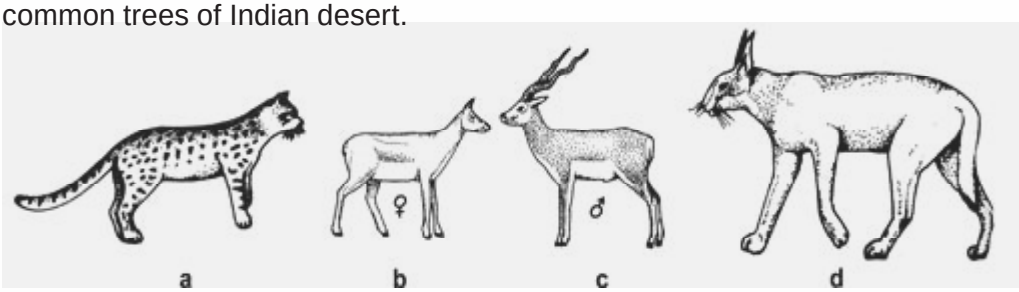


Fig. 6.9: Desert cat (*Felis libyca*).

6.4.4 Zone 4: The Semi-Arid

This zone with an area of 508,000 sq. km occupies 15% of the total area in our country. The presence of several grass species and palatable shrubs in these areas has made them a favourite of a vast number of wildlife species.

The Wildlife of the Semi-Arid Zone

This zone has strong biological links with western Asia, primarily with Pakistan, Iran, Middle-east and Northern Africa. Many of the plants found here show African affinity, e.g., *Acacia* sp. (see Fig. 6.10). The fauna consists of larger Lerbiveres-Blackbuck, Chowsingha, Gazelle and Nilgai. (Fig. 6.11)

Fig. 6.10: Plants of the semi-arid zone, *Acacia leucophloea (*Ronj).

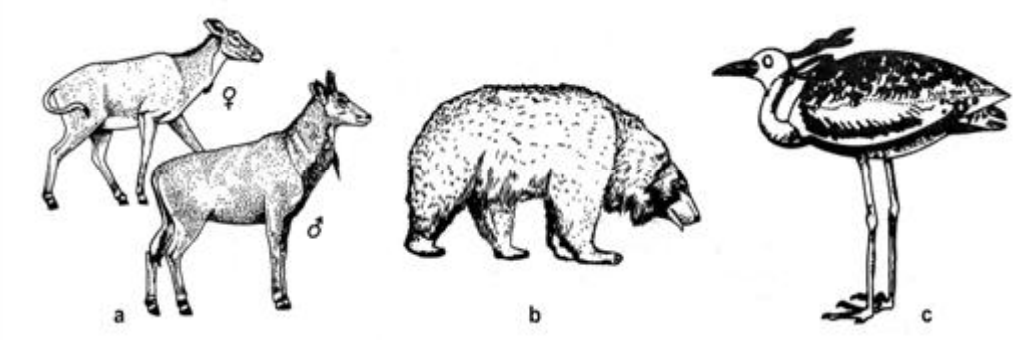


Fig. 6.11: Some faunal elements of the semi-arid zone, a) Nilgai (*Boselaphus tragocamelus*), female (♀) and male (♂) Sloth bear (*Malursus ursimus*), and c) Lesser florican (*Sypheotides indica*).

Fig. 6.12: A twig of *Myristica* along with a fruit.

6.4.5 Zone 5: The Western Ghats (Biodiversity Hot Spot)

The Western Ghats represent one of the major tropical evergreen forest regions in India. The total area of Western Ghats is about 160,000 sq. km. In the west, the zone is bound by the coast and in the east, it shares boundary with the Deccan peninsular zone. The tropical evergreen forests occupy about one third of the total area of this zone. In recent years, a large chunk of the forest cover has been lost and this zone is now of great conservation concern, more so because of its exceptional biological richness. About two-thirds of India's endemic plants are confined to this region. However, the potential of many of these species is yet to be tapped. Besides harbouring diverse biological communities, the forests in this zone also play an important role in maintaining the hydrological cycle.

The well known species found exclusively in Western Ghats include the following:

Among Primates – Nilgiri Langur and Lion-tailed Macaque (Fig.6.13b,c)

Rodents – Plataconthomys, the Spiny Dormouse

Squirrels – Several subspecies of *Ratufa indica* with separate forms in Maharashtra, Mysore, Malabar and Tamil Nadu Ghats. The Grizzled Squirrel is restricted to two localities in the drier Tamil Nadu forest.

Carnivores – Malabar Civet in southern evergreen forests, Rusty spotted Cat in northern deciduous forests.

Ungulates – Nilgiri Tahr (Fig. 6.13d) in Nilgiris to Agastyamalai montane grassland.

Hornbills – Malabar Grey Hornbill (Fig. 6.13e).

In addition to the above endemic species, the other species found are: Tiger, Leopard, Dhole (Fig. 6.13f), Sloth Bear, Indian Elephant and Gaur (Fig. 6.13g).

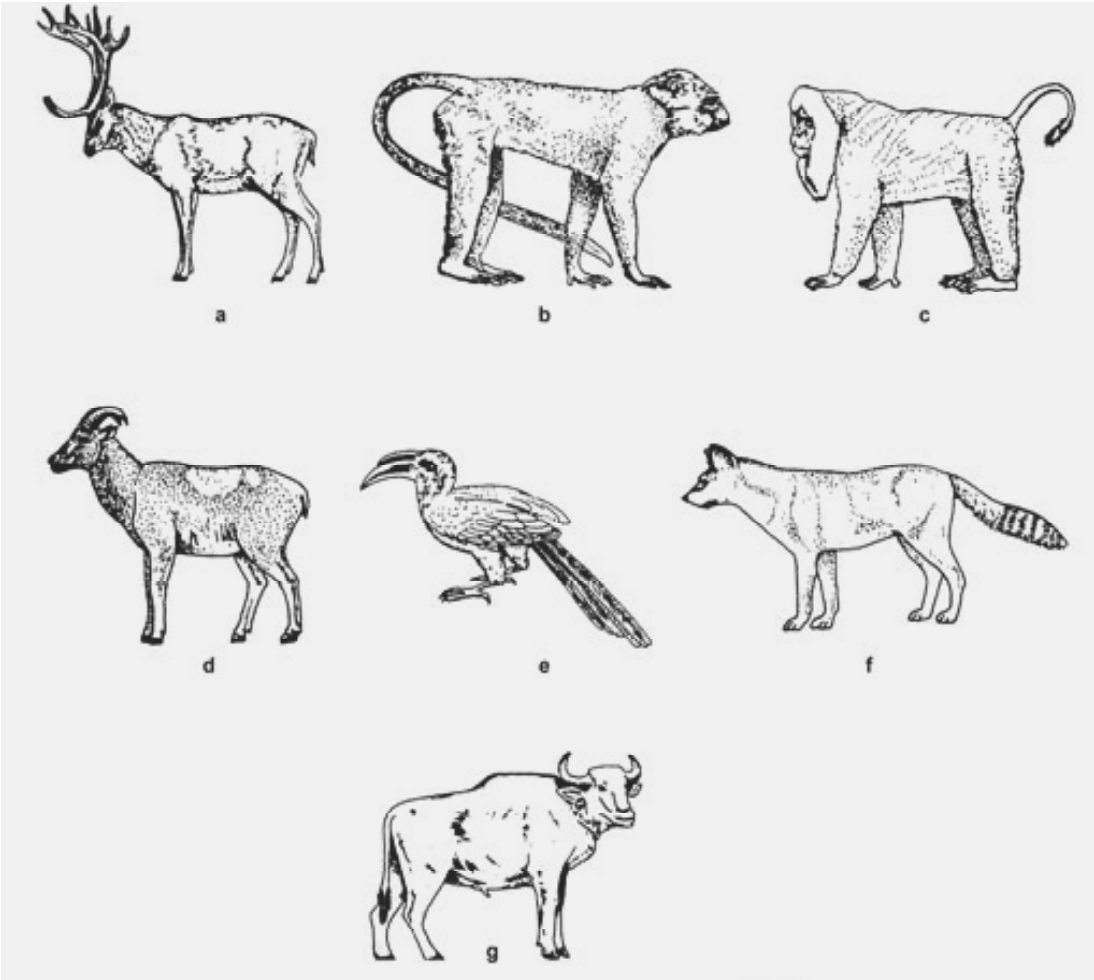


Fig. 6.13: The faunal elements of Western Ghats, a) Swamp deer (*Cervus duvauceli*); b) Nilgiri langur (*Presbytis johni*); c) Lion-tailed macaque (*Macaca silenus*); d) Nilgiri Tahr (*Hemitragus hylocrius*); e) Malabar grey hornbill (*Tockus birostris*); f) Dhole (*Cuon alpinus*); and g) Gaur (*Bos gaurus*).

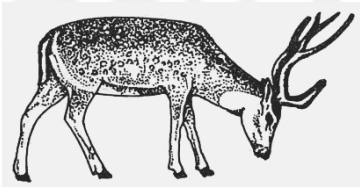


Fig. 6.14: Chital (*Axis axis*) found in the Deccan Peninsula.

6.4.6 Zone 6: The Deccan Peninsula

This zone covers the largest area in India that amounts to about 43% of the total land mass, and about 1,421,000 sq. km area. Though a large area of this zone has been greatly altered by humans, still some forest areas exist, particularly in Madhya Pradesh, Maharashtra and Odisha.

This zone has deciduous forest, thorn forests and degraded shrublands. There are small areas of semi-evergreen forests in the Eastern Ghats and, dry evergreen forests or thorn scrub on the coastal side of the plains of Andhra Pradesh and Tamil Nadu.

The faunal species are widespread throughout the whole zone, e.g., Chital (Fig. 6.14), Sambar, Nilgai, Chowsingha, Barking Deer, and Gaur. Some

species such as the Blackbuck are restricted to dry open area. Small, relict populations of species also exist, e.g., Elephant (Bihar-Odisha, and Karnataka-Tamil Nadu) and Wild Buffalo (in a small area at the junction of Odisha, M.P. and Maharashtra).

6.4.7 Zone 7: The Gangetic Plain

This zone has one of the most fertile areas in the world, and it supports a dense and growing human population. It covers an area of about 359,400 sq km. The original vegetation found in most of the area is no longer there, as a major portion of this area has been brought under cultivation.

Fig. 6.15: Gangetic dolphin (*Platanista gangetica*)-found in the gangetic plains.

The Wildlife of the Gangetic Plains

Small relict populations of Nilgai, Blackbuck and Chinkara, interspersed with dense cultivation presently exist in the western areas.

The wetlands and rivers also contain Crocodile – Mugger and Gharial - populations, reflict populations of Gangetic Dolphin (Fig. 6.15) and a rich, fresh-water turtle community having over 20 species.

6.4.8 Zone 8: North-East India

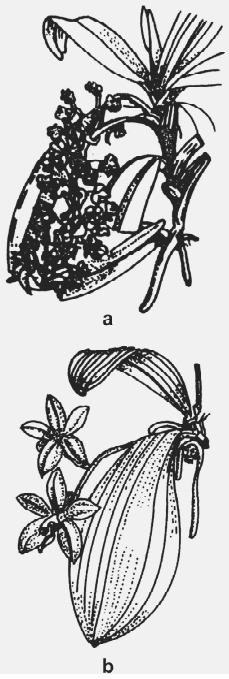


Fig. 6.16: Two orchid species of Andaman and Nicobar Islands; a) *Aerides emerici;* b) *Palaenopsis speciosa.*

North-East India represents the transition zone between the India, Indo-Malayan and Indo-Chinese regions as well as the meeting point of Himalayan mountains and Peninsular India. It is one of the most important zones in the Indian Subcontinent for its rich biological diversity and a large number of endemic species.

The Brahmaputra valley of this zone contains unique natural vegetation – swamps, grasslands and fringing woodlands and forests. The fauna consists of Rhinoceros, Buffalo, Swamp Deer, Hog Deer, Pygmy Hog and Hispid Hare. This area also contains the largest elephant populations. This is also the fly-way for waterfowl and other birds travelling between the warmth of the subcontinent and their summer grounds in Silberia and China.

6.4.9 Zone 9: The Islands

In this category we shall discuss the Andaman and Nicobar group of islands in the Bay of Bengal, and the Lakshadweep in the Arabian Sea. The Andaman and Nicobar islands are a long group of 348 north-south oriented islands.

The zone possesses a unique kind of plant and animal life exhibiting a high degree of endemism. One finds these islands with impoverished mammal fauna. This may be largely due to the isolation of Andaman and Nicobar islands and the small island size. Amongst mammals, species of rodents and bats dominate.

Out of the 15,000 species of flowering plants found in India, some 2,200 species are found in these islands (two such species are shown in Fig. 6.16). Over 200 are strict endemics.

6.4.10 Zone 10: The Coasts

India has a vast coastal stretch of about 5689 km (Srinivasan, 1969). On the west, the Arabian Sea washes the shores of Gujarat, Maharashtra, Goa, Karnataka and Kerala States. On the east, the Bay of Bengal washes the coasts of Sunderbans in West Bengal, Odisha, Andhra Pradesh and Tamil Nadu states. The southern promontory of Indian Peninsula is bathed by the Gulf of Manaar and Indian Ocean, along the coasts of southern portions of Tamil Nadu.

The Wildlife of Coasts

The geology of coasts is very varied and accordingly, five main communities have been described:

a) Mangroves – that have a variety of community types from seaward to landward facing areas of estuaries, lagoons and deltas.

b) Sandy beaches, including raised beaches and distinctive plant communities such as *Casuarina – Calophyllum – Pandanus*.

c) Mud flats with a range of successional stages to completely terrestrial vegetation.

d) Raised corals and rocky coast lines.

e) Marine angiosperm pastures

An endemic species is one that is restricted to a given area and is not found elsewhere.

Some of the interesting coastal wildlife species include: Dugong; Hump-back Dolphin of estuarine turbid waters; Estuarine or salt-water Crocodile; Olive Ridley, Green, Hawksbill, Leather and Loggerhead sea Turtles; the Estuarine Turtle – *Batagur basker* of Sunderbans and the huge Soft-shell Estuarine Turtle; *Pelochelys birbornii* off the Utkal-bengal Coast fish – mud skippers or semi-terrestrial Gobies, small Crabs in association with Anemones; avifaunal communities of mangrove, mud flats and lagoons. In the higher regions of mangroves, there are Spotted Deer, Pigs, Monitor Lizards, Monkeys, and the Sunderban Tiger.

An endemic species is one that is restricted to a given area and is not found elsewhere.

Green Nations

Plants, insects anything mentioned in a biology text book qualifies as a bioresource. Countries with vast bioresources are called Mega-Diverse.

Mega Diverse countries

Eighteen countries that control 70 precent of the world's bioresources have got together: India, China, Zaire, Indonesia, Columbia, Mexico, Ecuador, Kenya, Peru, Venezuela, Costa Rica, Bolivia, Malaysia, Madagascar. Philippines, South Africa, Congo and conservation priority in the selection of countries is based on species richness and species endemism

6.5 BIODIVERSITY HOT SPOTS

Hot spots are areas that are extremely rich in species, have high endemism and are under constant threat.

Myers (1988) identified 18 regions or "Hot spots" around the world. Interestingly these areas contain nearly 50,000 endemic plant species, or 20% of the world's plant species, in just 746,000 km^2, or 0.5% of the Earth's total land surface. A subsequent study done by the World Conservation Monitoring Centre, U.K. identified 21 "hot spots". A more recent study by Conservation International, which carries forward the work of Myers, has identified 34 global "biodiversity hot spots". These 34 hot spots cover only 1.4 percent of the Earth's land surface but contain about 44% of all vascular plants and 35% of vertebrates (excluding fishes), and 96% of the world's most threatened primate species. Among the 34 hot spots of the world four are found in India

extending into neighbouring countries – the Western Ghats/Sri Lanka Indo-Burma region (covering the Eastern Himalayas); the Himalayas; Sundaland (covers the Nicobar group of Islands) (Fig. 6.17). These areas are rich in floral wealth and endemism, not only in flowering plants but also in reptiles, amphibians, swallow tailed butterflies and mammals.

Tropical moist forests are believed to be the richest terrestrial ecosystems on earth. In the marine environment, coral reefs also possess extremely rich biodiversity. It is now suspected, however, that the richness of species diversity on sea floor may be equal or even greater than coral reefs.

Some countries are richer in biodiversity than others. Generally, the economically poor developing countries in tropical areas are richer in biodiversity than developed countries in temperate areas.

Small tropical oceanic islands have relatively fewer species due to their isolation, but they generally possess large number of endemics. Mauritius has a native flora of 878 higher plant species, of which 329 are endemic.

6.6 INDIA: A MEGA - BIODIVERSITY COUNTRY

Why India is one of the mega-diversity countries?

- Four hot spots out of 34 global biodiversity hot spots are in India with its neighbouring countries.
- The endemics of Indian biodiversity is high. About 33% of the recorded flora is endemic to the country. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora.
- India has 26 recognised endemism centres that are home to nearly a third of all the flowering plants identified and described to date in the country.
- India has two major realms called the Palaeretic and the Indo-Malayan and three biomes i.e. tropical humid forests, tropical deciduous forests and the warm deserts/semi-deserts.
- India has ten biogeographic regions.
- India is one of the 12 centres of origin of cultivated plants.

SAQ 3

Which parameters place India in the list of mega biodiversity countries?

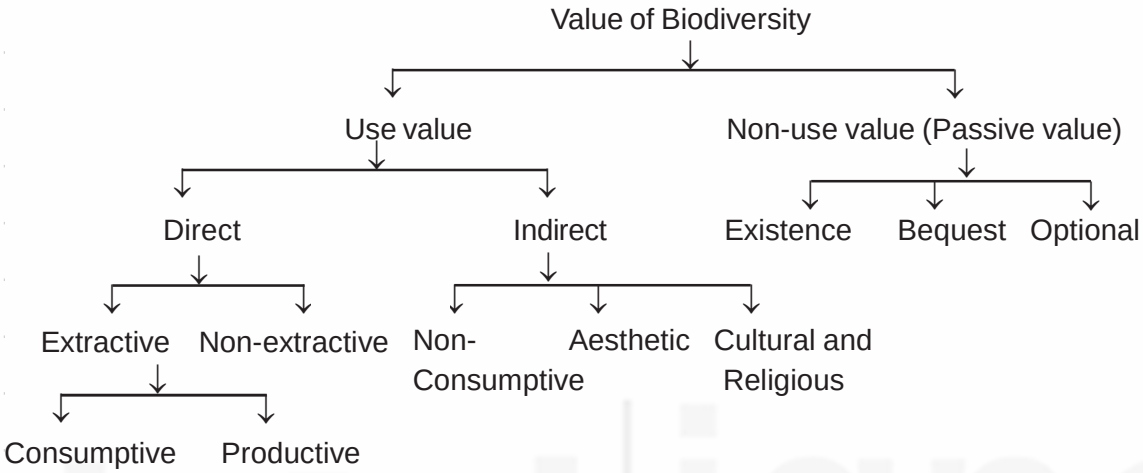
6.7 USE VALUES OF BIODIVERSITY

Despite its importance, determining the value or worth of biodiversity is

complex and often a cause for debate. This is largely due to the fact that the worth placed on biodiversity is a reflection of underlying human values, and **these values vary dramatically both among societies and individuals**.

In this Unit, we include spiritual, cultural and aesthetic values as a subset of indirect values or services, as they provide a service by enriching our lives.

Classification of values of biodiversity is provided in a key form below for your easy understanding.



6.7.1 Direct Use Value

Direct use values are for those goods that are ensured directly e.g. food and timber. Maintaining a wide range of components of biological diversity can be of direct use, especially in the fields of agriculture, medicine and industry. Direct use can involve the use of forests, wetlands or other ecosystems for timber extraction, collection of non-timber products, fishing, etc. Direct use values could be due to **extractive use** where resources are extracted and consumed, or due to **non-extractive use** when there is no extraction or removal of the resource that is used (e.g. bird watching, scientific research in an ecosystem).

6.7.2 Indirect Use Value

Indirect use value is for those services that support the items that are consumed. You will study about various indirect use values in this section.

Non-consumptive value

This is concerned more with nature's services which also make vital contributions to the welfare of society and to ecological processes without which our planet would be uninhabitable**.**

Aesthetic value

The appreciation of the aesthetic aspect of biodiversity is reflected in the trouble people take to maintain their home gardens, and the number of people throughout the world who visit national parks, botanical and zoological gardens, aquaria and places where one can experience natural landscapes or view diverse species.

Cultural and religious values

In all cultures of world, species and nature have inspired songs, superstitious beliefs, stories and folktales, and dance and drama, poetry, traditional crafts, local and national cuisines, local rituals, names of places, and even family and Christian names. The cultural value of biodiversity in human societies is often expressed in the respect for life forms or symbols of components of biodiversity. In some countries the tiger, lion, lizard, turtles and bison are part of religious and spiritual beliefs. For instance, the hanuman langur (*Semnopithecus entellus*) is considered sacred in India.

Ethical values

The ethical values of biodiversity highlight the intrinsic value of biodiversity for its own sake and it is independent of the varied economic, social and cultural uses of the large number of species by human communities. It underscores the fact that humans are only one of the millions of species that inhabit the earth, while each species is unique and is the result of evolutionary processes without human intervention, so that every species has a natural right to exist.

6.7.3 Non-use Value

Values for those things/organisms/entities – that we don't use but would consider as a loss if they were to disappear. These include **potential or option value, bequest value** and **existence value.**

- **Optional use values**

  Optional values are associated with potential use in the future. Accordingly one opts to conserve biodiversity based on the hope that it could be used directly or indirectly in the future, perhaps as a source of genetic material, for pharmaceuticals, or for crop enhancement.

- **Bequest value**

- **Existence value**

  There may also be non-use existence values for components of biological diversity due to the value placed on biodiversity purely based on its continued existence, irrespective of whether or not it will ever be used.

SAQ 4

Discuss about direct and indirect use values of biodiversity.

6.8 SUMMARY

Let us summarize what you have learnt so far:

- The term biological diversity was coined by Thomas Lovejoy in 1980 and the term biodiversity was coined by E.O. Wilson. Biodiversity is a measure of the relative diversity among organisms present in different ecosystems. Biodiversity is the totality of genes, species and ecosystems of a region.

- There are three levels of diversity i.e. **genetic**, **species** and **ecosystem**. All these levels are interacting and influencing the others.
- Genetic diversity underlies the differences among individuals of a given species. Genetic diversity allows a species to adapt to changing environmental condition.
- Species diversity is the most visible component of biodiversity. It means the differences between species. There are about 12.5 million species in the world out of which 1.7 million species have been described.
- India has been divided into ten biogeographic zones viz; Trans-Himalayas, Himalayas, Indian Desert, Semi-arid, Western Ghats, Deccan Peninsula, Gangetic Plains, North East India, Islands and Coasts. Each of these zones has certain geographical as well as biological peculiarities.
- Biodiversity hot spots are areas that are extremely rich in species, have high endemism and are under constant threat. There are 34 hot spots in the world; 4 of which are found in India extending into neighbouring countries.
- India is among the world's mega biodiversity countries because of various reasons, viz. 4 hot spots, 26 recognised endemism centres, two major realms, three biomes and ten biogeographic regions.
- The value of biodiversity is often divided into two main categories i.e. **intrinsic** or **inherent value** and **extrinsic** or **utilitarian** value. Intrinsic value describes the worth of an organism, independent of its value to anyone or anything else. Utilitarian value refers to something's value as determined by its use or function.
- Use values can be direct or indirect. Direct use values are for those goods that are consumed directly, such as food or timber and indirect use value are for those services that support the items that are consumed, including ecosystem functions like nutrient cycling.
- Non-use or passive values are for those entities that we don't use but would consider as a loss if they were to disappear. These include **existence value, bequest value** and **option value.**

6.9 TERMINAL QUESTIONS

1. Define biodiversity. Explain different levels of biodiversity.
2. Enumerate and analyse the wild life species that occur in the different biogeographic zones of India.
3. Discuss the criteria for identifying global biodiversity hot spots.
4. Explain the use values of biodiversity.

6.10 ANSWERS

Self-Assessment Questions

1. The variability among living organisms from all sources, including, inter

alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

2. Genetic diversity is the diversity of basic units of hereditary information which are passed down generations found within a species (e.g. different varieties of the same species). Species diversity means the differences between species (both domesticated and wild).
3. Following parameters place India in the list of mega biodiversity countries:

   i) Four hot spots out of 34 global biodiversity hot spots are in India with its neighbouring countries

   ii) The endemics of Indian biodiversity is high. About 33% of the recorded flora is endemic to the country. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora.

   iii) India has 26 recognised endemism centres that are home to nearly a third of all the flowering plants identified and described to date in the country.

   iv) India has two major realms called the Palaeretic and the Indo-Malayan and three biomes i.e. tropical humid forests, tropical deciduous forests and the warm deserts/semi-deserts.

   v) India has ten biogeographic regions.

   vi) India is one of the 12 centres of origin of cultivated plants.
4. Refer to Sub Sections 6.7.1 and 6.7.2.

Terminal Questions

1. Refer to Sections 6.2 and 6.3.
2. Refer to Section 6.4.
3. Refer to Section 6.5.
4. Refer to Section 6.7.

6.11 FURTHER READING

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

Internet Sites

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

http://www.epw.org.in

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

UNIT 7

ENERGY RESOURCES

Structure

7.1 INTRODUCTION

Modem industrial societies are characterised by the intensive use of energy. Can you think of a day in your life without electricity or other sources of energy such as fuels for cooking and transport? Think, all the things that you use are driven by energy! Energy is required to produce food and goods and reach them to you. You will agree that energy has been a crucial factor in the current model of development. There is a close relationship between energy consumption and economic growth as measured in terms of the growth of Gross Domestic Product(GDP)in any country. It is now argued that the cost and availability of energy are two major factors in promoting economic growth of society or country as a whole.

However, as the energy intensive industrial economies have expanded, their adverse impact on the environment has grown. This aspect has come under closer scrutiny in the past few decades and an understanding of the role of energy in economic development will help us develop models of eco-friendly energy usage. Therefore, we begin our discussion of the energy as resource with an understanding of the multi-faceted role of energy in economic development. We will examine the energy resource base at our disposal and the various energy options available to us. Finally, we will analyse the carrying capacity of the Earth in relation to our energy demand with a view of switching over to renewable energy sources.

Expected Learning Outcomes

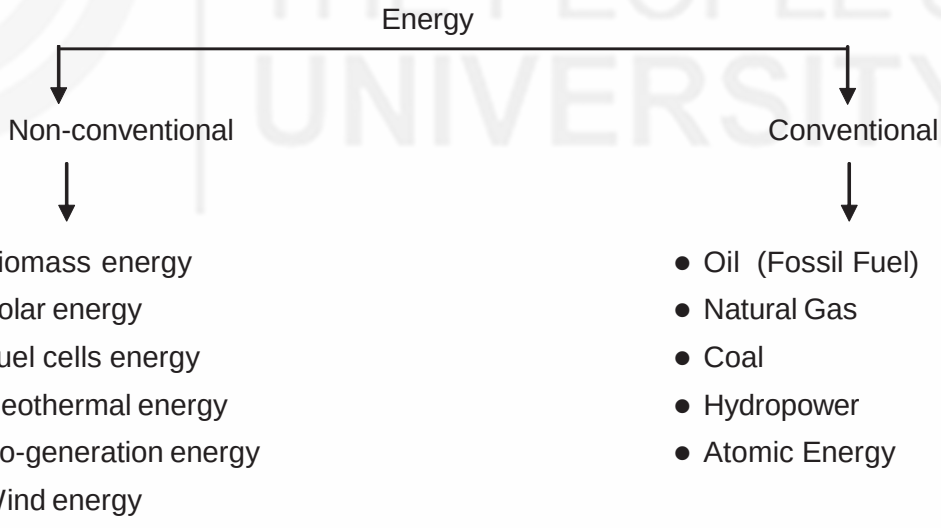
After studying this unit, you should be able to:

- ❖ discuss the role of energy as resource in economic growth;
- ❖ analyse the energy demand due to growing population andindustrialisation;
- ❖ describe the energy resource base of the Earth; and
- ❖ explain the management of energy with switching over to renewable sources.

7.2 ENERGY AS RESOURCE

The demand for energy doubles every 14 years and is taken as one of the indicators of development of a country. India, with 16% of the world's population consumes roughly 3% of the total energy produced in the world, in comparison of USA which has 6.25% of the world's population and utilizes 30% of the energy produced.Despite continuous increase in energy use, per capita consumption in India is still very low compared with other countries. Even today, about 80% of our population continues to depend on fuel wood, dung and agricultural wastes. We know that non-renewable sources of energy such as fossil fuels, coal and petroleum, are not going to last for long. Forests are also being depleted at the alarming rate due to indiscriminate felling of trees. It has become, therefore, necessary to think of alternative, non-conventional sources of energy.

Energy needs in India are met by harnessing two categories of energy sources as shown below.



7.2.1 Non-Conventional Sources

There are various non-conventional sources of energy which we will deliberate here.

Biomass energy

This is a renewable energy source derived from plant resources, animal waste and the waste of various human activities. It is also derived from the by-products of the timber industry, agricultural crops, raw material from the forest, major parts of household wastes and wood. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas.

Biomass does not add net carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels.

Biomass fuels used in India account for about one third of the total fuel used in the country. Over 90% of the rural households and about 15% of the urban households use biomass fuels (e.g. wood, cowdung cakes, crop residues and sawdust). The inefficient burning of such fuels in traditional chulhas is causing a serious problem of indoor air pollution and consequent health hazards. Moreover, the unsustainable level of consumption of fuel wood leads to deforestation and desertification, which degrades the environment. Thus proper management of biomass as a resource is very essential.

In this context, technological solutions, institutional arrangements, financial support and training schemes for ensuring adequate and affordable clean energy systems and services using biomass assume great significance. An initiative in this direction has come from the Ministry of Non-conventional Energy Sources (MNES). It has been promoting indigenously developed technologies for efficient utilization of biomass fuels with a focus on extraction of more energy, reduction of household consumption of firewood, generation of employment and improvement in the living standards of rural population.

Biomass gasifier is another technology in use for energy generation (Fig. 7.1). A biomass gasifier converts solid biomass, both woody and powdery, materials such as wood, agricultural and agro-industrial wastes into gas through thermochemical gasification process.Gasifier converts solid fuel into a more convenient-to-use gaseous form of fuel.

As much as 1890 Kcal of heat can be produced from half a kilo of dry plant tissue. This is equivalent to the heat available from 250 g coal.

It has been found to be more practical to compress biomass into briquettes (small hard blocks of different shapes used as fuel) and thereby improve its utility and convenience of use. In the dense briquetted form, biomass can either be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasifier.

Fig. 7.1: Biomass gasifier.

Solar Energy

Solar energy is the most readily available abundant source of energy. It is free as it does not belong to anybody. It is also non-polluting (Fig. 7.2).

Solar run refrigerators have been developed for rural areas. These keep vegetables and fruits fresh for a longer period.

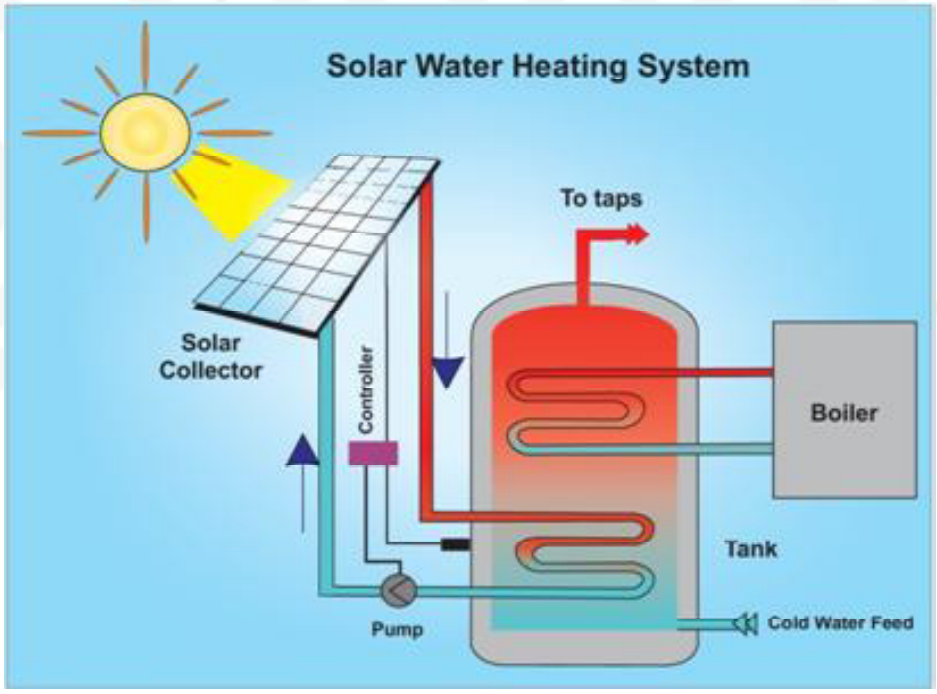


Fig.7.2: Solar energy being used for heating water.

The energy we get today from the fossil fuels like coal is in reality sun's energy, trapped in plants millions of years ago. Plants make their food and grow by using solar energy for photosynthesis. Millions of years ago, huge forests got buried in the earth's crust and they got transformed into coal and oil under great pressure and temperature therefore coal and oil are called fossil fuels.

Fig. 7.3: Solar run refrigerator.

Nowadays, we have learnt to harness solar energy for various purposes. Solar energy can be used directly to give us hot water during winter, or run a refrigerator (Fig. 7.3).It can be used, for room heating in colder regions (Fig. 7.4).Solar cookers are being used in many homes to cook food (Fig. 7.5). Solar energy can be used with the help of “photo voltaic cells” for producing electricity for driving vehicles and for illumination. Since this is an unfailing source of energy, it would be a great advantage to develop cheap and efficient photocells or photovoltaic devices to harness solar energy.

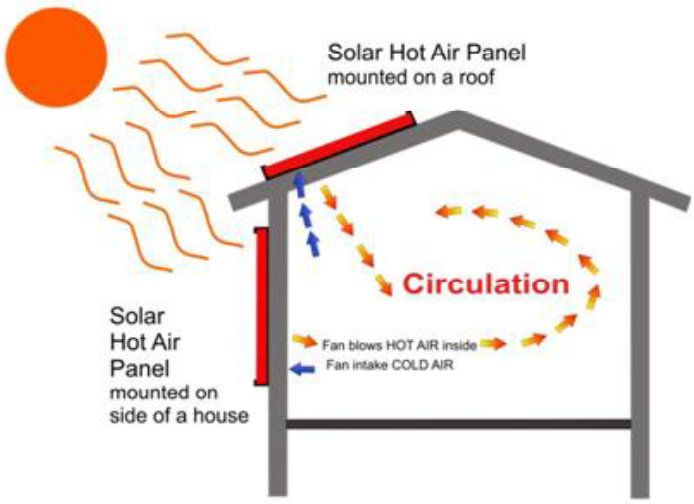


Fig. 7.4: Solar heated room.

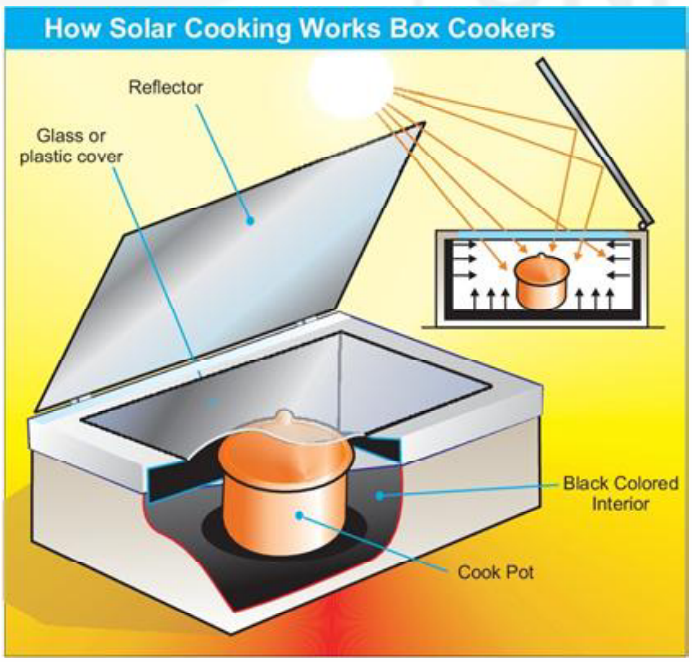


Fig. 7.5: Solar Cooker.

Solar radiation gets converted into electricity directly in Solar Photovoltaic (SPV) panels installed on buildings or in open spaces. This electricity can either be used as it is or can be stored in the battery to be used for domestic lighting, street lighting, village electrification, water pumping, desalination of salty water, powering of remote telecommunication repeater stations and railway signals. Solar passive buildings use solar energy in building designs and cut down on energy consumption for heating and cooling. This technology is fast gaining acceptance in urban architecture.

Fuel Cells

Fuel cells are electrochemical devices that convert the chemical energy of a fuel directly and very efficiently into electricity and heat, thus doing away with combustion (Fig. 7.6). A fuel cell consists of an electrolyte sandwiched between two electrodes. The most suitable fuel for such cells is hydrogen or a mixture of compounds containing hydrogen. Oxygen passes over one electrode and hydrogen over the other, and they react electrochemically to generate electricity, water and heat.

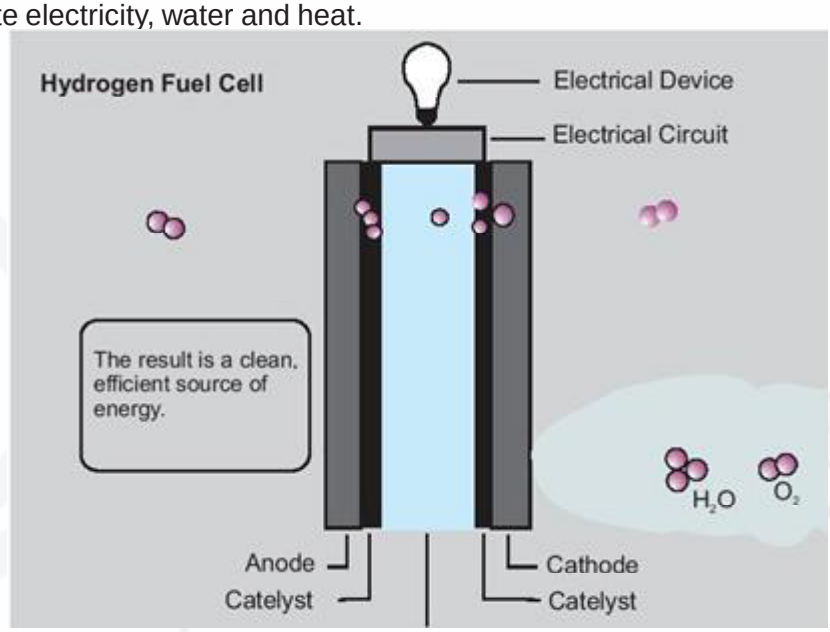


Fig. 7.6: Fuel Cells.

Fuel cells are being used in space flights and can be used in electric vehicles to dramatically reduce urban air pollution. Fuel-cell powered vehicles have very high energy conversion efficiency (almost double that of currently used engines). The emissions are significantly lower (CO_2 and water vapour being the only emissions). Fuel-cell-powered electric vehicles score over the battery operated ones in terms of increased efficiency and easier and faster refuelling. Fuel cell systems are excellent candidates for small-scale decentralized power generation for commercial buildings, hospitals and airports in remote locations.

On an average, the 60 million sq. km of tropical seas absorb solar radiation equivalent to the heat content of 245 billion barrels of oil.

Wave and Tidal Energy

Energy can also be obtained from **waves** and **tides**.These waves and tides are another source of energy which is perpetual and can be harnessed for generating electricity (Fig. 7.7), particularly where sea water can move into

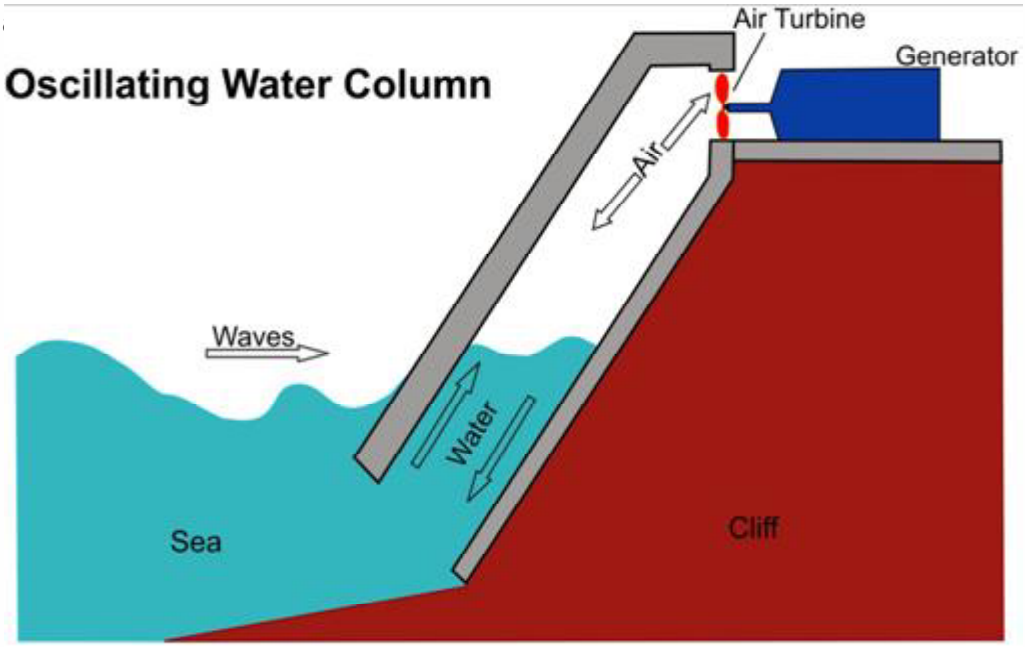


Fig.7.7: Tidal power station. Both incoming and outgoing tides are held back by a dam. The difference in water levels generates electricity in both directions as water runs through reversible turbogenerators.

Energy carried by water has also been widely used in India's hilly regions, since a wheel with pedals can be made to turn when it is put in a fast flowing stream. Flour mills of small size built on this principle were used in Kashmir fora long time. In fact, large "hydroelectric" power stations work on the same principle. A natural or artificial water fall is made to turn a modern kind of pedal wheel, called a turbine, which upon rotation generate electricity.

In India, the first wave energy project with a capacity of 150 MW, has been set up at Vizhinjam near Thiruvanathapurm. A major tidal wave power project costing Rs. 5000 crores, is proposed to be set up in the Hanthal Creek in the Gulf of Kachchh in Gujarat.

Geothermal Energy

Volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas are sources of **geothermal** energy. **Geothermal** means heat from the earth. In some countries, such as in the USA, water is pumped from underground hot water deposits and used to heat people's houses.

Hot water and superheated steam of hot springs can be used to generate electricity (Fig. 7.8). In our country there are about 46 hydrothermal areas where the temperature of the spring water exceeds 150°C. The thermal energy of hot springs can be used for generating electricity, heating buildings and homes glass-houses in colder areas for growing vegetables.

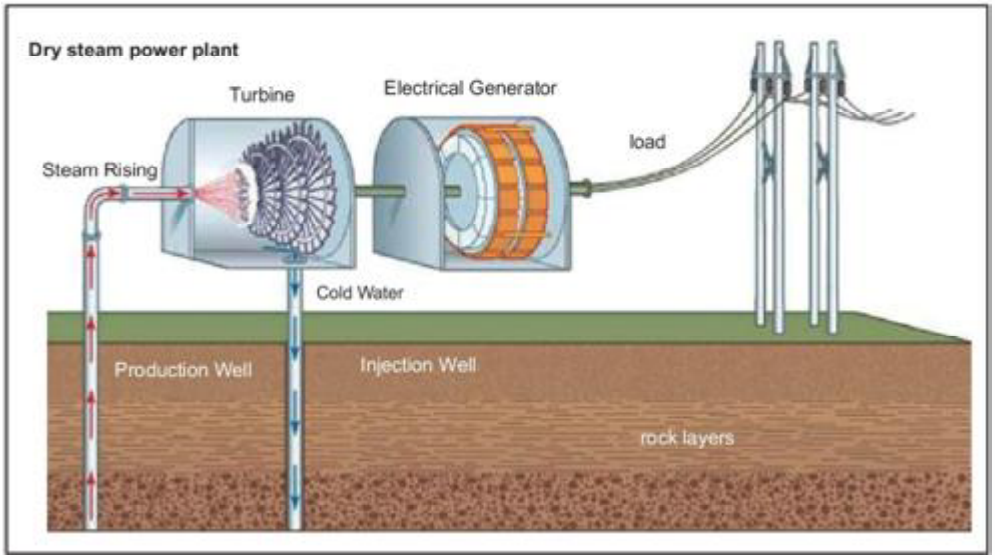


Fig.7.8: The geyser is the geothermal power operation and produces the energy directly from steam.

In India, the North-western Himalayas and the western coast are considered geothermal areas. Satellites like the IRS-1 have played an important role, through infrared photographs of the ground, in locating geothermal areas. The Geological Survey of India has already identified more than 350 hot spring sites, which can be explored as areas to tap geothermal energy. An experimental 1 KW generation project in the Puga valley in the Ladakh region is being used for poultry farming, mushroom cultivation and pashmina-wool processing, all of which need higher temperature.

Co-generation

This is the concept of producing two forms of energy from the fuel, one form being heat and the other being electrical or mechanical energy. In a conventional thermal power plant, high-pressure steam is generated by burning fuels. It is used to drive a turbine, which in turn drives an alternator to produce electric power. The exhaust steam is generally condensed to water which goes back to the boiler. (Fig. 7.9)

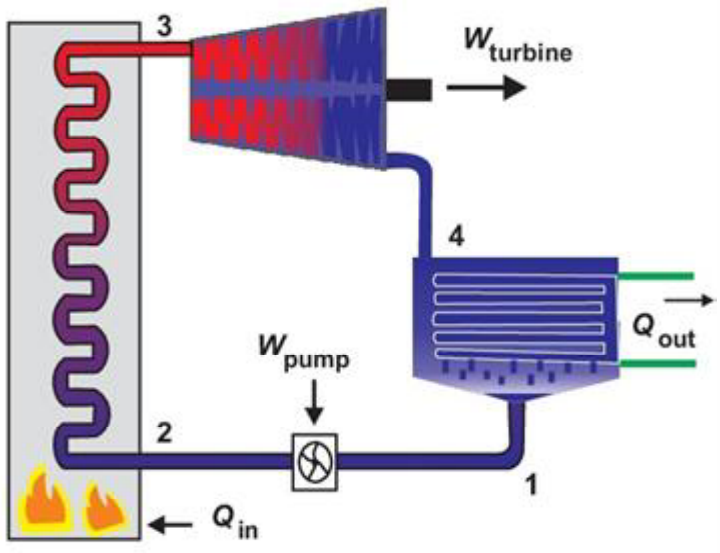


Fig. 7.9: Bagasse-based co-generation.

The efficiency of conventional power plants is only around 35% as a large amount of heat is lost in the process of condensing. In a co-generation plant, the low-pressure exhaust steam coming out of the turbine is not condensed, but used for heating purposes in factories or houses. Thus very high efficiency levels, in the range of 75-90% can be reached.The potential of power generation from co-generation in India is more than 20,000 MW even at conservative estimates.

Wind Energy

Wind Energy has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert the kinetic energy associated with the movement of air to more useful forms of power. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding,lifting water or to generate electricity. Wind turbines can be used singly or in clusters called 'wind farms'. Windmills have been used since long in many countries, but in India they have only been recently introduced (Fig. 7.10).

Fig. 7.10: Use of renewable energy as wind pump.

Biogas

You may have heard of the use of cattle dung for production of biogas which is a source of energy used for cooking (Fig. 7.11). Through a simple process cattle dung is used to produce a gas that contains 55-70% inflammable methane gas, and is clear and efficient fuel for use in rural areas. Water weeds like water hyacinth, water lettuce, salvinia, hydrilla, duck weeds and algae are found to be useful supplement to cattle dung. Biogas can also be used to raise steam, which in turn may be used for running engines or machines in factories or for running turbines to generate electricity. It has been found that large biogas plants can supply the needs of a number of families or even small villages. The residual dung or the digested slurry left after generating, biogas can be used as manure for agricultural purposes. This is an economical way of obtaining energy from organic wastes. In China and India, great efforts are being made to install tens of thousands of biogas plants in rural areas.

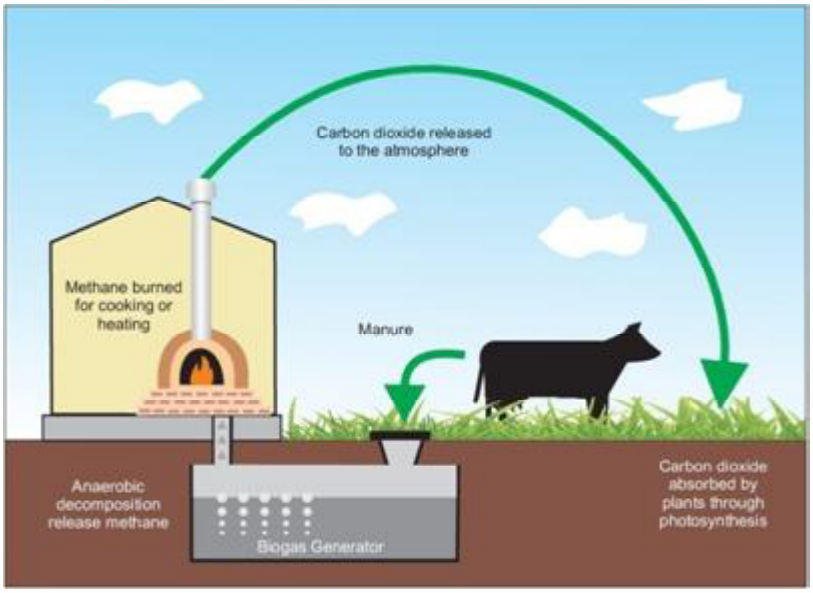


Fig. 7.11: Biogas Plant.

India has tremendous potential in non-conventional sources of energy. Our diverse geographical settings help in promotion of non-conventional energy sources of energy namely solar, wind and tidal. Looking at the future potential in generating solar energy, the International Solar Alliance was established in the year 2015. Major initiatives were taken by India for the establishment of this alliance. This would help us in developing clean and green energy that would address the problems emerging due to the use of conventional sources of energy like coal, petroleum and radio-active minerals. Therefore we can say these above mentioned non-conventional sources are the energy of future.

But, today our major energy sources are coal, fossil fuel, natural gas, hydro-power and atomic energy. These sources of energy are known as conventional sources of energy. Let us discuss these sources in detail in the following section.

7.2.2 Conventional Sources

The power production through conventional sources like oil, gas, coal and hydel lags far behind the current demand driven by growth in agriculture industry and the population. India's electricity sector currently faces problems of capacity, distribution losses, poor reliability, and frequent blackouts. Indian industry cites power supply as one of the biggest limitations on progress. One government estimate projects 8-10% annual growth in energy demand over the next 15 years if the economy grows as expected in the 7-8% per year range. The shortfall implies greater dependence on international markets.

Oil (Fossil Fuel)

Oil supplies nearly 30% of India's energy. Oil consumption in the country was approximately 1.93 million barrels per day (bpd) in 1999 and was about 4.7 million bpd in 2017. In 2017, India imported about 198 million tonnes of cruide oil and its products.

India draws most of its imports of oil from the Bombay High, Upper Assam, Cambay, Krishna-Godavari, and Cauvery basins. Oil reserves are estimated at 4.7 billion barrels. The Bombay High Field, India's largest producing field, generated 250,000 b/d in 1998 and 210,000 b/d in 1999.

Consumption of petroleum products rose from 57 million tonnes in 1991-1992 to 196 million tonnes in 2016. The India Hydrocarbon Vision 2025 report estimates future refinery demand at 368 million tons by 2025. Thus, India is becoming a major global market for petroleum products.

Natural Gas

About 7% of India's energy needs are met by **natural gas** especially in power generation, fertilizers, and petrochemicals production. Natural gas can serve to reduce dependence on foreign oil. Absence of sulphur dioxide and reduced levels of carbon dioxide and nitrogen oxide are major environmental benefits of using natural gas. Currently, India's natural gas consumption is 50 billion cubic metres (bcm) and is mostly met by domestic production. In 2017, India imported 27,570 million cubic metres of natural gas.

Coal (Fossil Fuel)

India depends on coal for more than half of its total energy needs. Nearly three quarters of the country's electricity and 63% of commercial energy comes from coal. India has huge coal reserves accounting for 8% of the world's total. It is the third leading coal producer in the world after China and the United States. Most of its coal demand is satisfied through domestic production with the only exception being coking coal that is in short supply. Despite India's wealth in coal reserves, only about 3% is coking coal so India's steel industry must import coking coal to meet about 25% of its annual needs.

Hydro Power

Hydro power is the cheapest, and cleanest and, hence, regarded the best source of energy (Fig. 7.12). However, obtaining electricity from mega dams has given rise to many controversies in recent times and small hydro power plants are emerging as viable alternatives. These plants serve the energy needs of remote and rural areas where the grid supply is not available.

Fig. 7.12: Hydro Power.

Atomic Energy

The energy released by splitting of atom in a controlled manner can be utilized for generation of electricity. The device used for this purpose is called an atomic reactor (Fig. 7.13). Nuclear reactors produce heat, which is used to generate steam, for rotating turbines for generating electricity. It is estimated that 1 kg of natural uranium, written as 235 U, generates energy equal to that produced by 35,000 kg of coal. Energy production from nuclear fuels like uranium is relatively clean, efficient, and can serve as a substitute for coal and petroleum. However, nuclear reactors need to be situated at places far away from human habitation. They have to be operated under strict safety control, to prevent any accidental leakages of radioactive material. The radioactive wastes have to be carefully disposed off. Currently, Nuclear Power Corporation of India Ltd.(NPCIL) is opening 21 nuclear power reactors with an installed capacity of 5780 MW at seven different sites.

Fig. 7.13: A view of atomic power station.

SAQ 1

Tick mark ( ) the correct options.

i. Solar energy is a

   a) renewable non-conventional energy

   b) non-renewable conventional energy

   c) non-renewable energy

ii. Plant manufacture their food by using

   a) Fossil fuel energy

   b) solar energy

   c) organic nutrient energy

iii. Use of non-conventional source of energy is

a) Cheap

b) Pollution free

c) Both cheap and pollution free

iv. Reactor generates

a) Biogas

b) Geothermal energy

c) Atomic energy

v. Energy we get from fossil fuels like coal is in reality

a) Geothermal energy

b) Sun's energy

c) non-conventional energy

7.3 THE CARRYING CAPACITY OF THE EARTH'S ENERGY BASE

The long-term sustainable carrying capacity for the human species on the earth varies with resource availability as well as culture and level of economic development. Thus, two measures of human carrying capacity arise:

- the biophysical carrying capacity; and
- the social carrying capacity.

The **biophysical carrying capacity** is the maximum population that can be supported by the resources of the planet at a given level of technology.

The **social carrying capacity** is the sustainable bio-physical carrying capacity within a given social organisation, including patterns of consumption and trade.

The social carrying capacity therefore must be less than the biophysical carrying capacity as it will account for the quality of life. Besides, it can give us an estimate of the number of humans that can be supported in a sustainable manner at a **given standard of living.**

In order to estimate the human population that can be sustained by the Earth, a standard of living or level of consumption must be selected or assumed. At this point, the introduction of social issues becomes important. For instance, very high global population could be supported at a very low level of food consumption, perhaps even on the brink of starvation. The result, however, could be a socially unstable situation. **A socially sustainable carrying capacity must be based on a level of consumption that meets basic human needs of food, water and space as well as provides opportunity to enjoy socio-political rights, health, education and well-being.**

Another important aspect of social sustainability is equitable distribution of resources. Inequitable distribution of wealth can lead to social instability and disruption.

SAQ 2

Fill in the blanks with appropriate words given is parentheses.

a. The carrying capacity of an ecosystem is defined as the …….. (minimum/ maximum) population size of a species that an area can support.

b. The amount of …… (heat/energy) consumed per person per year is a useful measure of standard of living.

c. North America's per capita energy use is …….. (less/more) than twice that of Europeans.

d. A socially …….. (non-sustainable/sustainable) carrying capacity must be based on level of consumption which meets basic human needs to food, water, and space as well as provides opportunity to enjoy socio-political right, health, education and well being.

7.4 ENERGY DEMAND DUE TO POPULATION GROWTH AND INDUSTRIALISATION

The human population of the developing world is predicted to increase from its current value of four billion to over eight billion by 2050, and by this time it will comprise almost ninety percent of the world population. Population growth' is one of the factors which drive the world-wide energy demand, especially the demand for electricity.

7.4.1 Energy Demand vis-à-vis Population Growth

The two main factors that lead to greatly increased world-wide demand for energy (especially electricity) during the next half-century are:

- population growth, and
- per capita economic growth in the less-developed countries.

Let us explain this further. Currently, the average person in the less-developed countries consumes only one sixth of the energy consumed by an average person in Western Europe or Japan (see Fig. 7.14).

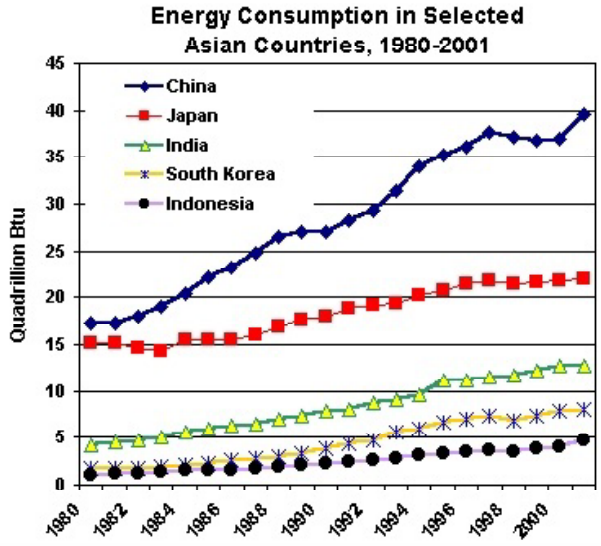


Fig.7.14: Energy consumption in selected Asian countries 1980-2001.

Doubling of per capita energy consumption in the less developed countries over the next 50 years would correspond to only a very modest degree of economic development. Yet, combined with the predicted population increase, it would lead to a two to three-fold increase in world energy consumption.

The actual increase in demand may be expected to be even greater. For example, there will be an increased demand from economic growth in the developed as well as developing countries. Improvements will undoubtedly occur in the efficiency of energy utilisation, but in the face of the expected increases in demand, these could only have relatively minor impact (Fig. 7.15).

Global energy and population

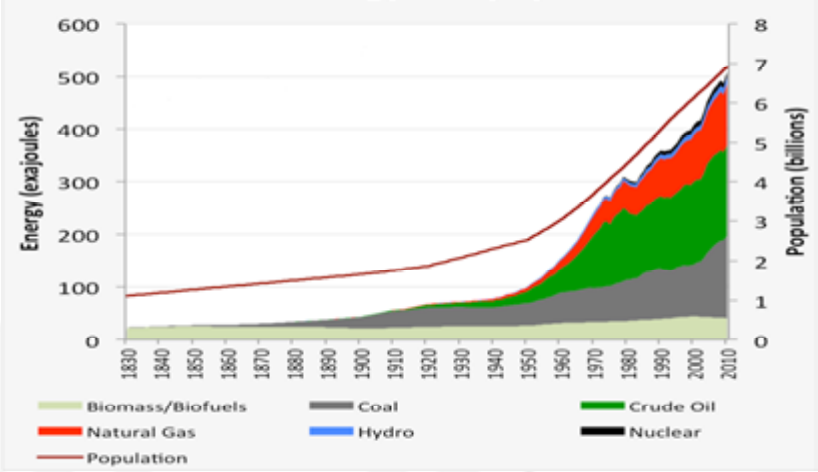


Fig.7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year.

GDP: It represents total dollar value of all goods and services produced over a specific time period.

It is one of the primary indictors used to gauge the health of country's economy.

7.4.2 Energy Demand in Industrialisation

During the initial stages of economic growth, the share of agriculture in total output falls and the share of industry rises. This is the industrialisation phase of development.In the later stages of development, the demand for services begins to increase rapidly,increasing its share of GDP (Gross Domestic Product). This latter stage is often referred to as the 'post-industrialised' society.

The growth of heavy industry (infrastructure development) during the industrialisation phase leads to enormous increases in energy consumption. Accordingly, the **energy intensity** of GDP **(defined as energy input per dollar of GDP)** increases as the share of industry in GDP increases. As development continues, however, the demand for financial services, communications, transportation, and consumer goods (light manufacturing) grows rapidly. As a result, the share of services and consumer goods increases, eventually accounting for over one-half of total output. Light industry (involved in the production of consumer goods) and services require less energy input per unit output than heavy industry. This leads to a reduction in overall energyintensity, i.e., the energy input per unit output (see Fig. 7.16).

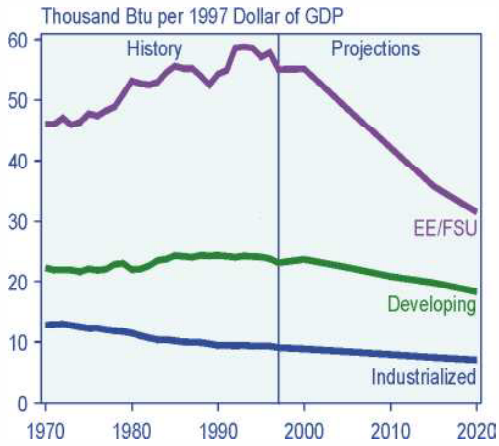


Fig.7.16: World energy intensity by region 1970-2020.

Although economic development leads to declining growth rates of per capita energy demand in the industrial sector, there is substantial growth in energy demand in the transportation, residential and commercial sectors.

Fig.7.17: An illustration of energy consumption in the developed world.

In a recent study of the effect of economic development on end-use energy demand (Fig. 7.17), it was found that **energy demand grows at different rates in different, broadlydefined,end-use sectors (industrial, transport, residential** and **commercial).**Specifically, it was found that per capita industrial energy demand rises very rapidly at the onset of development, accounting for the maximum energy use. The growth of energy demand in industry, however, quickly declines, and energy use in the other sectors eventually takes a majority share of total end-use energy consumption. In fact,energy demand in the transportation sector continues to grow well into the post-industrial phase of development, accounting for more than half of all energy use. A simulation of energy demand by sector for an average country based on these results is depicted in Fig. 7.18.

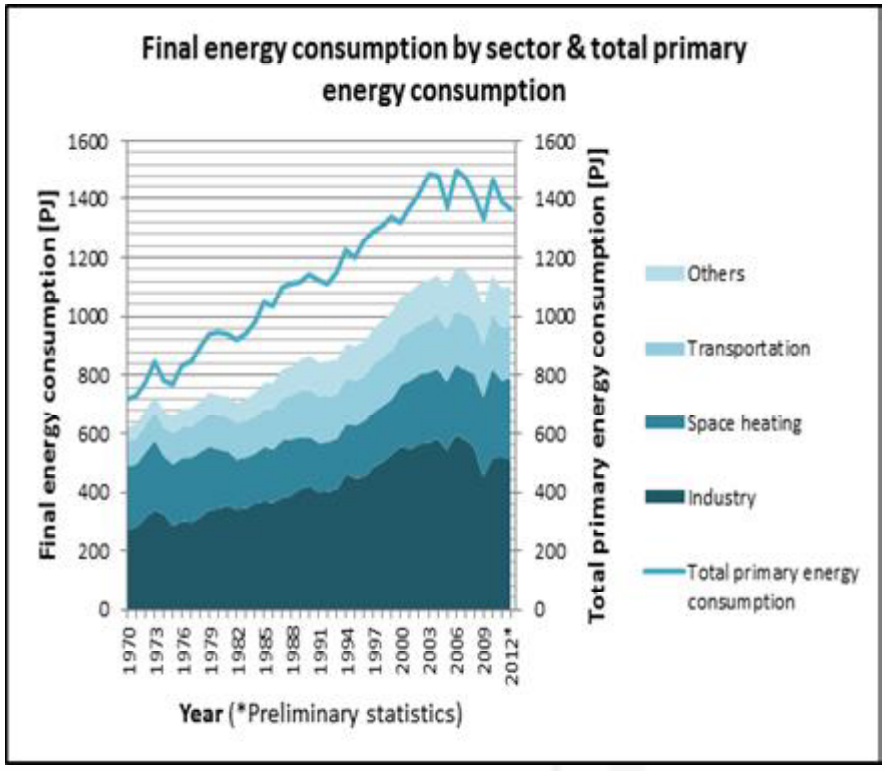


Fig.7.18: Simulated per capita end-use energy demand.

7.4.3 Energy Demand in Asian Developing Economies

Developing countries are playing an increasingly important role in the world energy markets, and their consumption of commercial energy has increased substantially over the past two decades. The increase has been particularly pronounced among the developing countries of East Asia and South East Asia and is expected to continue into the next century. However, the quantum of future energy demand by these lower-middle-income countries will depend on a host of factors, such as:

- the expected income levels;
- real energy prices;
- the continuing trend away from traditional non-commercial energy sources to commercial fuels; and
- the speed of shift toward energy-intensive activities due to urbanisation and industrialisation, increased motorisation, and household use of electrical appliances.

The growing concerns about the environment and the global nature of environmental problems have focused attention on the pattern and trend of energy demand in the developing economies. More than half of the total carbon dioxide emissions originate in the energy sector, and a large and increasing share of the flow of emissions in future will be from lower-middle-income countries. A detailed analysis of energydemand and the possibilities of inter-fuel substitution in the major coal-producingcountries, such as China and India, is very important. This is needed for a better understanding of global environmental problems and the energy needs of these economies.

SAQ 3

Discuss the trends in energy consumption from the 1950s onwards. How did the growth in population influence these trends?

7.5 FUTURE ENERGY NEEDS AND CONSERVATION

Energy is an essential input for industrial development. Energy is produced from commercial sources like coal, petroleum, hydroelectric schemes as well as from non-commercial sources like cow dung, fuel wood and agricultural wastes. Per capita consumption of commercial energy is sometimes used as an index of the economic advancement that a country has attained. India's per capita consumption of commercial energy, however, is very low. It is only one eighth of the world average.

Commercial energy accounts for a little over half of the total energy used in the country, the rest coming from non-commercial sources. Share of agriculture in commercial energy consumption has risen rapidly over the past two-and-a-half decades. Industry consumed about 78 per cent of the coal and 62 per cent of the electrical energy in the country in 1985-86. The transport sector accounted for 56 per cent of the total oil consumption during the year 1989. The energy consumption of these sectors as well as the household sector are increasing rapidly. The energy strategy, therefore, has to plan not only for an increase in indigenous availability but also aim at its efficient utilisation.

7.5.1 Conservation and Energy

Energy generation and environmental conservation are the twin issues arising from exploitative interaction of humans with natural resources.Excessive utilisation of coal and oil for generation of electricity leads to the multiple problems of acid rain, and rising carbon dioxide levels in the atmosphere. Huge dams can make substantial contributions to economic development in electricity in developing countries like India, but as in any large-scale electricity generating option, there are trade-offs. Reservoirs inundate forests, farmland and wildlife habitats and uproot entire communities of indigenous people.

The answer to the country's energy needs can only lie in adopting non-conventional sources of energy. A beginning is being made by Government of India to give the same type of resources and support to developing alternative sources of energy as have so far been extended to the development of conventional energy sources.

In the following sections we will study some of the important means of energy conservation through the incorporation of innovative and imaginative alternatives within conventional rural agricultural technologies.

7.5.2 Development of Non-Polluting Energy Systems in India

I) **Improved Chullahas:** In developing countries like India, the energy needs of rural poor are mostly met with by burning firewood. Traditional methods of cooking are very unhealthy for the cook, as they emit a lot of smoke. Also the heat released in burning is not efficiently utilised. Indian energy scientists have come up with smokeless stoves **(chulhas)** (Fig. 7.19) specially designed for Indian conditions. These 'Chulhas' are smokeless, permit shorter cooking time and there is also saving of fuel. In India, the overall renewable energy capacity targets have been raised from 35,776 MW in 2015 to 1,75,000 MW by 2022 (MOEF & CC, 2015). This comprises of 1,00,000 MW solar, 60,000 MW wind, 10,000 MW Biomass and 50,000 MW.

Fig. 7.19: smokeless stove (chulhas) .

The improved 'chulha' has invoked tremendous response and positive action from all concerned. Nearly 3,000 villages have been rendered 'smokeless' in the sense that in each house of these villages, either an improved 'chulha' or a biogas plant is used for cooking food. A trained work force of more than 50,000 persons, mainly women, was created to work as master craftsmen for constructing the improved chulhas.

II) **Energy from City Sewage:** The city sewage treatment plants use anaerobic digestion units for extracting methane from human night soil which is in the form of a sludge. The gas generated from the sludge is called sludge gas, which like biogas consists largely of methane. The Department of Non-Conventional Energy Sources has supported setting up sewage based biogas plants in Uttar Pradesh, MadhyaPradesh and Delhi.

One large size urban waste recycling plant is already operating at Okhla, Delhi. The plant comprises 15 digesters connected to 15 gas collectors. The total gas generation from the plant is about 0.6 million cubic feet per day having a heat value of 700-800"BTU" per cubic foot (equivalent to 500-570 cal per m3). The gas is being supplied to about 800 households over an area of four kilometers. The gas is about 50 per cent cheaper than the LPG gas. Another such project has been commissioned, recently at Pandraune in UP. Plants are under construction at Ayodhya in UP, Eshaopur in Delhi, and at Bhopal in MP. In Jabalpur, Municipal Corporation is setting up agarbage-based power plant to generate 7 MW electricity daily.

Many bio-organic wastes are released as by-products by distilleries in India. A new technology for waste recycling and disposal has been introduced for the first time in the country by a distillery in Gujarat. The technology, simultaneous with the treatment of 45,000 litres of waste, will generate energy equivalent to that given by10 tonnes of coal every day. The fuel is generated from the waste after fermenting the ash with yeast in a suitable culture medium. The 10 million litre capacity distillery can get 50 per cent of its fuel requirement from recycling its own waste. If all the 150 distilleries in the country adopt the technology there could be a saving of Rs 30 crores or **5,00,000** tonnes of coal annually. This will also result in an environmentally safe disposal of wastes.

III) **Solar Energy:** Biogas is a cheap and efficient fuel and its feedstock is renewable.More recently, other renewable sources for energy generation are being explored.Systematic efforts are being made to tap solar energy for meeting the demands of our rural poor. It is a decentralised energy system, which can be used to meet versatile needs of the Indian masses. Solar cooking, water heating, water desalination, space heating, crop drying, etc. are some of the modes of thermal conversion. Efforts are on to economically develop solar collectors for high temperature applications. More than 380 solar water heating systems are operating in the country. More than 1,000 large capacity water heating systems are under installation.

Solar energy can also be converted into electrical energy. Solar panels concentrate large amounts of light energy on photovoltaic cells which charge the batteries that serve as a source of electricity. This electricity can be used to run pumps, streetlighting system or even refrigerators. More than 160 solar photovoltaic pumps have been installed in the rural areas providing water for drinking and irrigation. Solar photovoltaic street lighting systems have been provided by Government of India in more than 150 villages on experimental basis. Installed in the remote villages, alsoknown as **Urjagrams**, far from power lines, solar energy makes electricity availableto people who would otherwise not be able to dream of thermal or hydel electrical energy.

IV) **Wind Energy:** Another renewable alternative source of energy is wind energy.Wind energy holds promise for systematic utilisation. The maximum exploitable potential has been estimated at about 3.2 xlo8 J/ year. It can be converted intomechanical and electrical energies and would be particularly useful in remote areas.Wind energy can be made to run turbine to generate electricity. According to Indian Meteorological Department average annual wind density of 3 kwh/m^2/day (read as kilo watt hours per square meter per day) is prevalent at a number of places in Peninsular and Central India. In some areas, the densities are higher than 10kwh/m^2/day during winter when energy requirements are very acute and 4kwh/m^2/day for 5-7 months in a year. At present this energy is being used to upwell ground water at four locations of Ajmer in Rajasthan. DNES has installed 924 wind pumps throughout the country. Wind electricity generators at appropriate locations(like Ladakh) are envisaged

with aggregate capacity of 2 MW, for lighting and pumping water in addition to devising charging of batteries. In the 8th Plan, some 85 new wind-powered mills are proposed to be installed at various locations in India, where the aerodynamics of the area provides conditions suitable for this venture.

Today, there are more than 100 manufacturers in the country engaged in the production and development of different renewable energy systems and devices. It is estimated that by the end of this century, 20 per cent of the total energy demand will be met from the following non-conventional energy sources.

Try the following SAQ to see what you have understood of the various

non-conventional sources of energy. Compare your answers with those given ‘ at the end of this unit.

SAQ 4

a. What is the difference between commercial and non-commercial sources of energy?

b. State whether the following statements are correct or incorrect. Indicate youranswer by putting a ( ) or (x) in the boxes provided.

   i) City sewage cannot be used for generation of biogas.

   ii) Smokeless ‘Chulhas’ permit shorter cooking time along with saving of fuel.

   iii) Gobar gas or biogas can be used for cooking, lighting and power generation for running refrigerators or tube well pump sets.

   iv) Urjagrams are earmarked villages in which non-conventional alternate energy generating systems have been installed by Government on experimental basis.

c. Compare and contrast conventional versus alternate systems of energy generation.

7.6 SUMMARY

Let us summarise what we have learnt so far:

- Today’s modern industrial societies are characterised by the intensive use of energy. You cannot think of life without electricity or other source of energy.
- India consumes roughly 3% of world’s total energy.
- Mainly there are two sources of energy viz i) Non-conventional sources such as biomass, solar, fuel cell, geothermal, Co-generation and wind energy, ii) Conventional sources of energy like natural oil energy, gas, coal and hydro power energy.

- The amount of energy consumed per person each year is a useful measure of standard of living.
- Energy demand of developing countries is increasing due to population growth and industrialisation.
- Renewable energy sources are virtually inexhaustible. They generate with minimal pollution, causing no oil spill, nuclear meltdown, nuclear water, smog or acid rain. Renewable energy sources have no fuel costs and are freely available.
- Switching to clean, renewable energy will bring us cleaner air and water while improving human health and increasing energy security.
- Conservation of energy sources is urgently required as its excessive consumption is not only costly but also leads to multiple problems. Moreover, dependence of modern human on innovative and non-conventional sources of energy has become the only alternative.

7.7 TERMINAL QUESTIONS

1. What are the differences between conventional and non-conventional sources of energy?
2. How is biogas helpful in meeting the energy crisis of people living in rural areas?
3. Discuss any two non-conventional means of generating energy.

7.8 ANSWERS

Self-Assessment Questions

1. (i) a (ii) b (iii) c (iv) c (v) b
2. (a) maximum, b) energy, c) more, d) sustainable
3. Refer to section 7.4.
4. a) The sources of energy which are produced on a large-scale for the purpose of sale are called **commercial,** such as coal, petroleum, electricity. Those sources which serve only local needs and are not produced on a large-scale are called **non-commercial** sources such as firewood, cowdung and agricultural wastes.

   b) i) × ii) ✓ c) ✓ iv) ✓

   c) Conventional systems of energy generation are less efficient, more polluting and non-renewable whereas alternate sources of energy are innovations providing clean and efficient means of energy generation using renewable resources.

Terminal Questions

1. The conventional sources of energy such as coal, petroleum are non-renewable; they make use of old technologies for energy generation and cause environmental damage. Non-conventional sources of energy such as solar energy, energy from biomass, are based on renewable resources; they make use of comparatively recent technologies and cause minimum damage to the environment. Non-conventional sources of energy are decentralised means of making energy available to rural poor located in remote areas.

2. Refer to section 7.2.

3. The two non-conventional methods of energy generation are: a) generation of electricity through solar cells, and b) generation of electricity through wind power. In the first case, solar panels collect solar radiation and reflect it on photovoltaic cells, which become charged and can be used as battery of cells. The second makes use of force of wind to rotate a motor which generates electricity.

7.9 FURTHER READING

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Acknowledgement for Figures

1. Fig. 7.1: Biomass gasifier.

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2. Fig. 7.10: Use of renewable energy as wind pump.

   https://en.wikipedia.org/wiki/File:Turbines-thar-india.jpg

3. Fig. 7.12: Hydro Power. (Source: http://www2.emersonprocess.com/SiteCollectionImages /News%20Images/Agua%20Verm080.jpg)

4. Fig. 7.13: A view of atomic power station. (Source: http://www.power-eng. com/content/dam/Pennenergy/online-articles/2013/February /Sequoyah-Nuclear-Plant.jpg)(Source: http://seco.cpa.state.tx.us/images/manure-biogas.gif)

5. Fig. 7.14: Energy consumption in selected Asian countries 1980-2001. (Source: http://cdn0.wn.com/o25/ar/i/aa/d36e6ebee51ddd.jpg)

6. Fig. 7.15: World population and global primary energy use projections to 2100. Notice that at present the world uses roughly 9 gtoe worth of energy per year. (Source: http://www.euanmearns.com/wp-content/uploads /2014/07/world_energy_population.png)

7. Fig. 7.16: World energy intensity by region 1970-2020.(Source: http://web.fc2 .com/jump/?url=http://oilpeak.web.fc2.com/myenvironmentalism/technology /ieo2000/figure-11.jpg)

8. Fig. 7.17 An illustration of energy consumption in the developed world Source:https://pixabay.com/photos/hong-kong-city-urban-skyscrapers-1990268/

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

Block

3

ENVIRONMENTAL ISSUES AND CONCERNS

BLOCK 3 ENVIRONMENTAL ISSUES AND CONCERNS

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

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

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

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

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

UNIT 8

BIODIVERSITY : THREATS AND CONSERVATION

Structure

8.1 INTRODUCTION

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

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

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

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

Expected Learning Outcomes

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

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

8.2 CAUSES OF BIODIVERSITY LOSS

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

8.2.1 Habitat Loss

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

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

Box. 8.1: Case study 1: Fragile habitats

Coral Reefs

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

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

Oceanic Islands

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

Habitat Islands

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

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

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

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

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

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

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

8.3 HUMAN–WILD LIFE CONFLICT

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

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

8.3.1 Selective Destruction of Species

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

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

8.3.2 Domestication of Selective Species

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

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

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

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

8.3.3 Use of Pesticides

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

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

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

8.3.4 Global Climate Change

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

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

SAQ 1

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

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

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

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

8.4 POACHING OF WILD LIFE

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

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

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

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

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

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

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

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

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

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

8.5 BIOLOGICAL INVASION

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

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

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

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

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

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

SAQ 2

a) Invasive species which causes skin allergies

i) water hyacinth

ii) congress weed

iii) mesquite

iv) sweet pea

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

c) Discuss the harmful effects of invasive species with example

8.6 NEED FOR CONSERVING BIODIVERSITY

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

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

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

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

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

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

8.7 CONSERVATION OF BIODIVERSITY

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

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

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

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

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

8.7.1 *In-situ* Conservation

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

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

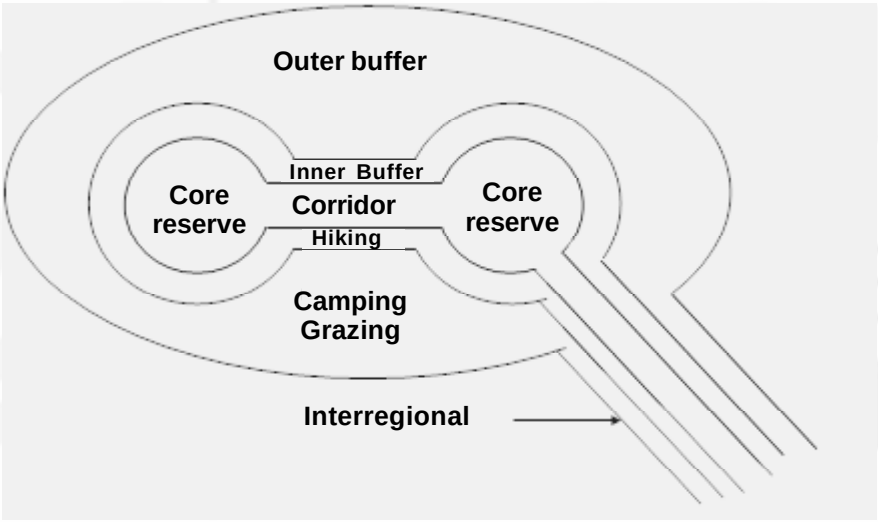

Fig.8.2: Structure of preserved areas

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

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

- **National parks and sanctuaries**

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

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

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

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

Box. 8.2: Tigers Reserves

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

Fig. 8.3: Indian Tiger.

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

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

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

Captive Breeding Programmes

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

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

Crocodile Conservation

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

SAQ 3

a) Total number of Biosphere Reserves in India are

   i) 12

   ii) 14

   iii) 16

   iv) 18

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

8.7.2 *Ex-situ* Conservation

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

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

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

- **Botanical Gardens**

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

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

- **Zoological Parks**

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

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

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

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

Ex-Situ conservation of wild animals in zoo

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

i) **Captive breeding**

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

ii) **Embryo Storage and transfer technology**

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

iii) **Artificial insemination**

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

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

iv) **Somatic cell cloning**

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

v) **Fostering**

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

vi) **Translocations**

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

vii) **Introduction**

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

viii) **Reintroduction**

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

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

Seed Bank

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

Seeds Storing

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

Tissue Culture

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

SAQ 4

a) Which of the following provides genetic insurance

   i) tissue culture

   ii) somatic cell cloning

   iii) introduction

   iv) seed bank

b) Artifical insemination can be beneficial in

   i) Dogs

   ii) Cats

   iii) Elephants

   iv) Snakes

8.8 NATURE RESERVES

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

Biosphere Reserves

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

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

Fig. 8.5: Sundarban Biosphere Reserve.

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

Wetlands

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

Fig. 8.6: Wetlands.

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

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

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

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

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

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

Bulwark a defensive wall, especially of earth

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

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

Fig. 8.7: Mangroves acting as bulwark for environment.

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

Box 8.3: Natural Wetlands of India

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

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

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

8.9 SUMMARY

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

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

8.10 TERMINAL QUESTIONS

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

8.11 ANSWERS

Self-Assessment Questions

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

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

Terminal Questions

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

8.12 FURTHER READING

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

Internet Sites

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

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

Acknowledgement for Figures

1. Fig. 8.3 Indian Tiger

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

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

3. Fig. 8.5 sundarban reserves

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

UNIT 9

ENVIRONMENTAL POLLUTION AND HAZARDS

Structure

9.1 INTRODUCTION

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

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

Expected Learning Outcomes

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

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

9.2 WHAT IS POLLUTION?

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

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

Pollutants can be grouped into two broad categories:

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

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

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

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

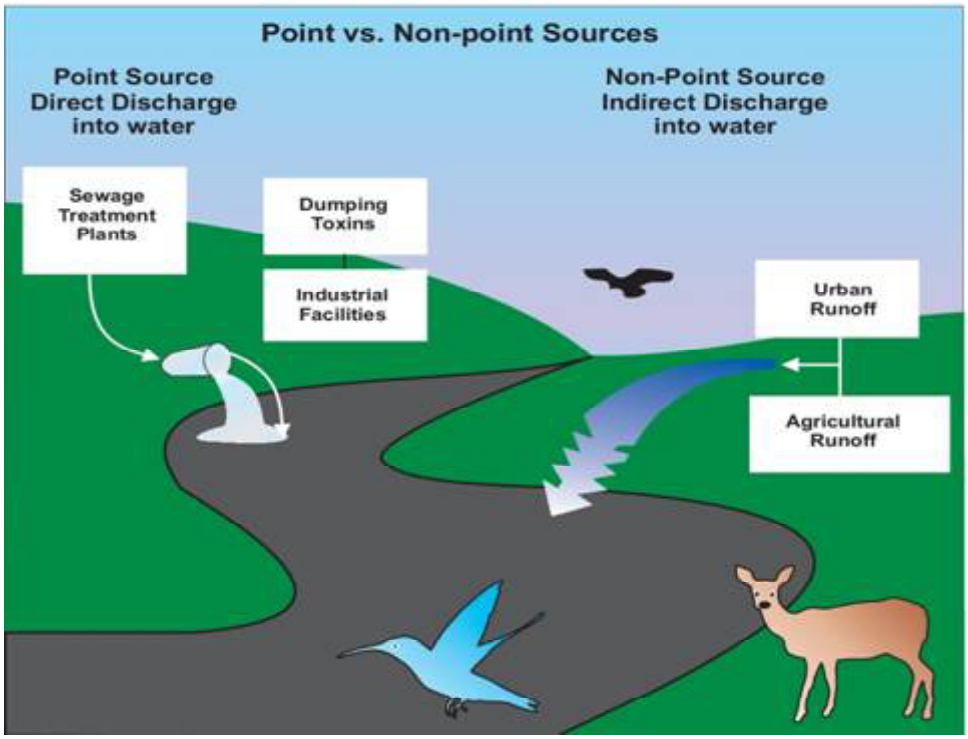

Fig. 9.1: Point and non-point sources of water pollution

9.3 CAUSES OF ENVIRONMENTAL POLLUTION

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

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

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

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

Source: Vital Signs, 1995, World Watch Institute

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

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

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

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

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

SAQ 1

Fill in the blanks:

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

ii) Plastics are …… type of pollutants.

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

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

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

9.4 AIR POLLUTION

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

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

9.4.1 Types of Air Pollutants

Broadly air pollutants can be grouped into following categories.

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

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

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

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

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

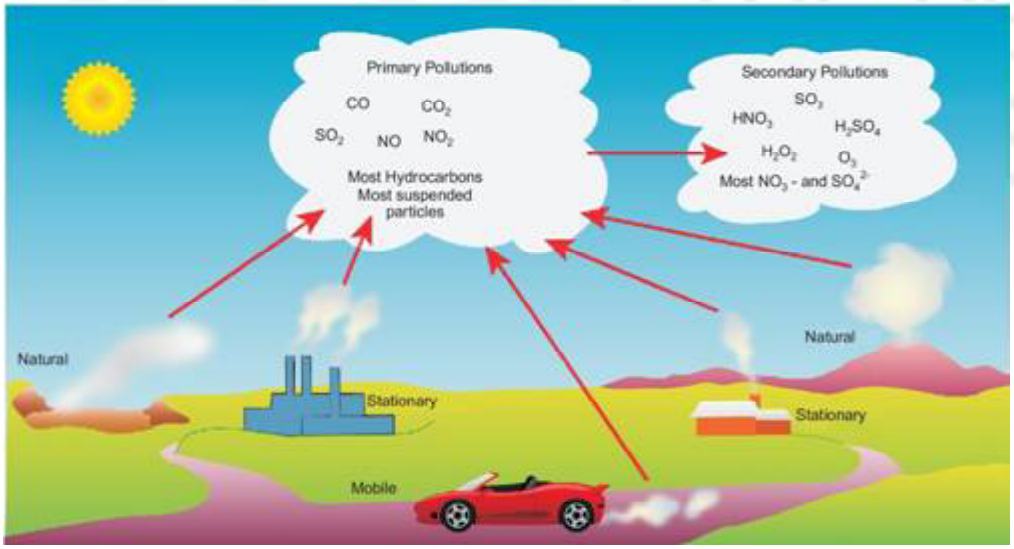

Fig. 9.2: Primary and secondary pollutants in the atmosphere result due to natural and human activities.

9.4.2 Major Air Pollutants

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

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

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

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

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

9.4.3 Air Pollution and Atmospheric Problems

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

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

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

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

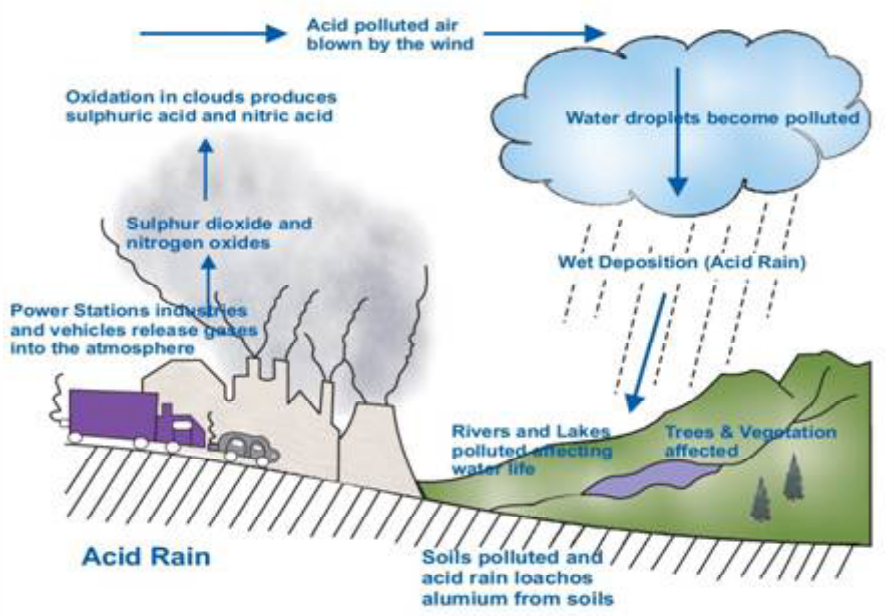

Fig. 9.3: Acid precipitation and its pathways.

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

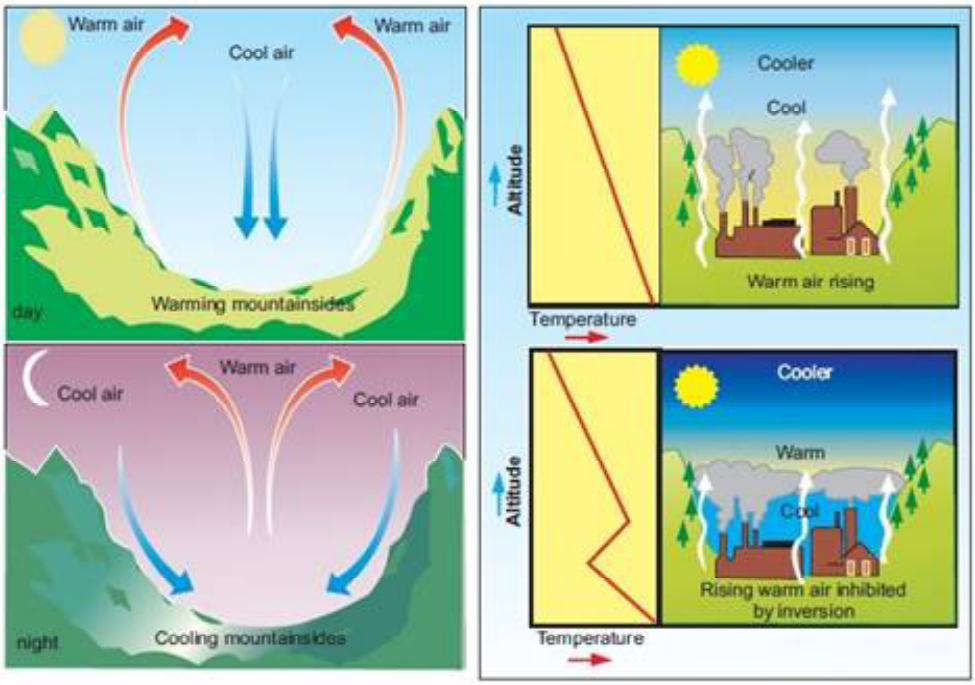

Fig. 9.4: Temperature inversion phenomenon. (a) Sun heats the ground during the day, warms the air near surface. Warm air rises up carrying dust and pollutant aloft. (b) At night the heat from the grounds devoid of greens as well as the paved streets quickly escapes into the sky

9.4.4 Case Study: Bhopal Gas Tragedy

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

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

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

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

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

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

SAQ 2

Match column A with Column B:

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

9.5 WATER POLLUTION

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

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

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

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

9.5.1 Types of Water Pollutants

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

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

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

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

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

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

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

9.5.2 Marine Pollution

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

Fig. 9.8: Oil spill in ocean killing animals.

9.5.3 Thermal Pollution

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

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

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

9.5.4 Water Quality Parameters

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

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

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

SAQ 3

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

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

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

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

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

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

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

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

9.6 SOIL POLLUTION

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

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

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

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

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

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

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

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

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

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

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

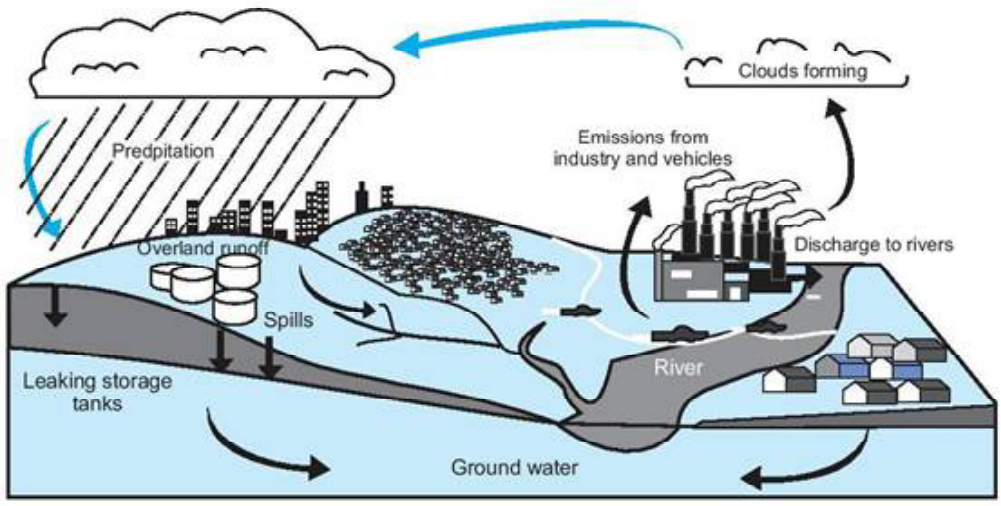

Fig. 9.9: Movement of chemicals through the components of the environment.

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

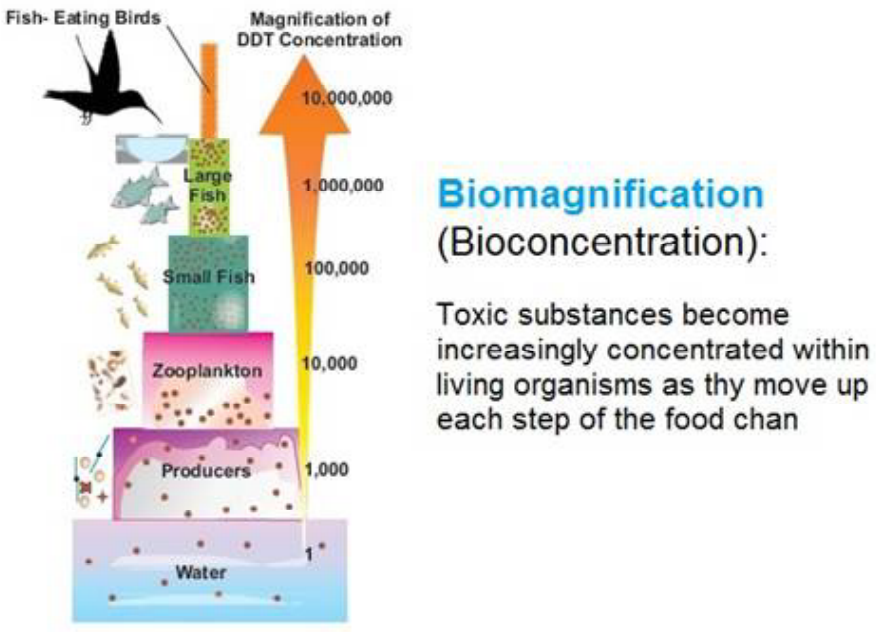

Fig. 9.10: Bioaccumulation and biomagnification of pollutants in the food chain.

9.7 NOISE POLLUTION

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

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

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

SAQ 4

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

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

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

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

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

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

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

9.8 SUMMARY

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

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

9.9 TERMINAL QUESTIONS

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

9.10 ANSWERS

Self-Assessment Questions

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

Terminal Questions

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

9.11 FURTHER READING

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Acknowledgement

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

UNIT 10

WASTE MANAGEMENT

Structure

10.1 INTRODUCTION

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

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

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

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

Expected Learning Outcomes

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

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

10.2 HAZARDOUS WASTES

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

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

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

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

Recyclable: paper, glass, metals, and plastics.

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

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

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

10.2.1 Toxic Versus Hazardous

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

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

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

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

SAQ 1

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

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

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

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

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

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

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

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

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

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

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

10.3 CONCEPT OF WASTE MANAGEMENT

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

i) Minimising the quantity of waste

ii) Recycling of industrial waste

iii) Treatment of the waste

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

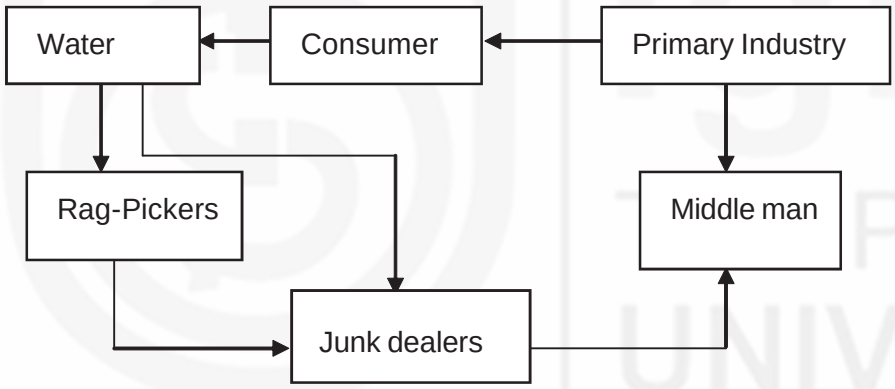

Fig. 10.1: Recycling of Wastes.

10.3.1 Waste Minimisation

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

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

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

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

Recycling: Some Benefits

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

Various ways of Reusing things:

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

10.3.2 Recycling Industrial Wastes

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

Scraps and Used Metals

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

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

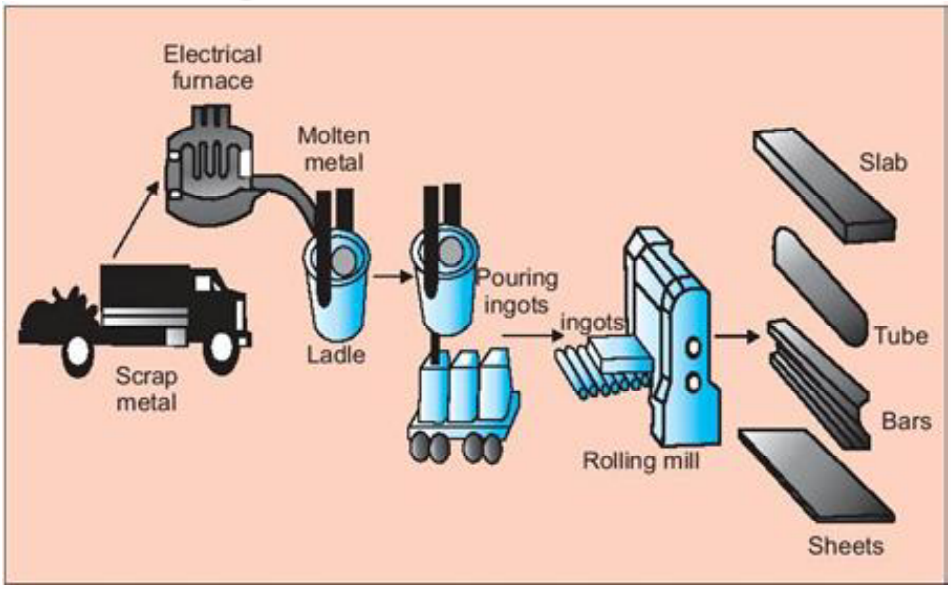

Fig. 10.3: "Minimills" remelt and reshape scrap iron and steel.

SAQ 2

A. Fill in the blanks using appropriate words :

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

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

b) ..... of industrial waste

c) ..... of the waste

d) ..... and disposal of waste

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

a) ..... modification

b) ..... of waste and

c) ..... segmentation.

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

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

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

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

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

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

10.3.3 Treatment of Hazardous Wastes

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

- physical treatment
- chemical treatment

- biological treatment
- solidification, and
- incineration

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

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

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

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

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

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

Box 10.1 : Waste Water Treatment

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

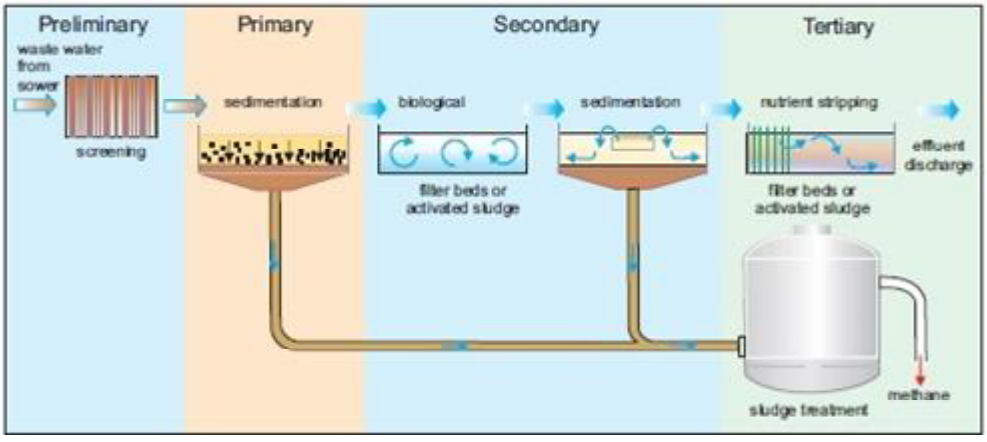

Fig. 10.4: Sewage treatment processes.

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

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

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

10.3.4 Solid Waste Management

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

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

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

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

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

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

SAQ 3

Fill in the blanks using appropriate words:

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

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

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

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

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

10.4 DISPOSAL OF WASTE

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

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

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

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

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

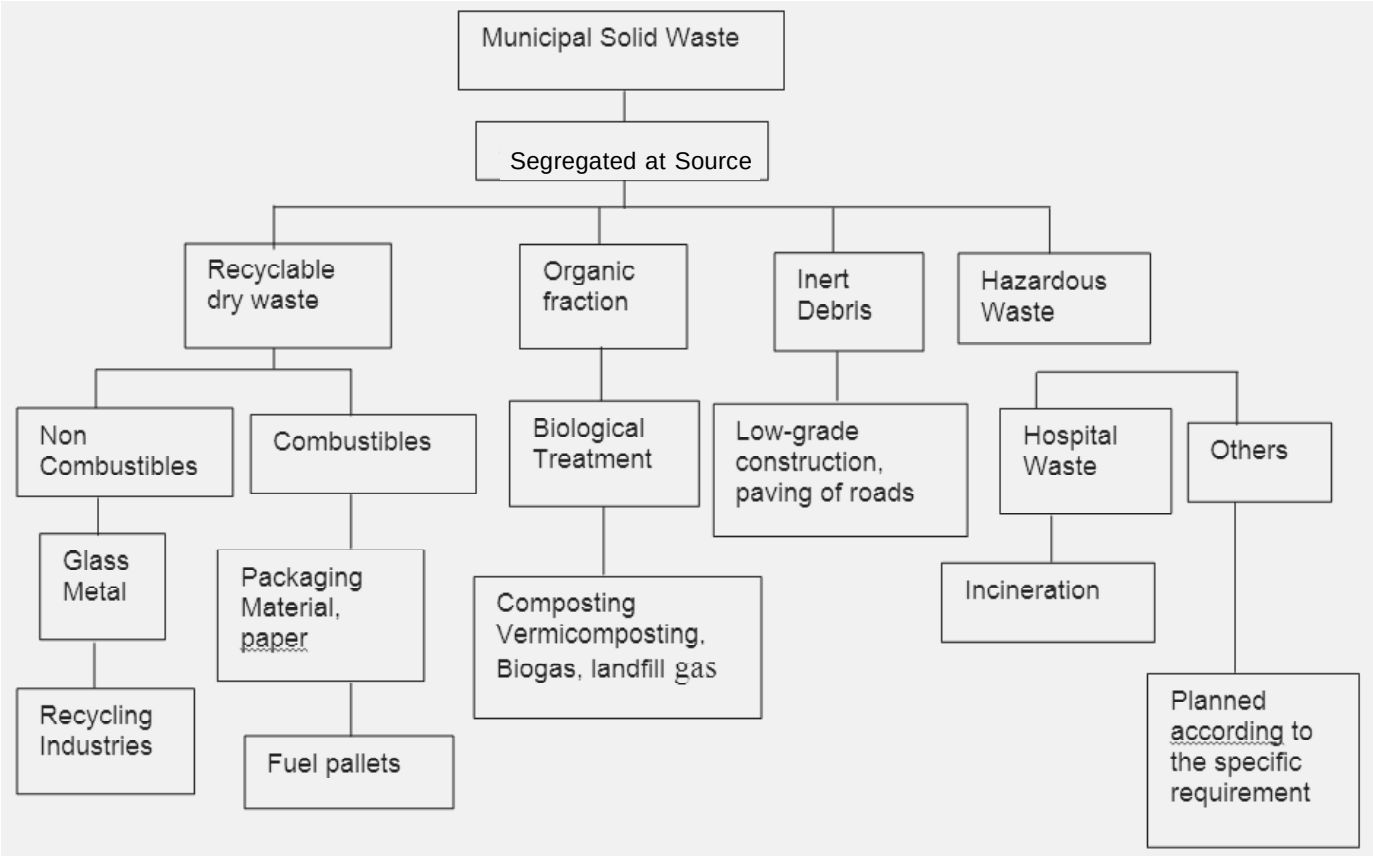

Fig. 10.5: Steps involved in the management of municipal solid waste.

10.4.1 Landfill Disposal

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

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

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

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

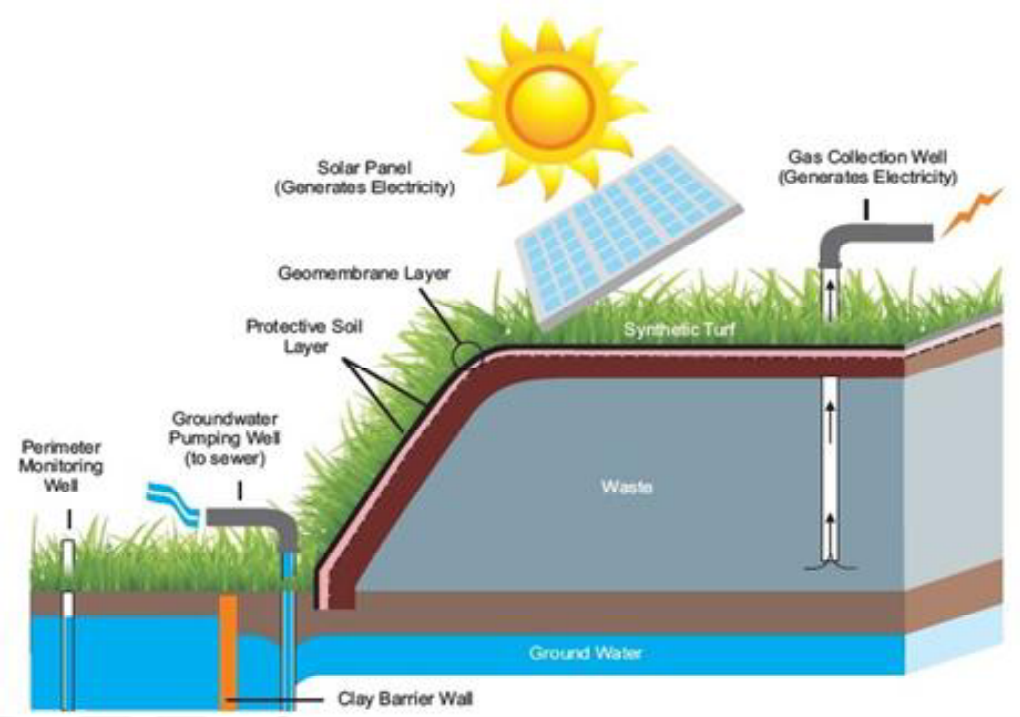

Fig. 10.6: Outline of a typical landfill site.

10.4.2 Incineration

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

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

10.4.3 Dumping at Sea

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

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

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

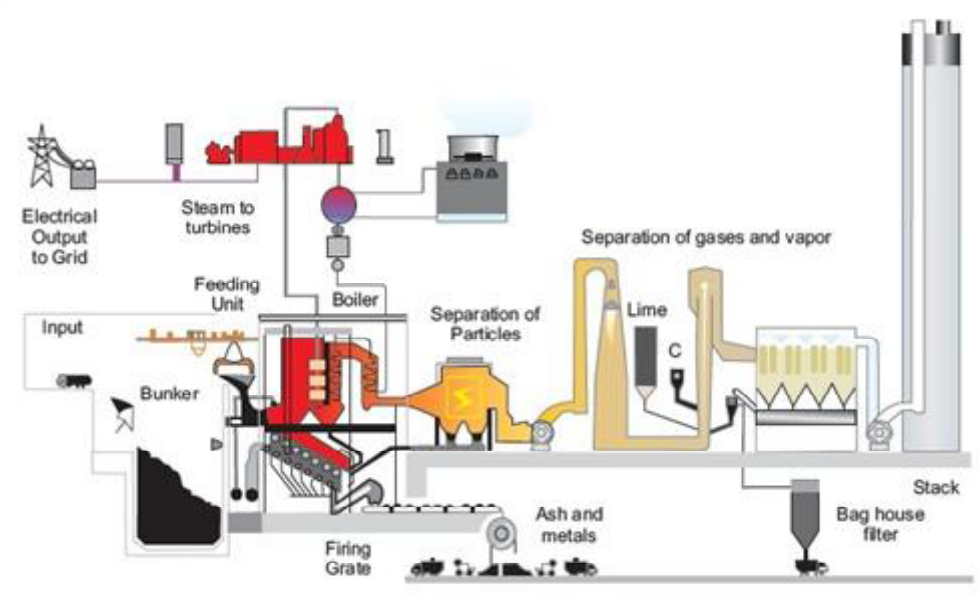

Fig. 10.7: A typical hazardous waste incineration unit.

10.4.4 Underground Disposal

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

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

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

SAQ 4

Fill in the blanks using appropriate words:

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

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

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

10.5 WASTE MANAGEMENT IN INDIA

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

10.5.1 Sources of Waste Generation

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

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

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

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

10.5.2 Prevalent Methods of Disposal

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

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

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

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

10.6 IMPACT OF IMPROPER WASTE DISPOSAL

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

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

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

i) direct ingestion through drinking

ii) inhalation of contaminants that volatilise from heated water

iii) absorption through the skin during washing and bathing

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

v) absorption through the skin when handling contaminated soil.

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

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

SAQ 5

Fill in the blanks using appropriate words:

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

a) Disposal along with …….....

b) Disposal in ..... areas

c) Disposal in river beds and …….....

d) Disposal into ..... and sea

e) ……..... burning

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

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

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

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

10.7 SUMMARY

In this unit we have learnt that:

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

10.8 TERMINAL QUESTIONS

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

   i) Toxic refers to an extrinsic property.

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

iii) Oily sludge has to be landfilled.

iv) Hospital waste has to be incinerated.

v) Pollution control facilities do not generate hazardous waste.

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

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

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

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

10.9 ANSWERS

Self-Assessment Questions

1. i. mutagenic, teratogenic, carcinogenic

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

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

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

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

   iii) reuse, recycling

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

3. i. detoxified, neutralised, harmless

   ii. output stream, energy

   iii. lagooning, sludge drying, storage

   iv. conditioning, digestion, composting, thickening

   v. oxidation, volume

4. i. economic, properties, non-compatible

   ii. home, foul, smoke, harmful

   iii. landfills, non-porous, leaking

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

   ii. soil, groundwater

   iii. food

   iv. air, fire

Terminal Questions

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

10.10 FURTHER READING

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Acknowledgement of Figures

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

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

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

   Source: CPCB Report on Management of Municipal Solid Waste

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

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

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

UNIT 11

GLOBAL ENVIRONMENTAL ISSUES

Structure

11.1 INTRODUCTION

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

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

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

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

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

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

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

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

Expected Learning Outcomes

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

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

11.2 GLOBAL WARMING AND CLIMATE CHANGE

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

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

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

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

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

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

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

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

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

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

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

More detailed information is available at the following websites:

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

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

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

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

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

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

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

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

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

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

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

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

http://unfccc.int/2860.php

http://newsroom.unfccc.int/

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

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

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

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

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

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

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

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

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

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

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

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

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

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

This is to be achieved through the following eight missions:

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

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

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

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

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

SAQ 1

What are greenhouse gases? Give some examples.

SAQ 2

What is full form of UNFCCC?

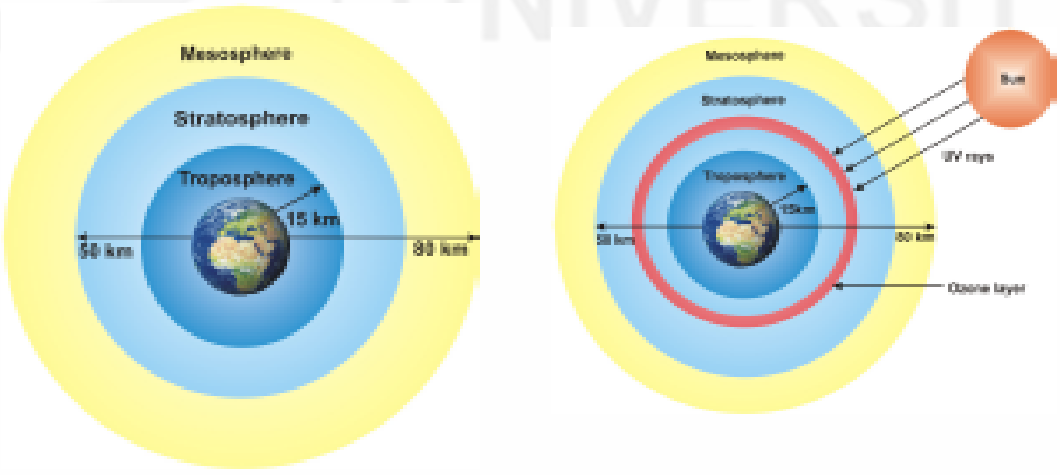
SAQ 3

Discuss the harmful effects of global warming.

11.3 OZONE LAYER DEPLETION

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

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



(a) (b)

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

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

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

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

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

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

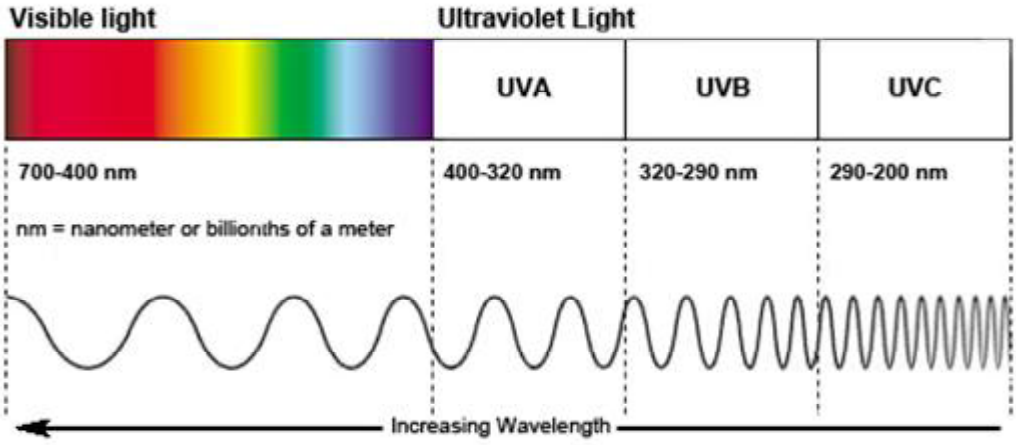


Fig.11.2: Various regions of ultraviolet radiation.

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

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

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

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

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

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

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

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

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

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

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

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

More information can be obtained from the following:

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

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

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

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

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

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

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

SAQ 4

Ozone is present in which zone of atmosphere?

SAQ 5

What are CFCs? Why are they harmful?

SAQ 6

When is ozone day celebrated?

11. 4 ACID RAIN

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

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

The pH of an acid is defined as follows:

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

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

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

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

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

Carbon dioxide — Water — Carbonic acid

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

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

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

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

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

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

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

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

Sulphuric acid

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

Nitric acid

Both sulphuric acid and nitric acid are strong acids.

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

Hence, acid rain is regarded a global issue.

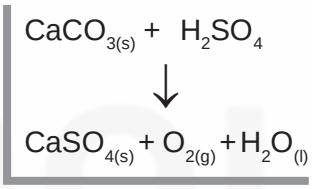
Effects of Acid Rain

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

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

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

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



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

SAQ 7

What is the pH of normal (unpolluted) rain?

SAQ 8

Name the acids mainly present in acid rain.

SAQ 9

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

11.5 ACTIVITIES

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

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

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

11.6 SUMMARY

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

11.7 TERMINAL QUESTIONS

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

11.8 ANSWERS

Self-Assessment Questions

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

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

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

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

Terminal Questions

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

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

11.9 FURTHER READING

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

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

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

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

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ABILITY ENHANCEMENT COMPULSORY COURSE ON ENVIRONMENTAL STUDIES

Block

4

PROTECTING OUR ENVIRONMENT: POLICIES AND PRACTICES

BLOCK 4: INTRODUCTION

In **Block 1,** Unit 1 introduces concept of environment and environmental studies. Unit 2 discusses about the concept of ecosystem and Unit 3 describes about major ecosystem. In Block 2, we discussed in detail about the importance of various natural resources, their uses in development and the effect of developmental activities on the environment. In Block 3, we discussed in detail about the various environmental issues and concerns such as loss of biodiversity, environmental hazards, pollution, waste management and some global environmental problems namely global warming, climate change, ozone layer depletion and acid rain.

In this block we will discuss about various policies and programmes initiated to tackle emerging environmental issues and concerns. This block has three units.

Unit 12 Environmental Laws: In order to protect human kind and other living beings from environmental problems, and to curtail the activities affecting the environment negatively, numerous agreements have been signed among the countries, and legislations have been enacted at national level. This unit will discuss some important environmental legislation. The coverage includes Indian legislations called Acts, and international legislations in the form of Conventions, Protocols and Treaties. The success of environmental legislations mainly depends on the way these are enforced. One section of this unit is, therefore, devoted to issues involved in enforcement of environmental legislations. At the end, contribution of people through PIL (Public Interest Litigation) and India's institutional arrangements for monitoring and enforcement have also been discussed.

Unit 13 Human Communities and Environment: In this Unit you will learn how over exploitation of natural resources has led to environmental degradation and indiscriminate industrialisation has led to deforestation and related problems of natural calamities, resettlement and rehabilitation. You will also be able to learn the Issues related to disaster management.

Unit 14 Environmental Ethics: This unit reviews the environmental ethics, our view and beliefs about nature and environment, issues of environmental equity, env mental crisis, environmental justice and racial discrimination at the policy and public level in managing the environment. This unit also discusses teachings about environment in the major religions practiced all over the world.

UNIT 12

ENVIRONMENTAL LEGISLATION

Structure

12.1 INTRODUCTION

In this course so far we have covered many environmental issues such as depletion of natural resources, degradation of land, pollution of water and air, impacts of agricultural practices, industrialization, urbanisation and some aspects of environmental management such as sustainable development, and conservation of natural and biological resources. We have also talked about the concept of environmental quality and environmental standards, which needs to be maintained.

As human civilisation progressed, man started altering the natural environment in the pursuit of creating an economic, social and cultural environment of his own choice. This slowly resulted in the depletion of natural resources and degradation of environment. Further, with increased human population, rapid industrialisation and urbanization, and developmental projects have placed a lot of strain on natural resources. Now situation is deteriorating so fast that environmental problems are posing threats to human health and to his very existence. In order to protect human kind and other living beings from environmental problems, and to curtail the activities affecting the environment negatively, numerous agreements have been signed among the countries, and legislations have been enacted at national level. In this unit, we will discuss some important environmental legislations. The coverage includes Indian legislations called Acts, and international legislations in the form of conventions, protocols and treaties.

The success of environmental legislations mainly depends on the way these are enforced. One section of this unit is, therefore, devoted to issues involved in enforcement of environmental legislations. At the end, contribution of people through PIL (Public Interest Litigation) and India's institutional arrangements for monitoring and enforcement have also been discussed.

Expected Learning Outcomes

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

- ❖ state various Acts enacted for the protection of environment at national level;
- ❖ describe various conventions and protocols framed for global environmental issues;
- ❖ explain the difficulties in the enforcement of the environmental legislations; and
- ❖ analyse the contributions of public interest litigation, Ministry of Environment, Forest and climate change, and CPCB in protection of environment.

12.2 CURRENT STATUS

In recent past, numerous environmental problems have become critically significant for mankind. These include air, water and land pollution, spread of toxic wastes, deforestation, mass extinction of wild life, problem of human settlement, climate change depletion of ozone layer and over exploitation of natural resources. An important aspect of environmental problems is that these have international repercussions, i.e. their impact is not confined to their source area alone but spills over far and wide. Pollution does not observe political territories and legislative jurisdictions. Thus, environmental problems are intrinsically global in nature. Therefore, to fight with the environmental problems we need not only legislation at national level but also mutually beneficial agreements at international level.

12.2.1 National Legislations

At national level a serious effort have been made for the improvement and protection of environment by an amendment to the Constitution of India. Our Constitution, originally, did not contain any direct provision regarding the protection of natural environment. However, after the United Nations Conference on Human Environment at Stockholm, the Constitution of India was amended, to include protection of the environment as a constitutional mandate. The constitution (Forty-Second Amendment) Act, 1976 has made it fundamental duty to protect and improve the natural environment by Clause (g) to Article 51A:

"It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and have compassion for living creatures."

There is a directive, given to the State as one of the Directive Principles of State Policy regarding the protection and improvement of the environment. Article 48A states "The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country". The Department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985, which was renamed as Ministry of Environment, Forest and Climate Change in May, 2014. This Ministry has the overall responsibility for administering and enforcing environmental legislations and policies.

The constitutional provisions are backed by a number of legislations – Acts and rules. Much of our environmental legislations are enacted as Acts by the Parliament or the State Legislatures. These Acts generally delegate powers to regulation agencies, to make rules for the purpose of their implementation.

Existing Indian environmental legislations can be grouped in following four categories:

a) Water Acts

b) Air Acts

c) Forest and Wildlife Acts

d) General Acts

To provide an overview of environmental legislations, a few important legislations of each category with brief description are given below:

a) Water Acts

To provide legislative support for prevention of water pollution, Parliament passed the Water (Protection and Control of Pollution) Act, 1974. The main objective of this Act is to prevent and control water pollution. Some important provision of the Water Act, 1974 and Amendment, 1988 are given below:

The Water (Prevention and Control of Pollution) Act of 1974 and Amendment, 1988

- The Act vests regulatory authority in state boards and empowers these boards to establish and enforce effluent standards for factories discharging pollutants into bodies of water. A Central Board performs the same functions for union territories and coordinates activities among the states.
- The boards control sewage and industrial effluent discharges by approving, rejecting or conditioning applications for consent to discharge.
- The state boards also minimise water pollution by advising state governments on appropriate sites for new industry.
- Act granted power to the Board to ensure compliance with the Act by including the power of entry for examination, testing of equipment and other purposes and power to take the sample for the purpose of analysis of water from any stream or well or sample of any sewage or trade effluents.

- The 1988 amendment strengthened the Act's implementation provisions. Now, a board may close a defaulting industrial plant or withdraw its supply of power or water by an administrative order; the penalties are more stringent, and a citizen's suit provision supports the enforcement machinery.

The Water (Prevention and Control of Pollution) Cess Act of 1977

The Act creates economic incentives for pollution control and requires local authorities and certain designated industries to pay a cess (tax) for water consumption. These revenues are used to implement the Water Act.

b) Air Acts

To provide legislative support for prevention and control of air pollution, the Government of India enacted a central legislation called the Air (Prevention and Control of Pollution) Act, 1981 referred to as Air Act, 1981. The act aims at prevention, control and reduction of air pollution. Some details of the Air Act, 1981 and Amendment, 1987 is given below.

The Air (Prevention and Control of Pollution) Act of 1981 and Amendment, 1987

- To enable an integrated approach to environmental problems, the Air Act expanded the authority of the central and state boards established under the Water Act, to include air pollution control.
- States not having water pollution boards were required to set up air pollution boards.
- Under the Air Act, all industries operating within designated air pollution control areas must obtain a "consent" (permit) from the State Boards.
- The states are required to prescribe emission standards for industry and automobiles after consulting the Central Board and noting its ambient air quality standards.
- Act granted power to the Board to ensure compliance with the Act include the power of entry for examination, testing of equipment and other purposes and power to take the sample for the purpose of analysis of air or emission from any chimney, fly ash or dust or any other outlet in such manner as may be prescribed.

· The 1987 Amendment strengthened the enforcement machinery and introduced stiffer penalties. Now, the boards may close down a defaulting industrial plant or may stop its supply of electricity or water. A board may also apply to court to restrain emissions that exceed prescribed limits. Notably, the 1987 Amendment introduced a citizens suit provision into the Air Act and extended the Act to include noise pollution.

c) Forest and Wild Life Acts

India is one of the few countries, which had a forest policy since 1894. To protect forest and wild life following legislations have been enacted.

The Wild Life (Protection) Act 1972 and Amendment, 1982

In 1972, Parliament enacted the Wild Life (Protection) Act. The Wild Life Act provides for state wildlife advisory boards, regulations for hunting wild animals and birds, establishment of sanctuaries and national parks, regulations for trade in wild animals, animal products and trophies, and judicially imposed penalties for violating the Act. Harming endangered species listed in Schedule 1 of the Act is prohibited throughout India. Hunting species, like those requiring special protection (Schedule II), big game (Schedule III), and small game (Schedule IV), is regulated through licensing. A few species classified as vermin (Schedule V), may be hunted without restrictions. Wildlife wardens and their staff administer the act.

An amendment to the Act in 1982, introduced a provision permitting the capture and transportation of wild animals for the scientific management of animal population.

India is a signatory to the Convention of International Trade in Endangered Species of Fauna and Flora (CITES, 1976). Under this, export or import of endangered species and their products are governed by the conditions and stipulations laid down therein. Indian government has also started some conservation projects for individual endangered species like Hangul launched in (1970), Lion (1972), Tiger (1973), Crocodiles (1974), and Brown-antlered Deer (1981), and Elephant (1991-92).

The Forest (Conservation) Act of 1980

First Forest Act was enacted in 1927. This is one of the many surviving colonial legislations. It was enacted to consolidate the law related to forest, the transit of forest produce and the duty payable on timber and other forest produce. Subsequently, the Forest (Conservation) Act was promulgated in 1980 to make certain reforms over the preceding Act of 1927.

The 1927 Act deals with the four categories of the forests, namely reserved forests, village forests, protected forests and private forests. A state may declare forestlands or waste lands as reserved forest and may sell the produce from these forests. Any unauthorized felling of trees quarrying, grazing and hunting in reserved forests is punishable with a fine or imprisonment, or both. Reserved forests assigned to a village Community is called village forests. The state governments are empowered to designate protected forests and may prohibit the felling of trees, quarrying and the removal of forest produce from these forests. Forest officers and their staff administer the Forest Act.

Alarmed at India's rapid deforestation and resulting environmental degradation, Centre Government enacted the Forest (Conservation) Act in 1980. Under the provisions of this Act, prior approval of the central Government is required for diversion of forestlands for non-forest purposes. An Advisory Committee constituted under the Act advises the Centre on these approvals.

Biodiversity Act, 2000

India is one of the twelve mega-biodiversity countries of the world and became a party to the International Convention on Biological Diversity in 1994. The

objectives of the convention are: the conservation of Biological Diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. To achieve these goals, Biodiversity Bill 2000 was introduced in Parliament in May, 2000. This was finally passed only in December 2002. This bill seeks to check bio-piracy, protect biological diversity and local growers through a three-tier structure of central and state boards and local committees. These will regulate access to plant and animal genetic resources and share the benefits. The Nation Biodiversity Authority (NBA) set up under the Act, deals with all cases of access by foreigners. Its approval will be required before obtaining any intellectual property right on an invention based on a biological resource from India, or on its traditional knowledge. It will oppose such rights given in other countries. The NBA enjoys the power of a civil court. In addition, centre may issue directives to state if it feels a naturally rich area is threatened by overuse, abuse or neglect.

d) General Acts

The most important legislation in this category is The Environment (Protection) Act of 1986. Through this Act Central Government gets full power for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating pollution. Details of this Act are given below.

The Environment (Protection) Act of 1986

In the wake of the Bhopal tragedy, the Government of India enacted the Environment (Protection) Act of 1986. The Act is an "umbrella" legislations designed to provide a framework for Central Government Coordination of the activity of various central and state authorities established under previous Acts, such as the Water Act and the Air Act.

In this Act, main emphasis is given to "Environment" defined to include water, air and land and the inter-relationships which exist among water, air and land and human beings and other living creatures, plants, micro-organisms and property. "Environmental pollution" is the presence of pollutant, defined as any solid, liquid, or gas substance present in such a concentration as may be or may tend to be, injurious to the environment.

"Hazardous substances" include any substance or preparation, which may cause harm to human beings, other living creatures, plants, microorganisms' property or the environment. The main provisions of this Act are given below:

- Section 3 (1) of the Act empowers the centre to take all such measures as it deems necessary for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution". Specifically, the Central Government is authorized to set new national standards for the quality of the environment (ambient standards) as well as standards for controlling emissions and effluent discharges; to regulate industrial locations, to prescribe procedures for managing hazardous substances; to establish safeguards preventing accidents, and to collect and dismantle information regarding environmental pollution.

- By virtue of this Act, Central Government has armed itself with considerable powers which include, coordination of action by State, planning and execution of nation wide programmes, laying down environmental quality standards, specially those governing emission or discharge of environmental pollutants, placing restriction on the location of industries and so on.
- The powers claimed are indeed comprehensive, the coverage includes handling of hazardous substances, prevention of environmental accidents, inspection of polluting units, research, establishment of laboratories, dissemination of information, etc.
- The Environment (Protection) Act was the first environmental legislation to give the Central Government authority to issue direct orders, included orders to close, prohibit or regulate any industry, operation or process or to stop or regulate the supply of electricity, water or any other service. Other power granted to the Central Government was to ensure compliance with the Act included the power of entry for examination, testing of equipment and other purposes and power to analyse the sample of air, water, soil or any other substance from any place.
- The Act explicitly prohibits discharges of environmental pollutants in excess of prescribed regulatory standards. There is also a specific prohibition against handling hazardous substances except in compliance with regulatory procedures and standards. Persons responsible for discharges of pollutants in excess of prescribed standards must prevent or mitigate the pollution and must also report the governmental authorities.
- The Act provides provision for penalties in the form of a fine or imprisonment or both.
- The Act provides that any person, in addition to authorized government officials, may file a complaint with a court alleging an offence under the Act.

National Environmental Tribunal Act of 1995

This act was passed by the Indian Parliament as a consequence of the Rio de Janeiro Conference. In 1995, the Central Government established the National Environment Tribunal under the National Environmental Tribunal Act 1995. This has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances.

National Green Tribunal (NGT) Act, 2010

Taking into account the large number of environment cases pending in higher courts and involvement of multidisciplinary issues in such cases, as well as the views of the Supreme Court of India, The Law Commission of India recommended the setting up of environmental Court having both original and Appellant jurisdiction.

The National Green Tribunal was established on 18.10.2010 under the National Green Tribunal Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other

natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues. The Tribunal shall not be bound by the procedure laid down under the Code of Civil Procedure, 1908, but shall be guided by principles of natural justice.

The Tribunal's dedicated jurisdiction in environmental matters shall provide speedy environmental justice and help reduce the burden of litigation in the higher courts. The Tribunal is mandated to make and endeavour for disposal of applications or appeals finally within 6 months of filing of the same. New Delhi is the Principal Place of sitting of the Tribunal and at present these are four zonal banches at Bhopal, Pune, Kolkata and Chennai.

The NGT jurisdictions include all environmental laws on air and water pollution, the Environmental Protection Act, the Forest Conservation Act and Biodiversity Act. The NGT has the authority to provide relief and compensation to the pollution victims.

SAQ 1

What are the main objectives of Enviroment Protection Act, 1986?

12.2.2 International Conventions

Similar to national legislations, there is no international legislation body with authority to pass legislations, nor are there international agencies with power to regulate resources in a global scale. There is an international court at Hague in the Netherlands, but it has no power to enforce its decisions. Powerful nations can simply ignore the court. As a result, international legislation must depend on the agreement of the parties concerned. Certain issues of multinational concern are addressed by collection of policies, agreements, and treaties that are loosely called International Environmental legislations. Most of the international legislations are international agreements to which nations adhere voluntarily. These agreements are generally finalized through international conventions or treaties. Nations that have agreed to be bound by the convention are known as Parties. Convention provides a framework to be respected by each party, which has to adopt its own national legislations to make sure that conventions are implemented at national level. To support the conventions, some time protocols are also framed. A protocol is an international agreement that stands on its own but is linked to an existing convention. United Nations has very important role in developing and implementing conventions.

The United Nations Conference on Environment and Development, 1972, Stockholm, popularly known as the Stockholm Conference, was the first step from the United Nations to address the growing problem of Environmental degradation at international level. It also gave birth to the United Nations

Environment Programme (UNEP). Key international environmental conventions which have been agreed since the Stockholm Conference include the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973), the Convention for the Prevention of Marine Pollution from Land-Based Sources (1974), the Convention on Long-Range Trans Boundary Air Pollution (1979), the Convention for the Protection of the Ozone Layer (1985), and the Convention on the Control of Trans Boundary Movements of Hazardous Waste and their Disposal (1989).

It was again in UN Conference on Environment and Development (UNCED); also known as "Earth Summit" held in Rio de Janeiro in June 1992 many global environmental issues were taken up. The Declaration is significant in highlighting the concepts of sustainable development, the pre cautionary principle and the polluter pay principle. The key outcomes of this meeting were:

Agenda 21: This is a comprehensive, non-binding action plan for sustainable development. The document outlines actions to address the social, economic and environmental dimensions of sustainable development.

The UN Commission on Sustainable Development (CSD): The UN Commission on Sustainable Development was created with the aim of promoting implementation of Agenda 21.

Beside these two important international conventions were agreed at the conference:

i) The Framework Convention on Climate Change (UNFCCC), and

ii) The Convention on Biological Diversity (CBD)

On the advise of the United Nations General Assembly, United Nations organized the conference, called the World Summit on Sustainable Development (WSSD), also known as Rio+10 or Earth Summit 2002 on the ten-year review of progress achieved by the implementation of the outcome of the United Nations on Environment and Development. It was held on Aug. 26 – Sep. 6, 2002, at Johannesburg. At Rio+10, sustainable development was recognized as an overarching goal for institutions at the national, regional and international levels. Some of the set up the summit goals are:

- The establishment of a solidarity fund to wipe out poverty. This fund would be sustained by voluntary contributions; however, developed nations are urged to dedicate 0.7% of their national income to this cause.
- Cutting in half by 2015 the proportion of the world's population living on less than a dollar a day. This is a reaffirmation of a UN Millennium Summit goal.
- Cutting in half by 2015 the number of people who lack clean drinking water and basic sanitation
- Substantially increase the global share of renewable energy
- Cut significantly by 2010 the rate at which rare plants and animals are becoming extinct

- Restore (where possible) depleted fish stocks by 2015, and
- Halving the number of people suffering from hunger.

Now we will take up few important conventions on some international environmental issues such as chemicals and hazardous wastes, ozone layer, climate change biodiversity and law of the sea.

Conventions on Chemicals and Hazards Wastes

The Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their Disposal was adopted in 1989 and enforced on 5 may 1992. The Convention is considered the response of the international community to their problem caused by the annual world wide production of 400 million tonnes of wastes which are hazardous to people or the environment because they are toxic, poisonous, explosive, corrosive, flammable, eco-toxic, or infectious.

The main principles of the Basel Convention are:

1) Trans boundary movement of hazardous waste should be reduced to a minimum consistent with their environmentally sound management.
2) Hazardous waste should be treated and disposed of as close a possible to their source of generation
3) Hazardous waste generation should be reduced and minimized at source it self.

The convention is further modified to ban exports of hazardous wastes to developing countries, on the grounds that those countries mostly have neither the expertise nor the facilities to manage such wastes.

Beside Basel convention, India is also a signatory to two similar type of international conventions:

The Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. Adopted in 1998, the Rotterdam Convention is intended to protect human health and the environment by prohibiting international trade in certain hazardous chemicals unless the importing state first gives its informed consent, and by facilitating information exchange to promote the safe handling and use of such chemicals.

The Stockholm Convention on Persistent Organic Pollutants (POPs). Adopted in 2001, bans or severely restricts production, trade, and use of twelve POPs known as the “u.” Most of these chemicals are no longer manufactured or used in industrialized countries; however, the nature of POPs means that people can be seriously impacted by releases of POPs that occur hundreds or even thousands of miles away. The Stockholm Convention contains provisions for the disposal and treatment of POPs wastes and stockpiles. It also establishes procedures for listing additional POPs that may be banned or severely restricted.

Conventions on the Ozone Layer

In Unit 11.3, you have already studied in details the causes and effects of depletion of ozone layer in the stratosphere. The United Nations Environment Programme (UNEP) has been addressing this issue since 1977. Under the

auspices of UNEP, the nations of the world arrived at *The Convention for the Protection of the Ozone Layer* in Vienna in 1985. Through this Convention, nations committed themselves to protecting the ozone layer and to co-operation with each other in scientific research to improve understanding of the atmospheric processes and serious consequences of ozone layer depletion.

To achieve the objectives of the Vienna Convention, *Montreal Protocol* on Substances that Deplete the Ozone Layer was agreed to by nations in 1987. Its control provisions were strengthened through five amendments to the Protocol adopted in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999). The Protocol aims to reduce and eventually eliminate the emission of man-made ozone depleting substances.

Conventions on Climate Change

UN Framework Convention on Climate Change is the landmark international treaty unveiled at the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992. The UNFCCC commits signatory countries to anthropogenic (i.e., human-induced) greenhouse gas emissions to levels that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure the food production is not threatened and to enable economic development to proceed in a sustainable manner.

Pursuant to the objectives of the Convention on Climate Change the *Kyoto Protocol* was agreed by the nations of world in December 1997 in Kyoto, Japan. There are now 196 Parties to the Convention and 192 Parties to the Kyoto Protocol.The Protocol does call on all Parties – developed nations and developing nations – to take a number of steps to formulate national and regional programmes to improve “local emission factors”, activity data, models, and national inventories of greenhouse gas emissions and sinks that remove these gases from the atmosphere. All parties are also committed to formulate, publish and update climate change mitigation and adoption measures, and to cooperate in promotion and transfer of environmentally sound techniques and in scientific and technical research on the climate system. The progress of convention on climate change and Kyoto Protocol was reviewed in twenty one session of the Conference of the Parties (COP 21) to the Climate Change Convention held in Paris, from 30 November to 12 December 2015.

This agreement seeks to accelerate and intensify the actions and investment needed for a sustainable low carbon future. Its central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. The Agreement also aims to strengthen the ability of countries to deal with the impacts of climate change.

During the Convention period, Governments also launched new joint initiatives. India and France led 120 countries in announcing an International Solar

Alliance supporting solar energy deployment in developing countries. More than 20 developed and developing countries launched Mission Innovation, pledging to double public investment in clean energy research and development over five years.

Conventions on Biological Diversity

Although not formally part of the UNCED preparatory process, the Rio Summit provided political impetus for completing the negotiations on the *Convention on Biological Diversity* (CBD). The aim of the CBD is to promote the conservation and sustainable use of biodiversity through commitments relating for example to: promoting scientific and technological co-operation, establishing protected areas, eradicating alien species, respecting and maintaining traditional knowledge and practices, and providing financial resources. In January 2000, the Cartagena Biosafety Protocol was adopted to address potential risks associated with cross-border trade and accidental releases of living modified organisms. Again in the World Summit on Sustainable Development (Johannesburg, 26 August - 4 September 2002), the world's Heads of State recognized the critical role which biodiversity plays in overall sustainable development and poverty eradication, human well-being and in the livelihood and cultural integrity of people. They noted that biodiversity is currently being lost at unprecedented rates owing to human activities and that there is a need to achieve a significant reduction in the rate of biodiversity loss by 2010.

In September 2005, 150 Heads of State, meeting at the World Summit in New York called on all States to fulfill their commitment and significantly reduce the rate of biodiversity loss by 2010.

There are few more Conventions on biodiversity issues: the Convention on Conservation of Migratory Species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975), the International Treaty on Plant Genetic Resources for Food and Agriculture (2004), the Ramsar Convention on Wetlands (1971), the World Heritage Convention (1972) and the International Plant Protection Convention (1952).

Conventions on Law of the Sea

The 1982 United Nations Convention on the Law of the Sea provides, for the first time, a universal legal framework for the rational management of marine resources and their conservation for future generations.

Some of the key features of the Convention are:

- Coastal States exercise sovereignty over their territorial sea which they have the right to establish its breadth up to a limit not to exceed 12 nautical miles; foreign vessels are allowed "innocent passage" through those waters;
- Ships and aircraft of all countries are allowed "transit passage" through straits used for international navigation; States bordering the straits can regulate navigational and other aspects of passage;
- Archipelagic States, made up of a group or groups of closely related islands and interconnecting waters, have sovereignty over a sea area enclosed by straight lines drawn between the outermost points of the

islands; all other States enjoy the right of archipelagic passage through such designated sea lanes;

- Coastal States have sovereign rights in a 200-nautical mile exclusive economic zone (EEZ) with respect to natural resources and certain economic activities, and exercise jurisdiction over marine science research and environmental protection;
- All other States have freedom of navigation and over flight in the EEZ, as well as freedom to lay submarine cables and pipelines;
- Land-locked and geographically disadvantaged States have the right to participate on an equitable basis in exploitation of an appropriate part of the surplus of the living resources of the EEZ's of coastal States of the same region or sub-region; highly migratory species of fish and marine mammals are accorded special protection.

SAQ 2

Fill in the blank with appropriate words

i) The United Nations Environment Programme (UNEP) was an outcome of the ..... conference.

ii) To achieve the objectives of the Vienna convention..... was agreed by the nations.

12.3 ISSUES IN ENFORCEMENT

In the earlier section of this unit you have learnt about various Environmental Acts at national level and Environmental legislations at international level. Now we will take up the issues involved in their enforcement.

12.3.1 Problems and Prospects

You must be aware that despite so many legislative measures the state of the environment in India continues to be gloomy. The rivers and the lakes continue to be polluted with sewage and industrial waste, bio resources continue to disappear. The air quality in some major cities is at alarming stage. According to the World Health Organization, at present the Capital city of New Delhi is one of the most polluted cities in the world. All these situations force us to know the answers of following questions. Where are the problems? What can be done to reverse the process and restore a balance state of the environment? Let us first, identify the basic problems in enforcement of national environment legislations.

- After an analysis of all enactments and provisions at national level, It is to be noted that nature of most of the existing environmental legislations are essentially punitive not preventive. Only once the chemicals or substances are discharged into the air or water or soil does the act apply. The preventive measures have hardly ever evoked or worked and the concerned agencies have moved into action only after the harm has been done.

- More serious problem in the implementation of environmental legislation is overlapping powers of authorities involved in supervising the safety mechanism and devices of companies, and in granting or refusing No Objection Certificate (NOC). Thus though the water and air pollution board may refuse to grant NOC, the Municipality may grant a license to an industrial unit based on which it may start its manufacturing activity.
- In some cases statutes of environmental legislations do not lay down any guidelines on the nature of the authority and their specific rights and the obligations. For example, Delhi State Government in 2009 has banned the manufacture and use of coloured plastic, without formulating the rule to prosecute defaulters. Because of this 2009 ban did not do too well. Again Delhi State Government amended this bill 2011 and imposed a blanket ban on use, storage, sale and manufacture of plastic bags in the city. This total ban again failed to make any difference in the city largely due to poor implementation and absence of strong rules.
- A common feature with environmental legislation in India is that they exclude peoples' participation in their implementation. The enterprises, which make profits at the expense of the environment, are always well represented and their interests well protected but not those of the common person who suffer the consequences of pollution and degradation.
- Sometime enforcement of legislation is difficult due to shortage of funds. Take for example the case of rivers pollution in India. It is well known that the major source of pollution of rivers is domestic sewage, which municipalities nonchalantly dump in the nearest rivers. The colossal cleaning up operation of rivers will be an exercise in futility if it is not accompanied by a massive effort to prevent the municipalities from dumping their wastes in the river. Everyone knows that the technology for treating municipal wastes exists. But many and most of the municipalities cannot afford it its cost .
- Public opposition also makes the implementation of environmental legislation difficult. As we have seen the difficulty in implementation of the Supreme Court ruling regarding mandatory use of CNG for all public transport vehicles in Delhi. Delhi Government has taken lot of time in implementing this order. Similarly public did not support the order of Supreme Court regarding ban on diesel public vehicles that were more than 10 years old and also complete ban on the registration of diesel vehicles in NCR region.

Nevertheless, despite the existing inadequacy of legislations and the complexity of judicial procedures, some new decisions of the court specially of NGT in recent past have generated a hope that with the passage of these enactments, environmental protection will be controlled to some extent in the country and that the offending companies /agencies will be brought to book by streamlining the enforcement agencies.

Now a day's judiciary is playing a vital role in the growth and development of environmental precedents. As a watchdog it strives to maintain the sanctity

and dignity of the Constitution so that it may not remain a mere paper tiger. But these are very few examples in which people through Public Interest Litigations (PIL) seek judiciary to enforce existing environmental legislations. For highlighting the contribution of PILs, we are giving few notable examples. In year 2000, Supreme Court ordered to shut down polluting factories in residential areas of Delhi. This order was opposed by thousands of workers and factory owners. But this move has and will definitely safe guard the health of many residents who are living nearby to the polluting industries. Due to excess noise during the festival periods, the local court in Kolkata passed strict limits on noise beyond certain limits and ordered its strict enforcement. Similarly, in the capital region of Delhi, all new vehicles from April, 2012 should have pollution prevention mechanism comparable to Euro-IV levels (known as Bharat Stage-IV) prevailing in many European countries.

In recent time, laws on disposal of plastics, packaging, locating and shifting of polluting industries, and common effluent treatment plants for small scale industries and making mandatory the use of CNG in vehicles used for public transport have all become very important and these legislations are being regularly followed by implementing authorities by the order of honourable courts.

Another good example of the success of PIL is case of Taj Mahal. In this famous case, Mahesh Chandra Mehta, a prominent environment lawyer, fought for ten years to persuade the Supreme Court to ban coal-based industries emitting effluents that damaged the soft marble of the Taj Mahal, India's architectural masterpiece. The court shut down 230 factories and directed more than 300 others near the building to install pollution-control devices. For this public service Mehta has won the 1997 Ramon Magsaysay Award. Mehta also campaigned for the introduction of lead-free gasoline in India's four largest cities, which has been done, and for 250 towns and cities near Ganga to install sewage treatment plants. The Supreme Court ordered over 2,000 industries along the Ganga to clean up or close. He also won a Supreme Court decision that forced a fertilizer factory to compensate thousands of people sickened by a 1985 gas leak.

Many of the legislations such as restraining the use of plastic bags can be fully enforced if public consciousness can be raised rather than await a judicial direction. After all, many environmental legislations are essentially "social code of conduct" that should automatically be a part of a better civic sense instead of a legal framework. Thus, public awareness and environmental education together can considerably reduce the needs for multitudes of environmental legislations since enforcement under the Indian context will continue to be difficult in foreseeable future.

Though, legislations and regulations are the foundations of most environmental protection policies. Public interest Litigations and People's Movement have also played very important role in environmental protection.

SAQ 3

Fill in the blank with appropriate words

i) The Delhi State Government banned the use of coloured plastic in the year ..... and amended this in the year ..... .

ii) In Delhi, all new vehicles should have pollution prevention mechanism comparable to ..... level.

12.4 INSTITUTIONAL ARRANGEMENT FOR MONITORING AND ENFORCENMENT

The Government of India recognizing the severity of environmental problems, in 1972 established a National Committee on Environmental Planning and Coordination (NCEPC) to advise the Government on environmental problems and make recommendation for their improvement. The NCEPC was replaced by a National Committee of Environmental Planning (NCEP) to discharge the following functions:

- Preparation of an annual 'State of Environment Report' for the country,
- Establishing an Environmental information and communication system to propagate environmental awareness through the mass media
- To sponsor environmental research
- Arranging public hearing or conferences and issues of environmental significance

In 1980, the Government appointed Tiwari Committee, which recommended formation of Department of Environment for ensuring environmental protection. On this basis, a full-fledged Department of Environmental was created with effect from November 1st, 1980 under the charge of the Prime Minister. Since January 1985, it formed a part of the newly created **Ministry of Environment and Forests**. This Ministry, renamed as Ministry of Environment, Forest and Climate Change (MoEFCC). This is the nodal agency for planning, promotion, coordination and supervising the implementation of the various environmental and forestry programmes. The Ministry has also overall responsibility for administering and enforcing environmental legislations and policies. The Ministry has also been designated as the nodal agency in the country for the United Nations Environment Programme (UNEP), International Centre for Integrated Mountain Development and looks after the follow-up of the United Nations' Conference on Environment and Development (UNCED). MoEFCC also implements in India the provision of the international agreement on biological diversity and on climate change. Within the overall frame work of its mandate, the activities of the Ministry includes

- Conservation and survey of flora fauna, forests and wildlife

- Afforestation and regeneration of degraded area
- Prevention and control of pollution,
- Protection of environment
- Environmental impact assessment
- Dissemination of environmental information
- Eco-regeneration
- Assistance to organization implementing environmental and forestry programmes
- Promotion of environmental and forestry research
- Extension, education and training to augment the requisite man power
- Coordination with Central Ministries, State Government
- Environmental policy and legislation, and
- International cooperation
- Creation of Environmental awareness among all sections of the population.

The Ministry has many Divisions, Departments and Boards to implement its own objectives and environmental legislation such as Botanical Survey of India, Zoological Survey if India, National Museum of Natural History, Indian Council of Forestry Research and Education, Indian Forest Services, Central Pollution and Control Board (CPCB), Forest Survey of India, National Afforestation and Eco-development Board, etc. In next part we will discuss the role of CPCB in environmental protection sketchily.

The Central Pollution Control Board (CPCB)

The Central Pollution Control Board (CPCB) was constituted in September 1974 under the provisions of The Water (Prevention & Control of Pollution) Act, 1974. The main functions of CPCB, as spelt out in The Water (Prevention and Control of Pollution) Act, 1974, and The Air (Prevention and Control of Pollution) Act, 1981, are:

i) To promote cleanliness of streams and wells in different areas of the States through prevention, control and abatement of water pollution; and

ii) To improve the quality of air and to prevent, control or abate air pollution in the country.

The CPCB advises the Central Government on all matters concerning the prevention and control of air, water and nose pollution and provides technical services to the Ministry for implementing the provisions of the Environmental (Protection) Act of 1986. Under this Act, effluent and emission standards in respect to various categories of industries have been notified. During 2000-2001 standards for coalmines, standards for effluents from textile industries and primary water quality criteria for bathing water have been finalized and notified in the Gazette.

Board has identified seventeen categories of heavily polluting industries. They

are: cement, thermal power plant, distilleries, sugar, fertilizer, integrated iron and steel, oil refineries, pulp and paper, petrochemicals, pesticides, tanneries, basic drugs and pharmaceuticals, dye and dye intermediates, caustic soda, zinc smelter, copper smelter and aluminium smelter.

CPCB in consultation with State Boards has also identified some critically polluted areas in the country, which need special attention for control of pollution. Action plan have been prepared and are being implemented in these areas.

The CPCB in collaboration with the SPCBs monitor the quality of fresh water resources of the country through a network of 507 monitoring stations located all over the country. Under the National Ambient Air Quality Monitoring Programme, 290 station covering over 90 cities/towns are being monitored by the CPCB.

SAQ 4

i) In which year was the Department of Enviroment created?

ii) State the functions of the Central Pollution Control Board.

12.5 ACTIVITIES

Activity 1

Only Central Government legislation is discussed in this unit, prepare a list of environmental legislations of your State and municipality area.

Activity 2

Discuss the outcome of the U. N. Climate Change Conference in Paris (COP 21) held on Nov 30-Dec.12, 2015.

Activity 3

Discuss the few path breaking judgements of NGT in recent past.

12.6 SUMMARY

In this unit you have studied that:

- The various national and international legislations, which have been framed to stop environmental degradation.
- India is one of the few countries of the world that have made specific reference in the constitution to the need for environmental protection and improvement. The Central Government State Governments have utilized this provision to pass various Acts in order to protect the environment from destruction.
- There is a great contribution of UN in addressing global environmental challenges. To implement the agenda of UN, there is movement towards

environment protection on a worldwide scale through special conventions, protocols and multilateral agreements.

- Despite of the presence of satisfactory legislative measures and administrative set-up, it is difficult to enforce the legislation due to lack of expertise, shortage of funds, and no seriousness on the part of implementing authority.

12.7 TERMINAL QUESTIONS

1. List the important categories of national legislations.
2. Write the various provisions of Kyoto Protocol.
3. Analyse briefly the issues in the enforcement of environmental legislation.
4. Explain the role of judiciary in Environmental protection.
5. List the important government agencies responsible for environment protection in India.

12.8 ANSWERS

Self-Assessment Questions

1. Protecting and improving the quality of the environmental and preventing controlling and abating the pollution.
2. i) Stock holm
   ii) Montreal Protocol on substances that deplete the ozone layer.
3. i) 2009, 2011
   ii) BSIV
4. i) 1985
   ii) a) Promote cleanliness of streams and wells.
   b) Improve quality of air and to prevent, control air pollution.

Terminal Questions

1. Important categories of national legislations are: (i) Water Acts, (ii) Air Acts, (iii) Forest and wild life Acts, and (iv) General Acts.

2. Refer to section 12.2.2
3. Refer to section 12.3.1
4. Refer to section 12.4
5. Important government agencies for environmental protection in India are:

   (i) Ministry of Environment Forest and Climate Change (MOEFCC), (ii) Council of Forestry Research and Educaiton (CFRE) , (iii) Central Pollution Control Board (CPCB). (iv) State Pollution Control Boards (SPCB), (v) Botanical Survey of India (BSI), (vi) Geological Survey of India (GSI) etc.

12.9 FURTHER READING

1. Divan, S. and Rosencranz, A. (2002) *Environmental Laws and Policy in India: Cases, Materials and Statues,* New Delhi:Oxford University Press.

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4. Bell, S. and Ball, S. (1996) *Environmental Law,* New Delhi: Universal Law Publishing Co.

5. Sahasranaman, P. B. (2012) *Handbook of Environmental Law,* New Delhi: Oxford University Press.

6. Techera, E. J. 1st Ed. (2012) *Handbook of International Environmental Law,* Routledge.

UNIT 13

HUMAN COMMUNITIES AND ENVIRONMENT

Structure

13.1 INTRODUCTION

In the previous unit we have discussed various acts enacted for the protection of environment and we also learnt various conventions and protocols framed for global environmental issues. You would have read as to how human beings have evolved in the natural systems as a result of interactive forces among the pre-existing biological forms. Though late to arrive on the evolutionary scene, human is the only life form to initiate drastic interventions in nature. Man has always been using natural resources around his dwellings to meet his basic, social and cultural needs. The customs, traditions, practices, beliefs, and rules ensured a balance between human needs and environmental conservation in ancient times. However, with passage of time this symbiotic relationship was gradually replaced by destructive dependence. At some point during this phase he apparently forgot that the ecosystem has certain carrying capacity that reflects a limit to its exploitability.

In this Unit you will learn how over exploitation of natural resources has led to environmental degradation and indiscriminate industrialisation has led to deforestation and related problems

of natural calamites, resettlement and rehabilitation. You will also be able to learn the issues related to disaster management.

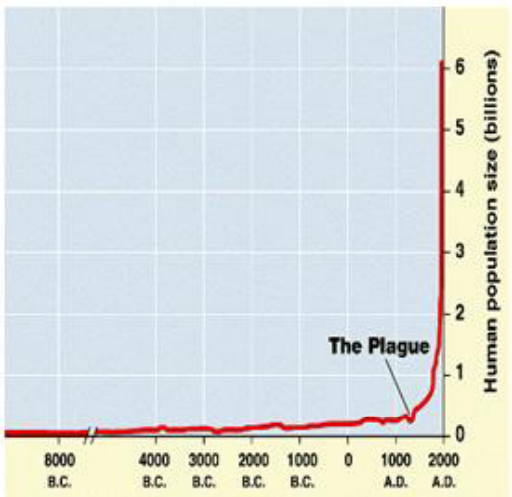
Expected Learning Outcomes

After studying this unit you should be able to:

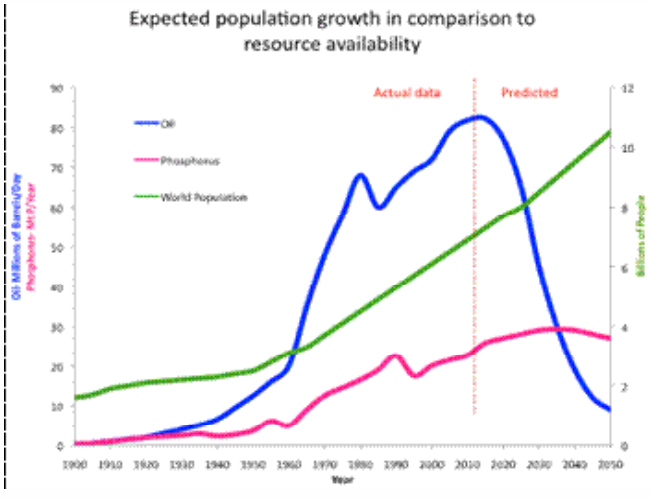
- understand the phenomenon of population growth and the human activities that are responsible for environmental degradation;
- quantify the extent to which human intervention has brought about environmental degradation;
- discuss natural calamites and their impact on society;
- highlight the need for preparedness; and,
- enumerate the issues related to human health and welfare, resettlement and rehabilitation of affected persons.

13.2 HUMAN POPULATION GROWTH

According to United Nations determinants and consequences of population trends, modern Homo sapiens may have appeared 50,000 B.C. At the dawn of agriculture almost 8,000 B.C. the world population was somewhere around 5 million. Throughout subsequent millennia the human population has been quite small. It has grown relatively slowly and even experienced occasional declines. Figure 13.1 shows the general trend of population growth in the last ten thousand years. As agriculture became more efficient, women began to bear more children and the human population increased. It was possible to grow more food in a given area of land. Hunter-gatherers were mostly nomadic and in their way of life, infants were a liability. In a stationary agricultural society, children are not much trouble and they can help in the farming. Therefore, the population increase between 10,000 BC and about 1800 AD was largely the result of increasing birth rates that coincided with the growth of agriculture.



(a)



(b)

Fig. 13.1: Growth of human population. (a) In the last half million years, note the rapid upturn in the world population in the last 2000 years. (b) During the past 400 years.

But our early ancestor were vulnerable to hostile environments, food was often scarce and famine and outbreak of diseases often took heavy tolls, Thus population growth remained low due to high death rates. For example, it is believed that during the 14th century the bubonic plague killed more than half the population of Europe and Asia. This is shown in Figure 13.1 (a) as a depression.

After 1800, a second and more dramatic increase in the rate of population growth occurred. This coincided with the industrial revolution. Cities grew rapidly, goods and services became more readily available. Progress in medical sciences and improved sanitation brought down the death rates drastically resulting in exponential increase in human population. From Figure 13.1 (b) we can also see that it took several thousand years for the human population to grow to 1 billion which occurred sometimes around 1800. In marked contrast, the population doubled to 2 billion persons in only 80 years and redoubled to 4 billion in hardly 45 years. Human population is expected to be 8.6 billion by mid 2030s, 9.8 billion by mid-2050s and 11.2 billion by 2100. According to one estimate worlds food resources can sustain a maximum of 10 billion people.

13.2.1 Population Growth Trends

In the present day world, there is an improved nutrition and better health care and consequently more newly born babies survive and people live longer. While this is good news, it is major cause in upsurge of population growth. Today total world population (2018) is more than 7.6 billion and it is increasing at the annual rate of 1.18. The total population of India at independence was around 350 million (35 crore). The total size of population increased nearly three fold and reached around 1000 million by the middle of year 2000. The population has increased to 1357 million (17.74% of world population) in 2018.

13.2.2 Human Activities and Environmental Degradation

Much before we faced the effects of globalisation, calamities like floods, earthquakes, eruption of volcanoes, and forest fires were wreaking havoc on human lives. But with rapid industrialisation, exploitation of non-renewable natural resources, construction of huge dams, deforestation, indiscriminate use of chemicals and human greed for quick returns with lower inputs contributed to the escalation of the occurrence of these calamities. This, coupled with human-made disasters like nuclear accidents, industrial accidents, disposal of toxic wastes, accidents in the transportation of hazardous wastes, oil spills and emission of Green House Gases, has created a situation that threatens the existence of humanity. There are sections of scientists and social scientists who argue that all environmental calamities are human-made disasters whereas others argue that development and economic growth cannot be achieved unless we take calculated risks. These issues are debatable but the issue at stake is the survival of humanity. It is to be acknowledged that the margin between natural calamities and human-made disasters is becoming thinner gradually and this is what we are going to discuss in the following sections.

SAQ 1

Fill in the blanks.

(i) Hunter-gatherers were mostly ……

(ii) After …… a second and more dramatic increase in the rate population …… occurred.

(iii) The population has increased to 1357 million in ……

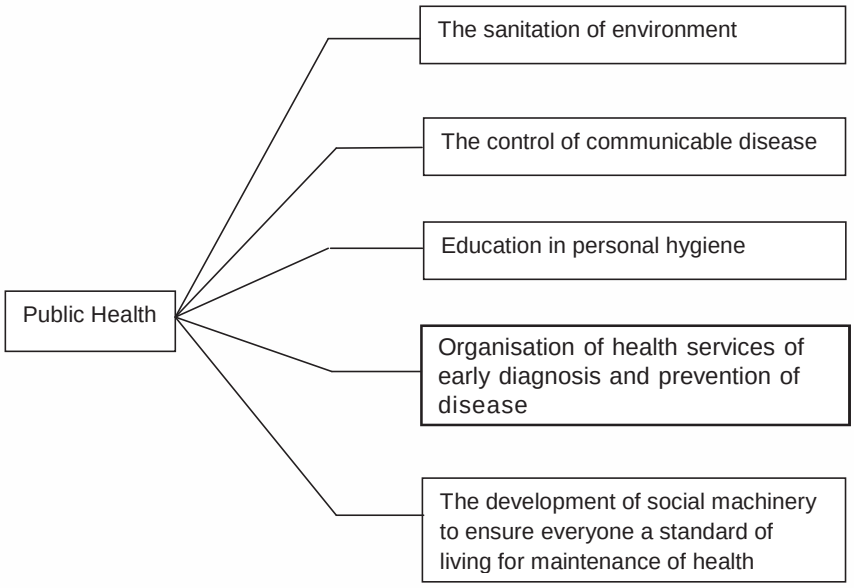
(iv) Human being has to depend on …… resources.

13.3 HUMAN HEALTH AND WELFARE

A broad and widely used definition of health given by the World Health Organisation (WHO) is that it is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". One measure of health is the ability to function effectively within a given environment. Since the physical, biological and social environment keeps on changing throughout the life of an individual, good health involves a process of continuous adaptation to such changes.

Environmental health can be defined as "the aspect of public health that is concerned with all external conditions such as all forms of life, substances, forces, problems and challenges and any other condition in the surroundings of human being that may exert an influence on their health and well-being". Disease, in this sense, represents a maladjustment of the human being to his her environment.

Although ancient civilisations were aware of the effects of environment on health, the importance of clean environment in the modern times was realised in Europe only after the Industrial Revolution in 1842. It was known as "the great sanitary awakening". As a consequence, the discipline of Public Health was established. It was defined as the science and art of preventing disease, prolonging life and promoting health and efficiency through organised community effort. The objectives of public health are given below.



So far, in the developing countries like ours, significant success has not been achieved for such desirable goals of public health. However, in developed countries, communicable diseases have been almost eradicated by improving sanitary conditions. So the emphasis in public health has moved to the preventive, therapeutic and rehabilitative aspects of chronic diseases and behavioural disorders, like smoking, drug abuse and alcoholism which are prevalent in these countries. Thus, today, public health gives emphasis on planning and evaluation of health activities, programmes and systems. With such challenges, public health is now termed 'Community Health'.

13.3.1 Community Health

Community health is defined more broadly and encompasses the entire gamut of community-organised efforts for maintaining, protecting and improving the health of the people. It involves motivation of the individual and groups to change the pattern of behaviour. In addition, it also seeks to plan medical care to achieve optimal health of the members of community as a whole. Previously, the subject of community health was covered in Hygiene, Public Health or Preventive and Social Medicine.

In community health, instead of studying individuals as a patient, it is essential to understand that:

- The patient represents the community.
- Diagnosis of disease in the community, (referred to as community diagnosis) is essential.
- Planning treatment for the community is the objective.

For example a single case of a cholera patient detected in a village is a danger signal. It shows that the disease is present in the community, there may be many cases of it and unless checked its spread will grip the whole village. So the appropriate measures for treatment and control of the disease are planned in advance. Since it is a water-borne disease, water sources-river, wells or underground water are examined for infection and accordingly treated. In addition, necessary treatment for the affected people and precautions such as vaccination for vulnerable people is also done.

13.3.2 Environment-Health Relations

We have already told you that an individual's health is the result of interaction of a large number of influences upon him or her. We can divide these influences into the following three groups: i) genetic influences, ii) behavioural influences and iii) environmental influences. We will now briefly describe these influences.

1. **Genetic Influences :** All organisms inherit a set of genes called genome from their parents. Genes determine the physical and physiological characteristics of an organism. That is why a child bears some resemblance to his parents. We also find that some humanbeings are born with abnormalities. The inherited abnormalities are called hereditary diseases which are passed on from parents to the offspring.

Some Common Genetic Diseases

Phenylketonuria

Haemophilia

Mongolism

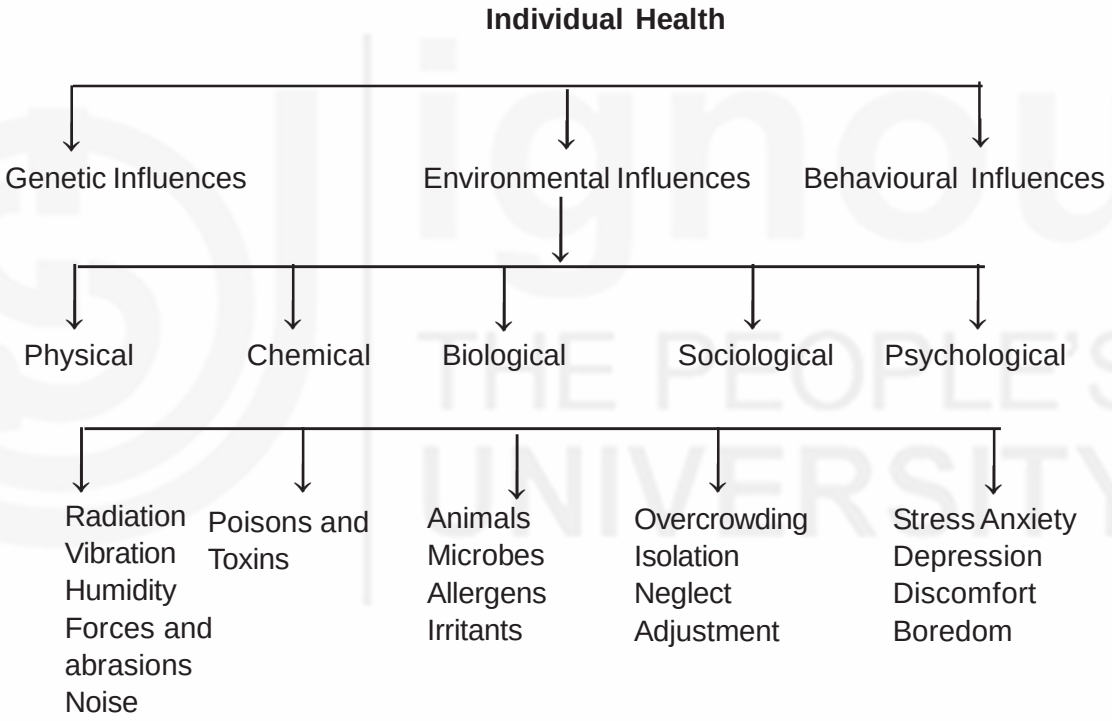
Sickle-cell anaemia

Thalesemia

There are other diseases such as allergies, diabetes, hypertension, and schizophrenia which cannot be regarded entirely genetic in the same sense as hereditary diseases. However, they are due to the **interaction of genes with environment.** These diseases are triggered and affected by nutrition, stress, emotion, hormones, drugs and other environmental interactions. In other words, they would not occur if the environment is favourable for the person. Such diseases are referred to as due to genetic influences.

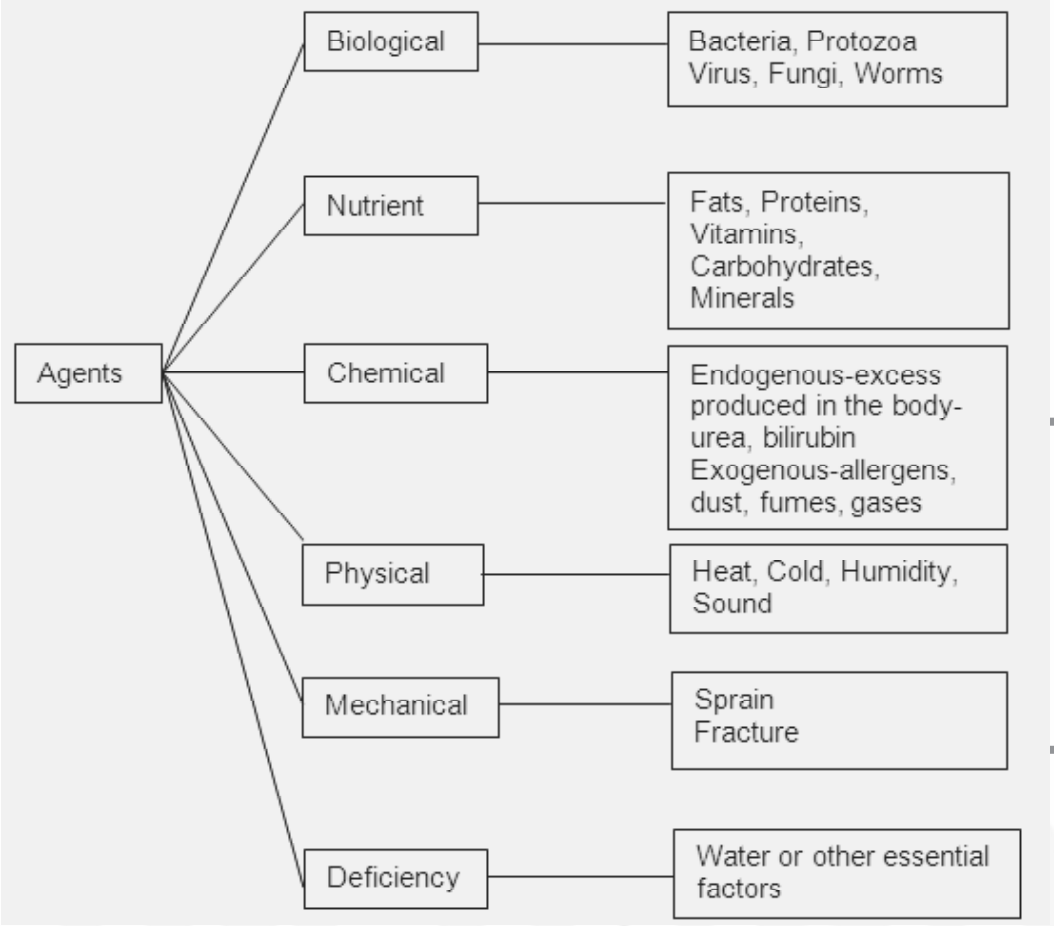
2) **Behavioural Influences :** Alcoholism, smoking, drugs, chewing tobacoo, or irregular food habits result in various kinds of ill-health. The habits of a person change throughout ones life time. These depend upon self-responsibility, nutritional awareness, stress management, physical fitness and environmental sensitivity of an individual.

3) **Environmental Influences:** You know the various components of environment. All of them exert influences on our health. As shown below these are physical, chemical, biological, sociological and psychological.



Agents of Ill-health

The agent of ill health or disease may be living or non-living matter, a tangible or intangible force, an excess or lack of a substance in the body. In some ailments like heart disease and peptic ulcer. the causative agent is not known. By and large, these agents are classified as given below:



Host: The organism (here the man) which the parasites enter

Pathogen: Parasite which cause the disease

Aetiology: The study of the cause or origin of disease.

13.3.3 Preventive and Mitigatory Welfare Measures

Disease is a complicated interaction between human and environment. Not long ago, human beings were victims of epidemics of plague, smallpox, cholera, influenza, etc. over which they had little control. Advances in science and technology have helped to understand these diseases and find their control. It was found that the spread of these diseases is linked with the environment. The deteriorating environment poses danager to the present and the future generations with new types of health problems. Hence, appropriate measures need to be taken immediately. However, the options we can exercise are rather limited and not clear-cut since they entail both costs and benefits.

The demands of modern life, it appears, cannot be met without compromising the quality of 'internal' environment. Let us take an example. Many of the serious ailments are due to the life style people have. One kind of situation arises from highly competitive culture, the so called rat race that brings physical comfort, but also tension, worries about work, career, economic status, etc. Tensions, worries and frustration can also predispose people for stress-related illnesses. In the other group are people who lack proper nutrition, poverty and ignorance suffer from various types of physical as well as psychological illnesses.

SAQ 2

a) Which among the following diseases are due to genetic influences?

i) Schizophrenia ii) Hypertension

iii) Hemophilia iv) Diabetes

v) Allergies vi) Sickle cell anaemia

vii) Mongolism (Down's syndrome) viii) Alcoholism

b) Match the following types of environmental influences with their respective category

Environmental Influences	Category
a) Toxin	i) Psychological
b) Radiation	ii) Biological
c) Stress	iii) Physical
d) Microorganism	iv) Sociological
e) Neglect	v) Chemical

13.4 NATURAL DISASTER

According to the World Health Organisation, an environment disaster or calamity is an event that causes damage, economic disruption, loss of human life and deterioration in the health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community or area.

Natural calamities adversely affect the lives of a large number of people, causing considerable damage to infrastructure and property. The ill effects are more pronounced in developing countries due to the lack of preparedness, lack of systems for sufficient warning, and lack of facilities for quick access to the site of calamity.

At the global level, Asia is more prone to natural calamities. It is reported that for each major natural calamity in Europe and Australia, there are ten in Latin America and Africa and fifteen in Asia. According to CRED World Disaster Report (1998), the ratio of those killed to those affected depends on the type of calamity, degree of preparedness and the density of population. Table 13.2 gives the annual average number of people killed or affected over a period of ten years (2005-2014).

Table 13.2: Annual average number of people killed or affected over a period of ten years (2005-2014).

Country	**People Killed** (approximate)	**People Affected** (approximate)
Bangladesh	10433	**42307931**
India	28777	**144142963**

Nepal	2683	**2197638**
Pakistan	82802	**49784339**
Sri Lanka	832	**9842558**
Bhutan	24	**20028**
Maldives	Data not available	**204649**

Source: CRED World Disaster Report (2015)

Natural calamities could be broadly classified under the following headings:

i. **Atmospheric** – Rains, Hail storms, winds, lightning, fog, heat/cold waves, etc.

ii. **Hydrological** – Floods, sea-shore waves, glacier advances, water logging, etc.

iii. **Geological** – Land slides, avalanches, earthquakes, volcanic eruptions, shifting sands etc.

iv. **Biological** – severe epidemics (in humans, plants, animals), forest fires, pest invasions (locusts) etc.

Under certain circumstances development can increase disaster proneness. The location of a dam in an area of high seismic activity, the construction of roads in difficult terrains or unstable geomorphologic conditions and promotion of water intensity crops in areas off unpredictable rainfall are examples of development measures dictated by policies of globalisation leading to or aggravating the phenomena of natural disaster. In spite of the absence of prediction mechanisms to pinpoint the location, the timing and intensity of natural disasters, the preparedness, appropriate management, the pre and post operative mechanisms would go a long way in mitigating people's suffering.

Let us now discuss briefly various kinds of natural disasters.

13.4.1 Earthquakes

It is now generally accepted that an earthquake occurs due to vibrations(s) of the Earth produced by the release of energy. This energy radiates in all directions from its source (epicentre). Earthquakes can also occur because of atomic (nuclear) explosions or by volcanic eruptions. Large reservoirs with their hydro-static pressure of water may also induce earthquake.

In Fig. 13.3 you can see the various seismic zones of India. These are explained below:

- **Zone V:** This is the most severe seismic zone and is referred to as Very High Damage Risk Zone.
- **Zone IV:** This is referred to as High Damage Risk Zone.
- **Zone III:** This is termed to as Moderate Damage Risk Zone.

- **Zone II:** This zone is referred to as Low Damage Risk Zone.
- **Zone I:** This zone is termed as Very Low Damage Risk Zone.

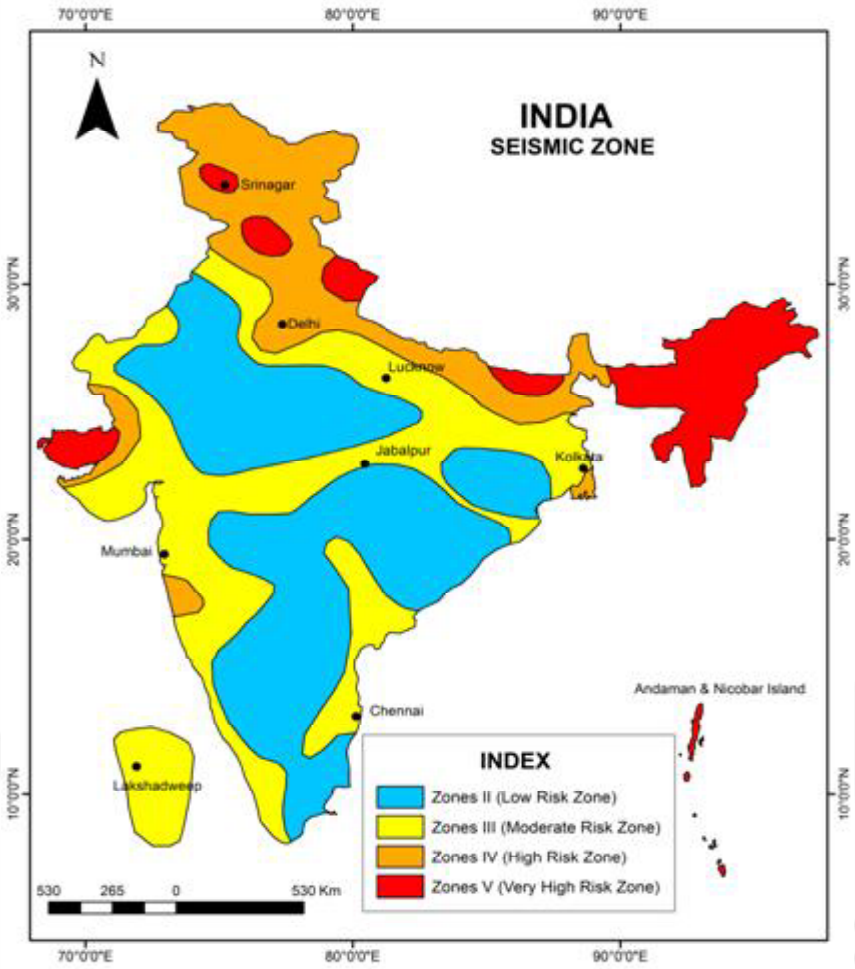


Fig. 13.2: Seismic zones in India.

In order to understand the strength and severity of an earthquake, it is necessary to measure its intensity. There are several methods to measure the intensity of the effect an earthquake produces on life and property. The Richter scale describes the amplitude of the earthquake wave radiating out in all directions from the focus (epicentre) which is closely related to the amount of energy released. This is also a measure of ground motion as recorded on a seismograph.

It is now accepted that people must be made aware of the methods of minimising the risks. Training the public in Earthquake Resistance Construction in the earthquake prone areas may yield some results.

13.4.2 Floods, Cyclones and Tsunamis

Water is essential for life. Water cycle ensures that the water that drains into the sea, evaporates and comes back as clouds to rain and snow over the earth, bringing fresh water. However, there are certain phenomena associated with the flow of water in nature that can cause untold misery to human beings. Principal among these are: floods, cyclones, hurricanes, and landslides. Tsunami caused a great deal of damage in South Asian countries and,

therefore, we have included it in our discussion. We discuss some of these calamities briefly.

Floods

Floods are the most common of all natural calamities (Fig. 13.3). Floods regularly claim thousands of lives and adversely affect millions of human beings annually worldwide. Bangladesh and India together account for over two-third of global death count each year. More than the loss of life and damage to property, millions of people are displaced every year due to floods in the South Asian countries.

A flood is the discharge of water that exceeds the canal capacity of the river. Floods are caused by different factors that include:

- climate extremes – heavy and prolonged rainfall
- melting of snow and ice
- collapse of dams
- deforestation and land slides
- silting of river beds reducing the carrying capacity of rivers
- lack of coordination between officials of adjoining countries or states facing similar problems.

Fig. 13.3: Village is over flooded with water.

It is possible to reduce the adverse effects of floods by construction of dams and reservoirs at appropriate places, strengthening the embankments on rivers and canals, improving the carrying capacities of rivers, canals and reservoirs by periodical deepening and deepening operations.

Weather forecasting and flood plain management techniques can help in minimising causalities and damage.

Cyclones

One of the most common coastal calamities is the cyclone. Cyclones claim many lives and cause immense damage to property every year.

Cyclones are caused in the tropical belt when sea water gets heated up to 27° C and more, so that low pressure areas develop above the water levels. The low pressure areas remain stationary for three to four days and draw energy from the sea surface. As the pressure in the centre falls, the wind speed increases and cloud burst starts spiralling around the centre causing squalls. As the pressure falls in the centre, the winds in the surrounding areas rush inwards creating spirally moving storms. The cyclone then moves landward towards areas of lowest pressure. Strong winds and heavy rain destroy and annihilate weather comes in their way.

A tropical cyclone that struck northern Bay of Bengal in 1970 caused tidal waves of 6 meters height killing three hundred thousand people and destroying 65% of the total fishing capacity of the coastal region.

Today, with the advancement in weather prediction techniques, remote sensing satellites and cooperation between countries in sharing information on weather conditions, it is possible to predict the birth of a cyclone and monitor its movements to pinpoint the area where it is likely to hit the coast. In spite of this, the damage caused is very severe, the well planned relief operations going haywire in the last minute.

Tsunamis

A tsunami is a wave in the ocean or in a lake that is created by a geological event. They are also known as tidal waves or seismic sea waves (Fig. 13.4). Most tsunamis are very weak and have heights of only a few centimetres. But the intensity varies from time to time. Near the place of origin tsunamis may have height of many meters. As they spread out or move into the deep ocean, their heights decrease. However, their heights increase again as the tsunami waves reach shallow water near impact areas. The expected heights for the larger tsunamis are around 9 – 20 meters. Tsunamis are most often caused by earthquakes and landslides. Volcanic eruptions can also cause tsunamis.

Fig. 13.4: A sight of Tsunamis.

On 26th December 2004 the Indian coastline experienced the most devastating tsunami in the recorded history. The tsunami was triggered by an earthquake of magnitude 9.0 on the Richter scale at 3.4° N, 95.7° E off the coast of Sumatra in the Indonesian Archipelago at 06:29 hrs IST (00:59 hrs GMT). It devastated the shores of **Indonesia, Sri Lanka, India, Thailand,** and other countries with waves of up to **15 m** high, even reaching the east coast of **Africa, 4500 km** west of the **epicentre**. Almost 79,900 people were killed by the earthquake and tsunami in Indonesia. Tsunami killed at least 41,000 people in Sri Lanka, 10,000 in India, and 4,000 in Thailand.

The mangrove forests and coral reefs are natural defences against tsunamis.

Box 13.1 : Mangroves as a Shield

> "Though we cannot prevent the occurrence of such natural calamities, we should certainly prepare ourselves to mitigate the impact of the natural fury on the population inhabiting the coastal ecosystems. Our anticipatory research work to preserve mangrove ecosystems as the first line of defence against devastating tidal waves on the eastern coastline has proved very relevant today. The dense mangrove forests stood like a wall to save coastal communities living behind them," said M.S. Swaminathan, Chairman, M.S. Swaminathan Research Foundation (MSSRF), Chennai. The mangroves in Pitchavaram and Muthupet region acted like a shield and bore the brunt of the tsunami. (The Hindu, 28 December, 2004).

The massive loss of life and property caused by Tsunami of 2004 could have been avoided if only we had an advance warning system. It was therefore decided to install the equipment required for predicting tsunamis. The indigenous warning system includes putting in place a Deep Ocean Assessment and Reporting System, around 20 data buoys and a software programme that would help predict the location, time and height of any tidal formations like tsunamis based on the changes and disturbances detected underwater following seismic changes. India has tied up with the Pacific Tsunami Warning Centre and countries such as Indonesia, Thailand and Myanmar for the required international co-operation in its proposed software programme for the networking of the available data on tsunami and deep water oceanic changes.

13.4.3 Droughts

A 'drought' can be defined as a prolonged period of unusually dry weather, with little rainfall, in a region where rains are normally expected (Fig. 13.5). As such a drought differs from a dry climate which is usually associated with a region that is normally or seasonally dry. Droughts often last for years. Drought is a creeping calamity because it develops slowly and has a prolonged existence.

Fig. 13.5: A scene of drought hit region.

Box 13.2 : Drought in Rajasthan – 2000

Rajasthan, the largest State in India with an estimated population of about 54 **million** was in the grip of a **severe drought in the year 2000**. Out of the 32 total district in the State drought was prevalent in 31 districts and among these 25 districts were affected severely. Around 73.64% villages were under the clutches of drought; affecting nearly 33.04 million people and 39.97 million cattle. The severity of the drought could be judged from the fact that **out of a total of 2647 major water reservoirs only 300 were filled in that year. Also, nearly 75 to 100% crop had been destroyed due water scarcity**. All this caused loss of livelihood leading to mass migration in search of employment.

Source: http://www.un.or.in/UNDMT/states/rajas/dstatus.html

Though climate is usually the prime reason for the triggering of drought, the situation is often made worse by the way people use the water resources. Felling trees for firewood, denuding the forest for agricultural or housing purposes, mining, unscientific farming method, indiscriminate drawing of ground water are identified as causes of droughts. It is argued that serious droughts in developing countries are more a function of global development policies than climatic conditions.

Droughts produce a series of direct and indirect impacts that usually extend far beyond the area experiencing the actual water shortage. These may be classified as

Economic – loss of crop, dairy, livestock, fishery produce;

Environmental – Damage to plant and animal species, erosion of soils; and

Social – Food shortage, damage to health, conflicts between water users.

It is possible to take precautions in drought prone areas by constructing reservoirs, educating people in water conservation, scientific farming and optimal use of ground water resources.

Ground water, which is found in aquifers below the surface of the Earth, is one of the most important natural resources. Ground water accounts for about 38 percent of the water in India and the city water departments supply this to

households and businesses (public supply). It caters to the need of drinking water for more than 97 percent of the rural population.

We now recount an illustrative example of proactive water harvesting in India.

Water Harvesting Measures

One of the effective measures to combat drought and the resulting water shortage is to adopt water harvesting measures. It means capturing rain where it falls or capturing the run off in your own village or town and taking measures to keep that water clean by not allowing polluting activities to take place in the catchment area. The water harvesting can be undertaken through a variety of ways. Some of these are:

- Capturing runoff from rooftops,
- Capturing runoff from local catchments,
- Capturing seasonal floodwaters from local streams, and
- Conserving water through watershed management.

These techniques can serve the following purposes:

- Provide drinking water,
- Provide irrigation water,
- Increasing groundwater recharge,
- Reduce storm water discharges, urban floods and overloading of sewage treatment plants.
- Reduce seawater ingress in coastal areas.

Box 13.3 : A Case Study of Hyderabad Metropolitan Water Supply and Sewerage Board

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) has set up an ambitious plan of taking up several water harvesting measures in the twin cities of Hyderabad and Secundrabad and its vicinity through active involvement of people to improve the ground water level. The water harvesting measures, under the Neeru-Meeru (Water and You) Programme, include construction of recharge pits or a mini-treatment units, planting saplings or any other action that would improve water recharge, and green cover which ultimately increase the ground water levels. They have plans to sensitise different opinion makers like ex-servicemen, retired officials, women's groups and NGOs.

The groups would be sensitised on motivational aspects and techniques of various water harvesting structures. The trained groups would in turn reach out to communities to explain its benefits. As part of the strategy, the Board has recently created water soldiers, by sensitising ex-servicemen. It has also proposed to involve the student community in a big way so that the schools, colleges and other institutions would contribute to the cause of improving ground water table, thus enabling it to cover 25% of the 7 lakh houses with some type of water harvesting method. You can find out more about this effort at the website:

Source : http://www.hyderabadwater.gov.in/RWH_Note.html

You may like to reflect on the issues discussed so far. Try the following SAQ.

SAQ 3

Match calamities given in **Column A** with the statements of **Column B:**

Column A		**Column B**	
i)	Earthquakes	a)	Discharge of water exceeding the canal capacity of the river.
ii)	Flood	b)	Caused in the tropical belt when sea water get heated up.
iii)	Cyclone	c)	A wave in the ocean created by geological events.
iv)	Tsunami	d)	A prolonged period of unusually dry weather with little rain falls.
v)	Drought	e)	Energy radiates in all direction from its epicentre.

13.5 PREPAREDNESS FOR DISASTER MANAGEMENT

There have been specific ways of countering and minimising natural disasters or calamities in general but some important strategies can be adopted.

Emergency preparedness is viewed as a programme of long term development activity whose goal is to strengthen the overall capacity and capability of a country to manage efficiently all types of emergencies and bring about an orderly transition from relief through recovery and back to sustainable development.

Emergency preparedness is an on-going multi-sectoral activity. It forms an integral part of the national system responsible for developing plans and programmes for emergency management, prevention, mitigation, preparedness, response, rehabilitation and reconstruction.

We now briefly describe the United Nations Environmental programme (UNEP) for disaster management.

Box 13.4 : Prevention and preparedness to reduce the costs of disasters

The fundamental goal of the United Nations Environment Programme (UNEP) disaster management programme is to reinforce the centrality of environmental concerns in disaster management. The other cornerstone is the adoption of preventive strategies and practical measures to reduce the potential loss of human lives and property, as well as destruction of the environment.

The success of this approach depends on increasing public awareness of the risks that natural, technological and environmental hazards pose to societies, and on educating people about the value of existing approaches for prevention and preparedness. UNEP contributes on this process through its programmes on environmental law, early warning and assessment, and Awareness and Preparedness for Emergencies at Local Level (APELL).

APELL programme, developed in conjunction with governments and industry, recognises that the incidence and effects of environmental disasters can be reduced by prevention and preparedness initiatives at the local level. The APELL concept has been successfully introduced to more than 30 countries and in more than 80 industrial communities worldwide.

The figure below presents the framework for disaster management. You may like to examine its applications in your specific context and modify it.

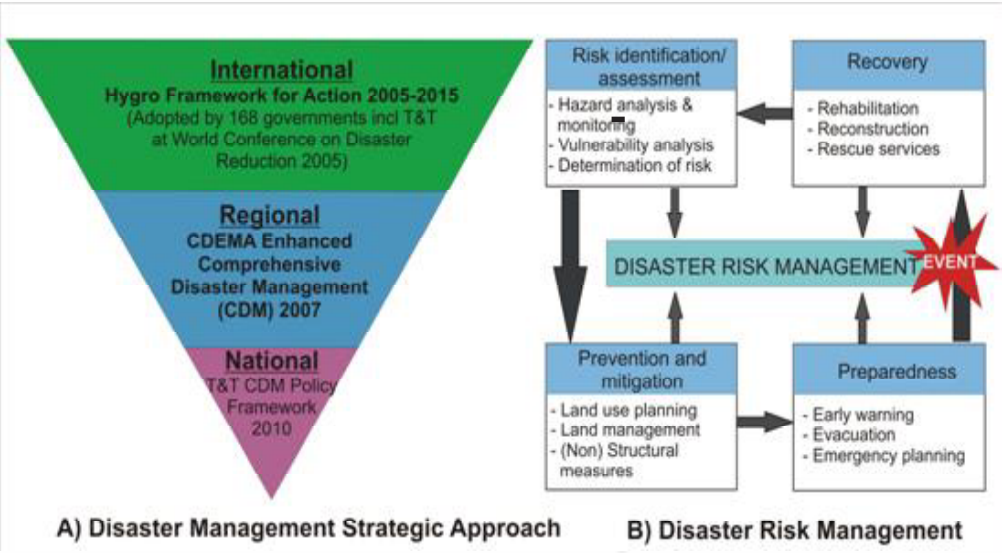


Fig. 13.6: A framework for disaster management.

Effective risk management of any calamity depends on the implementation of a sequential series of actions. The individual stages often overlap but it is crucial that they operate as closed loop because the major objective is to learn from the past experiences and prepare an action plan based on the feedback.

- Pre-planning covers a wide range of activities like construction of defensive engineering works, land use planning, formulation, dissemination and maintenance of evacuation plans;
- Preparedness for disaster management reflects the degree of alertness, immediately before and after the occurrence of calamity, arrangement for emergency warnings and preparedness based on earlier experiences;
- Response deals with events immediately before and after occurrence of the calamity and pressing into service relief activities;

- Recovery and reconstruction are long term activities that attempt to return to normalcy after the occurrence of the calamity.

It is unfortunate but true that environment is clearly not something which humans value. It is usually low on the priorities of people except when they are faced with threats to their own lives or immediate possessions.

We end this section with an exercise for you.

SAQ 4

a) What steps can be taken to prevent and mitigate human suffering due to droughts?

13.6 RESETTLEMENT AND REHABILITATION OF PEOPLE: PROBLEMS AND CONCERNS

It is a well-known fact that both natural and human made disasters force people to move out of their land. For example, Tsunami in South Asia in December 2004, Latur and Gujarat earthquakes, the Orissa super-cyclone and scores of floods and droughts in other parts of our country have rendered thousands of people homeless and jobless. Disasters, like the Bhopal gas tragedy in Union Carbide factory, derailment of trains, are examples of human made disaster. Landslides, common in the Himalayas, are example of nature's fury rendered damaging manifold due to faulty planning.

Strategies for rehabilitation of such displaced people are in the first place by way of preventive action. For instance, care is taken to build earthquake proof houses, gather advance information about cyclones and arrange for timely evacuation, build appropriate bunds in flood prone areas, maintain bridges that take regular up and down passing of trains/ road transport vehicles on them in order to avert likely disasters.

Secondly, advance preparation on the part of administration and local communities are made to face the consequences of sudden calamities. For both these, the primary necessity is that of creating awareness among the people in general and among administrative personnel in particular.

Development projects such as roads, dams and mining come into existence after a fairly long period of planning and awareness of displacement caused by such projects already exists among those who initiate the projects. Despite this, the project authorities pay little attention to the processes of resettlement and rehabilitation of displaced people. Those who give up substantial portions of their assets for the sake of development projects need to be recognized as stakeholders in development projects. They too should benefit from the development.

This section provides guidance for all stakeholders in collaborating to achieve equitable and appropriate support for all of the affected population, depending on their needs.

Shelter, Settlement, and Reconstruction

1. Shelter is critical to survival. From the emergency phase until durable solutions, it is necessary to provide security and personal safety. Shelter and settlement support human dignity and family and community life.
2. More secure shelter in a safer settlement constitutes the immediate and sustainable physical foundation to livelihoods development.
3. Transitional reconstruction begins immediately after a disaster, as people recover what they can, however, for those affected badly it can often occur over a number of years. During transitional reconstruction, some people move, for example from owning an apartment to renting a house. For others, such a those squatting in informal settlements, a disaster may offer an opportunity for as sustainable and legal solution to their housing needs.

13.7 CASE STUDIES AND PEOPLE'S MOVEMENT

Though legislations and regulations are the foundations of most environmental protection policies, the global nature of resources and pollution make international legislations and conventions essential. Public interest Litigations and People's Movement have also played very important role in environmental protection. In this section we will take up a few cases of PIL and people's movement in India against environmental degradation.

Taj Trapezium Zone

Problem of pollution has now become so severe that it is not only affecting human health and livestock but it is also damaging buildings and monuments. Over the past four decades, the fate of the India's most emblematic monument, the Taj Mahal, has repeatedly come into the spotlight because of the ill effect of the pollution caused by the iron foundries, Mathura refinery, glass factories of Firozabad and brick kiln in the Taj Trapezium Zone (TTZ). This is the area around Taj spreading over 10,400 sq.km. On repeated occasions, sulphur dioxide emissions from industries in this area reached levels ten times above the prescribed standard level. Combined with oxygen and moisture, sulphur dioxide converts to highly corrosive acid, sulphuric acid.

Blaming pollution and regulatory negligence of Taj's decay, Mahesh Chandra Mehta, a prominent environmental lawyer, filed a case before the Supreme Court of India in 1984. Mehta pleaded with the court to order the various industries to take anti-pollution measures or to close. He also stressed that pollution was affecting the health of the workers and people living in Agra. Because of Mehta's efforts, in 1996, the Supreme Court finally ruled that the industries in the area were actively contributing to air pollution and ordered major industries units to install pollution control devices. "Not even one per cent chance can be taken when human life apart- the preservation of a prestigious monument like the Taj is involved," stated the court order. The court ordered 292 coal-based industries to switch to natural gas or else to relocate outside the protected zone by April 30, 1997. Because of the

opposition from industries and workers court order was not enforced completely. The Supreme Court struck again in 1997 ordering the closure of 53 iron foundries and 107 other factories in Agra that had not cleaned up their act. The Supreme Court later also banned cars and parking within 500 meters of the Taj's boundary walls. Experts agree that some of these measures have helped to improve air around the Taj.

Chipko Movement

From the last 19th century the Himalayan forests, have been subject to rapid exploitation (Fig. 13.7). This large-scale destruction has led to severe ecological problems. Rapid soil erosion, growing frequency of floods, reduction in the availability of firewood and fodder, landslides and disappearance of water table, caused concern among people. In upper Alkananda Valley. People also resented the conversion of natural forests into monoculture plantations.

Fig. 13.7: Chipko Movement.

To check environmental degradation in this region, voluntary organizations like the Gangotri Gram Swarajaya Sangh (GGSS) in Uttarakashi and Dasholi Gram Swarajaya Mandal (DGSM) in Gopeshwar started Chipko Movement in the 1970s. Environmentalists like Chandi Prasad Bhatt and Sunderlal Bhauguna led the Chipko Movement in Garhwal Himalayas.

Chipko means to hug the tree. Volunteers in their attempt to stop commercial felling threatened to hug the trees if the saws came near them. Their activities popularised the movement through folk songs, street plays and widespread campaign. Its slogan was "What do the forest bear? Soil, water and pure air, Soil, water and pure air are the basis of life".

As a result of this struggle, the Government replaced the contractor system and formed Uttar Pradesh Forest Department Corporation (UDFDC) and the forest related activities were encouraged through local cooperatives. In 1981, as a response to Sunderlal Bahuguna's indefinite fast, the Government constituted an eight member expert committee to prepare a comprehensive report on the Himalayan forest policy. The government later put a fifteen-year moratorium on commercial tree fellings in the Uttrakhand Himalayas.

Silent Valley Movement

This movement is regarded as one of the most important ecological movements in India. Silent valley is the narrow valley of the Kunthi River in the state of Kerala in the south west of India at high elevation (Fig. 13.8). Its 8950 hectares of rain forest is rich with valuable plants and animals. In 1973, the state government of Kerala decided to build a dam across the gorge in order to generate hydro electricity. It would have drowned valuable forest and threatened the loss of wild life. Even the government's ecological task force expressed its dissatisfaction over the loss of forest and wild life.

Fig. 13.8: Silent Valley

By 1979, students, voluntary organization like Kerala Sastra Sahitya Parishad (KSSP), science forums, teachers, progressive citizens and journalists began to work against the project. In 1979, Save Silent Valley Committee emerged. This hue and cry among all circles led the government headed by the then Prime Minister Mrs. Indira Gandhi, to set up a high-level technical committee chaired by Prof. M.G.K. Menon and accepted its recommendation that the project should not be proceeded with and that the Valley should be preserved as a precious biosphere reserve.

SAQ 5

Fill in the blanks, with appropriate words.

i) Both natural and human made …….. force people to move out of their land.

ii) …….. is crucial to survival.

iii) …….. has banned cars and parking within 500 meters of the Taj boundary.

iv) …….. like Chandi Prasad Bhatt and Sunder Lal Bahuguna led chipko movement in Garhwal Himalayas.

v) …….. is the narrow valley of the Kunthi river in the state of Kerala.

13.8 SUMMARY

Let us summarise what we have learnt so far:

- The primitive hunter-gatherers skilfully manipulated their environment in a way that it would not deplete future supplies. In contrast, agriculture has had a conspicuous impact on the environment. Industrial societies intensively utilized the environment.
- Industrialization surpasses the environmental impacts of permanent agriculture. For most of human history, people lived in small groups and population grew at a slow average rate. As a result of industrialization and medical development, average growth rate increased rapidly. The rapid increase in population size had severe effects on the other species, and, on the air, water and soil upon which we and other forms of life depend.
- The health of an individual is affected by genetic, behavioural and environmental influences. Disease represents a maladjustment of human beings to their environment.
- Since the individual of a community share a common environment, their health problems are generally common. Therefore, these are investigated and healthcare is planned at the community level.
- Most natural calamities like earthquakes, floods, droughts, and cyclones cannot be predicated in advance and when they occur they cause great loss of life and extensive damage to property and infrastructure. Natural calamities have been occurring from times immemorial but of late the damage caused has become qualitatively and quantitatively more.
- Under certain circumstances development can increase disaster proneness. The location of a dam in an area of high seismic activity, the construction of roads in difficult terrains or unstable geomorphologic conditions and promotion of water intensity crops in areas of unpredictable rainfall are examples of development measures dictated by policies of globalisation leading to or aggravating the phenomena of natural calamities.
- In spite of the absence of predication mechanisms to pinpoint the location, the timing and intensity of natural disasters, the preparedness, management, the pre and post operative mechanisms help in the mitigation of people's suffering and in reconstruction mechanisms.
- It is well known that both natural and human made disasters force people to move out of their lands.
- Strategies for rehabilitation and resettlement for displaced people are in the first place by way of preventive action. Provision of shelter is top priority.
- Taj Trapezium zone, Chipko movement, and Silent Valley movement Narmada Bachao Andolan are a few cases of PIL and people's movements in India against environmental degradation.

13.9 TERMINAL QUESTIONS

1. What factors have led to the rapid growth of population in the world? Why is it important to contain our population growth?
2. Discuss the causes of flood in your region? What steps can be taken to prevent and mitigate human sufferings due to floods, cyclone and tsunami?
3. Analyse the various dimensions of natural disaster management.
4. Describe the need for resettlement and rehabilitation of people following a natural disaster.
5. Discuss the following
   a) Taj Trapezium zone
   b) Silent Valley Movement
   c) Chipko Movement.

13.10 ANSWERS

Self-Assessment Questions

1. (i) nomadic ii) 1800, growth iii) 2018 iv) natural
2. A. iii), vi), vii)
   B a) v b) iii c) i d) ii e) iv
3. i) e ii) a iii) b iv) c v) d
4. The question is based on section – 13.4 but while answering this question you refer to subsection 13.3.3 with regard to drought.
5. (i) disasters (ii) shelter (iii) Supreme court (iv) Environmentalists
   (v) Silent Valley

Terminal Questions

1. Refer to section 13.2
2. Refer to sub-section 13.4.2
3. Refer to section 13.5
4. Refer to section 13.6
5. Refer to section 13.7

13.11 FURTHER READING

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Acknowledgement

1. Fig. 13.4: A sight of Tsunamis.

   Source: https://www.sutori.com/item/untitled-264a-d50b

2. Fig. 13.5: A scene of drought hit region.

   Source: https://www.thehindu.com/sci-tech/A-video-on-groundwater-depletion-in-India/article16876049.ece

3. Fig. 13.7: Chipko Movement.

   Source: https://www.indiatimes.com/news/india/chipko-andolan-was-the-strongest-movement-to-conserve-forests-india-needs-it-again-342183.html

4. Fig. 13.8: Silent Valley

   https://commons.wikimedia.org/wiki/File:Kuntipuzha_River_in_Silent_Valley_National_Park.jpg

UNIT 14

ENVIRONMENTAL ETHICS

Structure

14.1 INTRODUCTION

In Unit 13 we have discussed human population growth and its impact on environment and human health and the issues related to natural disasters together with problem of resettlement and rehabilitation. In this unit, we will discuss about many social issues in terms of ethical and moral dimensions in respect of environmental management.

Many environmental problems are in fact social issues in terms of moral and ethical values. Building a just, stable, harmonious world for the future generations should be the central organising principle for civilisation.

This unit reviews the environmental ethics, our views and beliefs about nature and environment, issues of environmental equity, environmental crisis, environmental justice and

racial discrimination at the policy and public level in managing the environment, and teachings about environment in the major religions practiced in South Asia.

Expected Learning Outcomes

After studying this unit, you should be able to:

- ❖ discuss different ethical approaches and attitudes towards nature and environmental management;
- ❖ explain the importance of equity for environmental management;
- ❖ discuss the necessity of justice in dealing with environmental crisis;
- ❖ describe the effects of discriminatory policies and plans for environmental management; and
- ❖ explain the teachings of different religions about environmental management.

14.2 ETHICAL USE OF NATURAL RESOURCES

The release of noxious gases into the atmosphere, the destruction of forests and the over-exploitation of natural resources have caused irreversible environmental damage throughout the world. In some cases the damage is so severe that life-support systems, both local and global, are being threatened. Unless we curb our desire for more and more material possessions and unceasing economic growth, continued ecological damage will be unavoidable. To solve our environmental problems, there has to be a change in the way we think about and the way we interact with our environment.

Ethics, seeks to define as to what is right and what wrong we have done on a universal basis. For example stealing, lying, cheating, killing and indifference to the well-being of others are considered to be unethical. Preserving human life, concerns for others, honesty and truthfulness are considered to be ethical.

Moral values reflect the dominant belief of a particular culture about what is right and what is wrong. For example killing a person is wrong but during the wartime, killing an enemy soldier is not considered as an immoral act. It is difficult to define what is wrong and what is right because of the differences in cultural and religious beliefs. Some individuals consider it unethical, immoral to unnecessarily waste resources while others argue that maximising consumption is a moral act because it promotes the economic growth, that is a source of jobs and funds for helping the poor and protecting the environment.

When we use the term “Environmental Ethics” we refer to it as a discipline that studies the moral relationship of human beings, and also the value and moral status of the environment and its non-human contents.

Why do we need a new set of ethics for the environment? The answer includes three factors.

1. **New effects on nature:** As our modern technological civilisation affects nature greatly, we must examine the ethical consequences of these new technological actions.
2. **New knowledge about nature:** Modern science demonstrates as to how we have changed and are in the process of changing our environment in ways not previously understood, thus raising new ethical issues. For example, until the past decade, few people believed that human's activities could be changing the global environment. Now, scientists however, believe that burning fossil fuels and clearing forests have increased the amount of carbon dioxide in the atmosphere, and that this causes changes in our climate. Hence the emphasis is on a global perspective.
3. **Expanding moral concerns:** Some people argue that animals, trees, and even rocks have normal and legal rights. These expanded concerns lead to a need for a new ethic.

For most of human history, ethics has concentrated on "human rights", the rights of individuals, of families and ethnic groups. However ethics now include the rights of animals, plants and the environment beyond the human rights to rule and use them.

14.3 THREE VIEWS ABOUT NATURE

There are essentially three views of nature:

1. The Western (European and North American),
2. The Sineatic (Chinese, Korean and Japanese) and
3. The Indian (a combination of Hindu, Buddhist and Jain philosophies).

In the past the western view considered that nature was alien and hostile to human beings; it had to be conquered, and subsumed under human control.

The Sineatic concept of nature is that it is beautiful and perfect, but it has to be transformed to be loved. Nature creates an aesthetic awe. "Rather than being hostile, humans are part of nature, in the Sineatic view, human being have their place in nature".

The Indian spiritual tradition combines perspectives on nature from Hinduism, Buddhism and Jainism. In this case, nature is a mother. She cannot be tamed by her children. She is a Goddess.

14.4 ATTITUDES TOWARDS NATURE

The way we treat the environment reveals much about our beliefs regarding ourselves and the world around us? Some people regard human beings as merely one of the many species of animals; others view human being's role as caretaker or stewards of nature. This differing points of view often lead to contradictory environmental polices. Let us see some of the popular points of view towards environment.

14.4.1 Anthropocentrism

The people having an anthropocentric or human centred attitude towards nature assign significantly greater value to human being than any other non-human organisms or things. According to anthropocentric attitude, protection or promotion of human interests or well-being at the expense of nonhuman things turns out to be nearly always justified. Aristotle maintains that 'nature has made all things specifically for the sake of man' and that the value of nonhuman things in nature is merely instrumental.

In the early 1970s, with the emergence of environmental ethics as a new discipline, a challenge was posed to anthropocentrism. Environmental ethics questioned the assumed moral superiority of human beings over other species on earth and the rationales for assigning intrinsic value to natural environment. However, some theorists working in the field see no need to develop new, non-anthropocentric theories. Instead, they advocate what may be called *enlightened anthropocentrism* (or, perhaps more appropriately called, *prudential anthropocentrism*). Briefly, this is the view that all the moral duties we have towards the environment are derived from our direct duties to its human inhabitants.

14.4.2 Stewardship

Many tribal or indigenous people, both hunter-gatherers and those in traditional agricultural societies, have a strong sense of stewardship or responsibility for a particular part of nature. As custodian of resources, they see their proper role as working together with human and non-human forces to sustain life. Humanity and reverence are essential in this worldview, where humans are seen as partners in the natural process rather than masters-not outside of nature but part of it. Stewardship requires a person to consider the entire universe as her or his extended family, and all living organisms are members of the household. In this humane view, stewardship need not reject science or technology. If we are part of nature, then our intelligence and discoveries are parts of nature too. As stewards of our environment, we have a duty to use the power of science and technology to improve rather than destroy or degrade the world.

14.4.3 Ecofeminism

Many feminists argue that neither anthropocentrism, nor stewardship is sufficient to solve environmental problems or to tell us how we ought to behave as moral agents. They argue that all these philosophies have come out of a patriarchal system based on domination and duality. This worldview assigns prestige and importance to some things but not others. It claims that men are superior to women, minds are better than bodies, and culture is higher than nature. Feminists see an important connection between patriarchal domination, exploitation, and ill-treatment of woman, children, minorities and nature.

Ecofeminism is radically a new vision. It is rooted in women's biological, procreative and maternal role. Ecofeminism finds instant rapport with Eastern

concepts of 'Mother Nature'. According to some experts on the subject, 'The capitalist, patriarchal World system' is founded upon and sustains itself through three 'colonisations' - of women, of foreign people and their lands and of nature. The ecology of nature is linked to the biology of women's bodies, and the exploitation of nature to the exploitation of women's wombs. It is anti-modern science and economic growth, as both are characteristic of a violent male ethos. It envisions a work of subsistence life style, in harmony with nature and pervaded by 'feminist principle'. For the greater good of both man and woman, ecofeminism seeks to forge a 'new sexual and reproductive ecology'.

Ecofeminist, a pluralistic, nonhierarchical, relationship oriented philosophy suggests that humans could reconsider their relationship to nature in nondominanting ways and this is proposed as an alternative to patriarchical systems of domination. Ecofeminism is concerned not so much with rights, obligations, ownership and responsibilities as with care, appropriate reciprocity and kinship. It promotes a richly textured understanding or sense of what human life is and how this understanding can shape people's encounters with the natural world.

According to this philosophy, when people see themselves as related to others and to nature, they will see life as bounty rather than scarcity, as a network of personal relationships rather than isolated egos. However, Ecofeminism has been subjected to severe criticism for its impracticability and its peculiar biases and distortions. It is argued all development is not patriarchal and anti-women.

14.4.4 Biocentrism and Ecocentrism

Many modern environmentalists criticise stewardship as being too anthropocentric. They instead favour the biocentric attitude thinking that all living organisms have values and rights regardless of whether they are useful or not. Aldo Leopold, in his famous essay on the Land ethic, included the whole biotic community as part of the land. Leopold pointed out that the history of civilisation has been accompanied by a gradual extension of inherent values and rights, first to men, then to women, children and minorities and more recently to nonhumans such as corporations and states. Leopold argues that values should be extended to the recognition of inherent worth to other organisms as well.

Some philosophers assert that even nonliving components of the landscape such as rocks, rivers, mountains or ecological processes such as succession or the hydrological cycle have a right to exist in their natural state without human interference. This attitude is described as ecocentric because it claims moral values and rights for both organisms and ecological systems. People having anthropocentric approach believe that the environment is in perfect balance until the evolution of modern humans who have disrupted the web of life in their quest to dominate nature; a quest which is leading to their own destruction if they do not relearn to live in harmony with the natural world.

SAQ 1

Match Colum A with Colum B:

Colum A		Colum B	
i)	Western view	a)	Strong sense of responsibility for a particular part of nature
ii)	Anthropocentrism	b)	All living organisms have values and rights
iii)	Stewardship	c)	All philosophies have come out of a patriarchal system
iv)	Ecofeminism	d)	God created humans in his own image
v)	Biocentrism and Ecocentrism	e)	Nature was alien and hostile to human being

14.5 ENVIRONMENTAL EQUITY

An ideal of equal treatment and protection for various racial, ethnic, and income groups under environmental statutes, regulations, and practices are applied in a manner that yields no substantial differential impacts relative to the dominant group - and the conditions so-created. Although environmental equity implies elements of “fairness” and “rights”, it does not necessarily address past inequities or view the environment broadly, nor does it incorporate an understanding of the underlying causes and processes.

There are three categories of environmental equity issues:

14.5.1 Procedural Inequity

This issue addresses the questions of fair treatment: the extent that governing rules, regulations, and evaluation criteria are applied uniformly. Examples of procedural inequity are “stacking” boards and commissions with pro-business interests, holding hearings in remote locations to minimise public participation, and using English-only material to communicate to non-English speaking communities.

14.5.2 Geographical Inequity

Some neighbourhoods, communities, and regions receive direct benefits, such as jobs and tax revenues, from industrial production while the costs, such as the burdens of waste disposal, are sent elsewhere. Communities hosting waste-disposal facilities receive fewer economic benefits than communities-generating the waste.

14.5.3 Social Inequity

Environmental decisions often mirror the power arrangements of larger society and reflect the still-existing racial bias in these States. Institutional racism has influenced the noxious facilities and has let many black communities become “sacrifice zones”.

14.6 ENVIRONMENTAL JUSTICE

The right to a safe, healthy, productive, and sustainable environment for all, is the one where “environment” is considered in its totality to include the

ecological (biological), physical (natural and built), social, political, aesthetic, and economic environments. Environmental justice refers to the conditions in which such a right can be freely exercised, whereby individual and group identities, needs, and dignities are preserved, fulfilled, and respected in a way that provide for self-actualisation and personal and community empowerment. This term acknowledges environmental "injustice" as the past and present state of affairs and expresses the socio-political objectives needed to address them. *"Environmental justice has been defined as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity and /or socioeconomic status."*

This concept applies to governmental actions at all levels - local, state and central as well as private industry activities. Providing environmental justice goes beyond the stated definition and includes a guarantee of equal access to relief and meaningful community participation with government and industry decision-makers.

14.7 ENVIRONMENTAL RACISM

It is sometimes thought that environmentalism is an elitist movement, for those who have money and leisure, and who can afford to worry about maintaining open spaces for recreation, and preserving economically valueless species as a matter of principle. It is said that from the point of view of the poor, providing jobs and a good standard of living should have higher priority than a clean environment, which is a luxury that comes after other needs are met.

However, others believe that the environmental consequences of our use of natural resources fall disproportionately on certain disadvantaged racial, ethnic, and socioeconomic groups. For instance, a good case could be made that hazardous waste sites are usually located in disadvantaged communities, and in disadvantaged nations, and that the people in these locations bear the consequences of the use of hazardous materials, without reaping the benefits proportionately. The environmental justice movement is concerned with such issues.

SAQ 2

Fill in the blank with appropriate word:

i) ……. decisions often mirror the power arrangements of larger society.

ii) Environmental justice affirms the sacredness of mother …….

iii) Environmental ……. demands the right to participate equal partners.

iv) ……. is an elitist movement for those who have money and leisure.

v) ……. tend to be poor and more disadvantaged than others working in the dirtiest …….

14.8 RELIGIOUS TEACHINGS ABOUT ENVIRONMENT

World religious and individual spiritual traditions can provide a framework for changing our attitudes. World religions teach us that the land, rivers, mountains, minerals, oceans are held in trust for God, but can be wisely used for the general welfare of humanity. Put another way, our religions tell us that we should consider ourselves only as trustees of the universe, and as trustees we are authorised by God to use natural resources, but we have no divine power over nature and the elements. From the perspective of many religions, the abuse and exploitation of nature for immediate gain is unjust and unethical.

All religions and cultures have something to offer to conservation and environment protection. From each religion, several injunctions or exhortations can be brought forth to form a code for environmentally sustainable development. No religion says that we have the right to destroy our habitat, and no religion sanctions environmental destruction. On the contrary, penalties and admonitions are mentioned for those who do so. This is amply demonstrated in the codes of all the religions. A brief review of teachings about respect of nature and conservation of natural resources as given by Hinduism, Jainism, Buddhism, Christianity, Islam and Sikhism is given in the following sections.

14.8.1 Hinduism

In Hinduism one finds a most challenging perspective on respect for nature and environmental conservation, and the sanctity of all life on this planet and elsewhere is clearly ingrained in this religion. Only the supreme God has absolute sovereignty over all creatures, including humans. Human beings have no dominion over their own lives or over non-human life. Consequently they cannot act as viceroys of God, nor can they assign degrees of relative worth to other species. The sacredness of God's creation demands that no damage may be inflicted on other species without adequate justification. Therefore all lives, human and non-human, are of equal value, and have the same right to existence.

According to Hindu scriptures people must not demand or take dominion over other creatures. They are forbidden to exploit nature; instead they are advised to seek peace and live in harmony with nature. The Hindu religion demands veneration, respect and obedience to maintain and protect the harmonious unity of God and nature. This is demonstrated by a series of divine incarnations, as enunciated by Dr. Karan Singh in the Assisi Declaration:

> *The evolution of life on this planet is symbolised by a series of divine incarnations beginning with fish, moving through amphibious forms and mammals, and then on into human incarnations. This view clearly holds that man did not spring fully formed to dominate the lesser life forms, but rather evolved out of these forms itself, and is therefore integrally lined to the whole of creation.*

Almost all the Hindu scriptures place strong emphasis on the notion that not killing His creatures or harming His creation can receive God's grace. Many trees and plants were worshipped during the time of Rig. Veda (about 1500 BC) because they symbolised the various attributes of God.

Environmental awareness was realised even in the pre-vedic period. There are references to 'Tree Worship' in Mohanjodaro and Indus civilisations. Environmental awareness was more manifest among humans during the Vedic period. The concept Aranyani the queen of forests identical to the concept of tree Goddesses of Indus people. Aranyanis are worshiped as the presiding spirit of forests, conceived as women is praised, honoured by herbs and described as mother of wild animals (Rigveda). Instances of attribution of divinity to plants are found in Rigveda and Atharvaveda.

Animals and nature were revered along with Gods. Hanuman and Ganapati are the most powerful deities, Peepal, Ganga, Himavan, Tulsi, Banyan trees are considered holy even today.

Vedic man identified at least four major components – Sun, Agni, Prithvi, and Sky that sustained life and therefore worshiped them as deities.

(O king of trees, these are Brahma by your root Vishnu by the middle of our body and Shiva by your front. Thou combine all the deities. We salute you. Disease vanish at your sight and by touch of you the sins Vanish. Ever cool and lasting. We salute you. (Rigveda 1-48-5).

Charrk Samhita, classical literature on Ayurvedic medicines, deals with divine herbs, with deep insight into preservation of environmental balance to benefit personal health and pollution free environment.

Planting of Trees has been proclaimed as conductive to great merit in Purans. Agni Purana and Varah Purana mention the benefits arrived from trees.

Durga Shaptasati prescribes so long as mother earth is full of trees and forests with hills, she would continue to nurse and rear the human race.

Ecological balance between nature and human beings has been depicted as part and parcel of human life and a sense of reciprocity has been felt. Such reciprocity finds references in kautilya's Arthasastra for state policies.

Through such exhortations and various writings, the Hindu religion provides moral guidelines for environmental preservation and conservation. From the perspective of the Hindu, culture the abuse and exploitation of nature for selfish gain is considered unjust and sacrilegious.

14.8.2 Jainism

Jainism places great emphasis on the principle that one should refrain from avoidable acts that are harmful to others. According to Jainism violence grows out of passion, and one who has passion causes self-injury. Preventing injury to oneself and others is accomplished through control of speech, control of thought, regulation of movement, care in taking things up and putting them

down, and examining food and drink, and a vow is taken by Jains to do all of these things.

Ahimsa (non-violence), which is the fundamental tenet of the Jain way of life, a term that is clearly allied with realism, common sense, and personal worth, and responsibility. It touches the deepest and noblest aspects of human nature: *'it adheres to the universal law which states that like, order comes of order, and peace can only be achieved through peace.* It maintains that in all situations the ends and means are one and the same, and that truth, honesty and compassion must be the foundation of any truly civilised community.

14.8.3 Buddhism

At the very core of the Buddhist religion are compassion, respect, tolerance and ahimsa (non-injury) towards all human beings and all the other creatures that share this planet.

Buddha also set down rules forbidding the pollution of rivers, ponds and wells. As Buddha says in Sutta-Nipata:

> *Know ye the grasses and the trees ....Then know ye the worms, and the different sorts of ants.... Know ye also the four-footed animals small and great... the serpents... the fish which range in the water... The birds that are borne along on wings and move through the air....*

Buddhists regard the survival of all species as an undeniable right, because as co-inhabitants of this planet, they have the same rights as humans. In Buddhism the rivers, forests, grass, mountains and night are highly respected and regarded as bliss bestowers. Buddhist thinkers have always had great respect for the sun, moon and other planets.

The teachings of Buddhism have concentrated on the theory or Karma and the theory of cause and effect. They demonstrate that unmindful neglect of these principles of right living may lead to chaos, and thus to environmental crisis. That is why there should be no exploitation of nature beyond what is needed for survival, and if we believe that all life forms are interconnected, our exploitative tendencies towards nature can be controlled. This message that all life is interconnected and should be cared for – is the foundation of the Buddhist ethics of nature.

14.8.4 Christianity

There is a common thread in the Old and New Testaments concerning the concept of nature and the rules governing our responsibility to it. Although certain verses in Genesis (1:26 and 1:28) have been interpreted as giving humans dominion and absolute control over nature, there are places where the responsibility of human beings has been clearly delineated. For example *"And the Lord God took the man and put him into the Garden of Eden to dress it and keep it"* (Genesis 2:15).

The word 'dress' has been interpreted as the duty of man to manage, and the word 'keep' has been interpreted as protecting the natural world from harm.

Furthermore the scripture clearly establishes God as the sole owner of the natural world, while humanity is actively responsible for the care of the world:

'The earth is the Lord's and everything in it, the world, and all who live in it'. (Psalm 24:1), and

Every animal in the forest is mine, and the cattle on a thousand hills (Psalm 50:10)

Furthermore, we are advised that we have no rightful ownership over the land: 'because the land is mine, and you are but aliens and my tenants.'

The Bible also confirms that the purpose of creation is to proclaim God's glory because it is His handiwork. Divine life is actively manifested in and through the created world. As such the Earth is not to be considered as a lifeless entity or a means to some higher end. To an extent, a harmonious triadic relationship exists between the divine and humanity, among human beings themselves, and between human beings and nature, and failure to maintain this harmony may alienate humanity from its creator and also from nature.

14.8.5 Islam

In Islam the Holy Quran and the divinely inspired words of Prophet Muhammad (Peace be upon him) form the foundation of and rules for the conservation of nature. The Quranic message is one of unity, harmony, balance and order. The Quran stresses that nature's laws must be observed, and that defined limits should not be exceeded. Man was created so that he could become a manifestation of divine attributes and serve as a mirror to reflect the beautiful image of God. The Quran says:

> *"Surely, your Lord is Allaha, who created the heavens and the earth in six days.... His is to create and to govern (Quran 7:54). And there is not a thing but we have unbounded stores there of and We send it in regulated quantities (Quran 15:21). Indeed, we have created everything in proportion and due measure (Quran 54:49).*

Thus everyone has to observe the balance and acknowledge that certain limits should not be exceeded. In other words humanity has only a guardianship role in God's heaven and earth, and not a position of outright ownership; this guardianship has obligations. The Islamic ethic holds that we have a choice in our interaction with nature. People have been given the intellect and the ability to decide what is just and unjust; what is right and what is wrong.

According to Islam the riches of the earth are a common heritage. Everyone may benefit from them, make them productive, and use them for their own well-being and improvement, but our quest for progress and development must not be detrimental to the environment; instead it should ensure conservation.

In both the Quran and the Shariah, the legal codes of Islam, the rights of the natural world are strongly expressed and the abuse of them by humans is condemned. The Quran says:

> "He set on the Earth, firmly rooted, mountains rising above it, and blessed the Earth and provided sustenance for all, according to their needs.

14.8.6 Sikhism

Baba Guru Nanak Dev, the founder of the Sikh religion, assigned divine attributes to nature. According to Sikhism, people should respect God's creations and know the eternal truth regarding their place in the universe. God had not granted any special or absolute power to humans to control and dominate nature. To the contrary, the human race is an integral part of nature and is linked to the rest of creation by indissoluble bounds.

God Himself is the source of the birth, sustenance and eventual destruction of all living organisms. It is He who created the universe through His divine will and with His word. According to the Sikh holy book, the *Guru Granth Sahib*, 'From the Divine Command occurs the creation and the dissolution of the universe. The basis of creation was divine will, and the universe was produced by *His Hukum* (command). However, it should be noted that God is submerged in creation, as stated in the *Adi Guru Granth Sahib* (p.16)

From Primal truth emanated air

From air emanated water

From water emanated three worlds

And Himself the merged with the creation

Sikhism teaches that the natural environment and the survival of all life forms are closely linked in the rhythm of nature. The history of the Gurus contains many stories of their love and special relationship with the natural environment – with animals, birds, vegetation, earth, rivers, mountains and the sky.

SAQ 3

Match the religious teachings given in Column B with that of religious philosophies of Column A.

Column A		Column B	
i)	Hinduism	a)	Compassion, respect, tolerance and ahimsa
ii)	Jainism	b)	God took the man and put him into the Garden
iii)	Buddhism	c)	Riches of the earth are a common heritage
iv)	Christianity	d)	People should respect God's creation
v)	Islam	e)	Violence grows out of passion
vi)	Sikkhism	f)	Human beings have no dominion over their own live

14.9 ENVIRONMENTAL COMMUNICATION AND AWARENESS

Education for environmental awareness is essential for the younger generation as well as for the older generation. It also needs to cover both urban and rural

population. The beneficiaries at the grassroot level are as much a clientele for environmental education as are the policy makers, the decision makers and the project implementers. Hence, environment education needs to be conveyed to these different categories of people through formal education systems, non-formal education systems and the use of mass media.

14.9.1 Among Students Through Education

Education in India is mainly a state subject and the responsibility is that of the Ministers of Education at the Centre and the States. The education system is divided into two major stages, namely, school and university education. Let us see what is the place of environment education at these two levels.

Stage-wise content

School stage: Four components are required to build up the social awareness about environment education at the school level. These are awareness, exposure to real life situations, concepts of conservation and sustainable development. These four considerations can be further adjusted in terms of the requirements at primary, secondary and higher secondary levels.

Awareness involves making the individual conscious about the physical, social and aesthetic aspects of environment. One has to appreciate the fact that humans are only one of the numerous species on the Earth; they are linked with the life support systems with six elements: air, water, land, flora, fauna and sunlight. These elements are crucial to the well being of human kind as well as other species.

Real-life situations bring people closer to the environment. These conditions are location-specific, with different environment aspects being emphasised in different areas.

As far as conservation and sustainable development are concerned, the main focus would be on sustainable utilisation of resources and not on exploitation. Contrary to the earlier notion of resource like water, soil and air being unlimited, the emphasis is now on their finite nature and thus the limits to the growth of living systems. Sustainable development aims at utilisation of resources not only by the present generation but their preservation for the future generations also, so that life can be sustained for a long period of time. Population growth and planning also form a part of this thinking.

At the primary stage of education, greater emphasis could be laid on awareness followed by real-life situation and conservation. This would prepare the child to understand the need for sustainable development at a later stage. The focus could be on sensitising child to environment. From the lower secondary stage onwards, the emphasis on awareness will begin to decrease in favour of increased knowledge about real-life situations, conservation and sustainable development. And at the higher secondary stage, conservation should get a priority over other factors. The methodologies may range from observation to practical experiences and action—oriented feedback. The school as well as college education on environment may be summarised as follows (Table. 14.1)

Table 14.1: Summary of school and college education on environment

Stage	Objectives	Content	Teaching Strategy
Primary	Awareness	Surroundings from home to outdoor situations	Audio-visual and field visits
Lower Secondary	Real life experiences, awareness and problem identification	As mentioned above for primary stage and general sciences	Classroom teaching, practicals, and field visits
Higher Secondary	Assimilation of knowledge, problem identification and action skills	Science based and action oriented work	Classroom teaching and field work
Tertiary/ College	Sustainable development, based on experience with conservation	College/University based on Science and Technology	Classroom teaching, practicals and action oriented field work

For the school stage, National Council of Educational Research and Training (NCERT) has done substantial work in designing syllabi, developing suitable text books and support materials like guide books, charts and video tapes.

University Stage: University education has three major components – teaching, research and extension, the last being the weakest link. In higher education, irrespective of the field- medical, engineering, science, fine arts, management or law – the relevant aspects of environment should be part of the curriculum.

14.9.2 Among General Population Through Various Media

So far we have been dealing with the clientele which are well defined and within the boundaries of formal education system. But there is a need to cut across the boundaries of illiteracy and reach the masses. This can be done only through the channels of adult education. Though programmes for adult education are already in progress and are duly emphasised by the New Education Policy, the time has come to emphasise environmental education for sections like women, tribals, agricultural labour, slum-dwellers and residents of drought-prone areas. The neoliterates from these groups will help to spread the environmental message to the grassroots level. Voluntary agencies have played an important role in adult education apart from the Directorates of Adult and Continuing Education. Some methods for creating environmental awareness are:

i) Incorporation of topics in regional languages and local dialects in the primers of adult education programmes.

ii) Information packs like posters, slides and audio-visual materials which can be utilised by the adult education centres as well as by the workers of other development agencies like agricultural extension services and primary health centres.

iii) Special exhibitions and programmes in rural areas at the time of fairs and festivals.

14.9.3 Among Functionaries and Opinion Leaders Involved with Environmental Management

There are various kinds of people engaged as functionaries in environment management. They may be government officers at various levels and in various departments like irrigation, power, agriculture, industry, health, town planning. There are voluntary organisations also working actively in these areas. Politicians and social workers also get involved in environmental issues from time to time. Those functionaries and leaders who are concerned with critical decisions should be given necessary orientation and training from time to time through carefully designed courses at their training institutions or in specialised institutions.

The National Institute of Rural Development can play an important role as far as rural functionaries are concerned. The University Department of Environment Studies/Sciences can also undertake such orientation or training colleges and programmes for specific groups. All state governments have their staff training colleges and programmes. Environmental education should become a necessary part of their curricula. The Department of Environment of the government should have a list of clientele group for systematic orientation. They should plan a series of publications for mailing to these people regularly: It should be the responsibility of the functionaries and opinion leaders to first get educated in these matters and pass this information on the other levels.

Ministry of Environment, Forests and Climate Change, Govt. of India has created an information system called ENVIS. Its main centre is located in Delhi and it has been entrusted with the responsibility to collect, compile and provide information on different aspects of environment to the users.

ENVIS can also provide information on a large number of topics related to environment as given in Table 14.2. This is, in fact, a major success. Functioning of ENVIS is being improved steadily.

Table 14.2: ENVIS centres and areas of their activities

Institutions	Area
Central Board for the Prevention and Control of Water Pollution, (CPCB) New Delhi	Pollution control (water & air)
Industrial Toxicology Research Centre, (ITCR) Lucknow	Toxic chemicals
Society for Development Alternatives, (SDA) New Delhi	Environmentally sound alternatives, appropriate technology
Environmental Service Group, (ESG) New Delhi	Media and Parliament related to environment
Institute for Coastal & Offshore Research, (ICOR) Andhra University, Visakhapatnam	Coastal and offshore ecology; Remote sensing for environmental mapping; and Eastern Ghats ecology
Tata Energy Research Institute, (TERI) New Delhi	Renewable energy resources and environment
Centre for Environmental Studies, (CES) College of Engineering, Anna University, Chennai	Eco-toxicology, Bio-degradation of wastes; Environmental impact assessment and systems analysis
Centre for Theoretical Studies, (CTS) Indian Institute of Science, Bangaluru	Western Ghats ecology
Environmental Planning & Coordination Organisation, (EPCO) Department of Environment, Bhopal	Environmental management
National Institute of Occupational Health, (NIOH), Ahmedabad	Occupational health

In addition to the National Environmental Awareness Campaign, the Ministry of Environment, Forest and Climate Change provides funds for organising eco-clubs in educational institutions, for holding seminars and workshops, for making films on environment and various other activities which can create awareness. State Governments also allocate funds for this purpose. Communication media like Doordarshan, and All India Radio also highlight and project the importance of environment. As a result general consciousness towards environment has grown during the last few years. Now, we find that environmental issues are discussed even by common people. Ministry of Environment, Forest and Climate Change, Government of India, has also brought out a Directory of Voluntary Organisations working in the field of environment under its ENVIS programme.

Propagation of environment awareness programmes needs a lot of searching and hunting. This process can be summarised as given in Fig. 14.1.

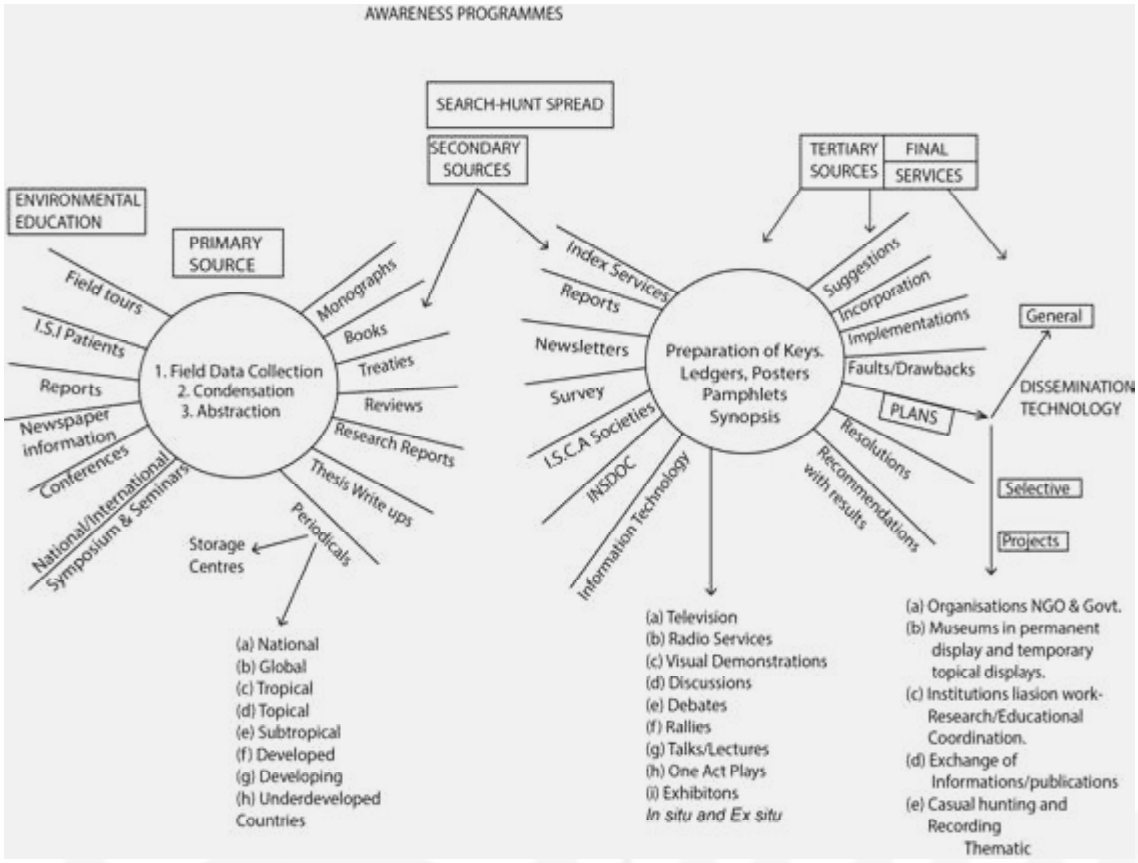

Fig. 14.1: Searching and hunting the information for analysis and propagation.

14.10 COLLECTIVE ACTIONS

Although it is effective to change your behaviour and activities towards sustainable patterns, it is more productive and more satisfying to work collectively for the purpose. Collective action multiples individual's power as

- You get encouragement and useful information from meeting regularly with others who share your interests.
- When working individually it is easy to get discouraged by the slow pace of change.
- Having a support group helps maintain enthusiasm.

However, there is a broad spectrum of environment and social action groups. Some will suit your particular interests, preferences or beliefs more than others.

Options that can be used for collective action include the following.

Student Environment Groups

Organisations for school and college students could be among our most active and effective groups for environmental change. By teaching them ecology and environmental ethics at elementary and secondary school level and by training them about environmental problems and their solutions and involving them in community projects, the purposes of environmental management could be served very effectively.

Margaret Mead once said

"Never doubt that a small, highly committed group of individuals can change the world; indeed, it is the only thing that ever has."

Organising an Environmental Campaign

It is the most effective tool to bring the attention of the national and international planners, decision makers and managers towards a particular issue. It is a very dynamic process in which you must constantly adapt to changing conditions. Some basic principles apply in most situations for organising the environmental campaign. An environmental campaign should be inclusive of all stakeholders, should benefit the common people, and should be backed by scientific knowledge.

Using the communication media to get your message out is an important part of the modern environmental campaign.

SAQ 4

Read the following sentences and write true (T) or false (F):

i) Education for environmental awareness is essential only for younger generation. [ ]

ii) Real life situations bring people closer to the environment. [ ]

iii) At the primary level of education greater emphasis could be laid on awareness and conservation. [ ]

iv) Environmental engineering includes subject like architecture, civil engineering. [ ]

v) Ministry of Environment, Forest and Climate Change, Govt. of India has created an information system called ENVIS. [ ]

vi) It is doubtful that a small highly committed group of individuals can change the world. [ ]

14.11 SUMMARY

Let us summarise what we have learnt so far:

- Many environmental problems that we face today are the result of our attitudes and cultural beliefs about environment and its management.
- Environmental degradation is considered as the result of western belief about environment according to which environment is only for human use. For most of human history, ethics has concentrated on human rights (anthropocentrism); it is only recently that ethics has formally begun to define the rights of animals, plants and other organism (biocentrism).
- Whatever our beliefs and attitudes may be, some mismanagement is done at policy and planning levels where basic condition of equity is not considered and discrimination on racial and class basis is common. Environmental justice seeks to eliminate those conditions in which communities on racial basis or on the basis of their low-income status are exposed to an inequitable share of pollution.

- It is clear from the study of teachings of different religions that every religion gives due worth to environment. Religions teach us that we should consider ourselves as trustees, not the master of environment. As trustees or stewards of environment, we can use the resources but we should not exploit them.
- For changing attitude of individuals, environmental education is an effective tool. However, individual efforts could do less for the environmental problems at international and global level.
- Student groups and environmental campaigns are effective collective actions, if organised properly.

14.12 TERMINAL QUESTIONS

1. What is Environmental ethics? Explain it.
2. Explain the importance of equity for environmental management.
3. How can we preserve, protect and sustain the environment and create appropriate relationship with nature while at the same time enjoying the benefits of industrial and technological developments.
4. What are the various religious teaching that speak about sacredness of the environment?
5. In what ways can environment groups and environmental campaigns serve as effective tools of disseminating environmental awareness?

14.13 ANSWERS

Self-Assessment Questions

1. i) e ii) d iii) a iv) c v) b
2. i) Environmental ii) Earth iii) Justice iv) Environmentalism
   v) Minorities, Jobs
3. i) f ii) e iii) a iv) b v) c vi) d
4. i) F ii) T iii) T iv) T v) T vi) F

Terminal Questions

1. Refer to Section 14.2
2. Refer to Section 14.5
3. Refer to Section 14.6
4. Refer to Section 14.8
5. Refer to Section 14.9 and 14.10

14.14 FURTHER READING

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GLOSSARY

Abyssal : Deep water, i.e., approximately below 1,000 meters

Acid Rain : Toxic gases like SOX and NOX dissolve in rain water to form sulphuric acid and nitric acid and come down as acid rain.

Agenda 21 : A non-binding action plan of the United Nations with regards to sustainable development. The "21" in Agenda 21 refers to 21st century.

Agro-forestry : It is a land use management system in which trees or shrubs are grown around or among crops or pastureland.

Anthropocentrism : Human centred attitude towards nature assign significantly greater value to human being than any other non-human organisms or things.

Atomic energy : The energy released by splitting of atom in a controlled manner can be utilized for generation of electricity.

Autotrophs : Organisms that synthesise their own food e.g. green plants.

Benthic : On or near the bottom of an ocean or lake

Biocentrism : Attitude and thinking that all living organisms have values and rights regardless of whether they are useful or not.

Biodiversity : The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems.

Biodiversity hot spots : Hot spots are areas that are extremely rich in species, have high endemism and are under constant threat.

Biological oxygen demand (BOD) : This is a measure of oxygen used by microorganism such as bacteria to decompose the organic matter like sewage, dead plant leaves, grass blades and food wastes.

Bio magnification of pollutants : Bio magnification is the phenomenon of increase in the concentration of a pollutant from one link in a food chain to another.

Biomass : Weight of living material

Biophysical carrying capacity : Biophysical carrying capacity is the maximum population that can be supported by the resources of the planet at a given level of technology.

Biosphere : It is a narrow layer around the surface of the earth where life can exist.

Biota	:	The organisms i.e. flora and fauna of an area
Biotic	:	Pertaining to life
Carbon sink	:	This is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.
Carnivore	:	Animals which feed on other animals
Chemical oxygen demand (COD)	:	It is the amount of oxygen required to degrade or breakdown the organic chemical compounds of wastewater.
Climate change	:	Any significant long-term change in the expected patterns of average weather of a region or the whole earth over a significant period of time.
Climbers	:	Climbing plants
Co-generation	:	Producing two forms of energy from the fuel, one form being heat and the other being electrical or mechanical energy.
Community health	:	This is broadly encompasses the entire gamut of community-organised efforts for maintaining, protecting and improving the health of the people.
Convention	:	An agreement between states covering particular matters especially one less formal than treaty.
Cyclone	:	A large scale air mass that rotates around a strong centre of low atmospheric pressure.
Decomposer	:	Micro-organisms such as bacteria, fungi and maggots that obtain energy from breakdown of dead organic matter and convert them into more simple substances.
Deforestation	:	Permanent removal or destruction of indigenous forests.
Determinism	:	Human being is subordinate to natural environment because all aspects of human life not only depend on but are dominantly controlled by the physical environment.
Detritus	:	Fresh or decaying organic matter of plant and animal origin
Disaster	:	An event that causes damage, economic disruption, loss of human life and deterioration in the health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community or area.
Drought	:	A 'drought' can be defined as a prolonged period of unusually dry weather, with little rainfall, in a region where rains are normally expected

Dunes : Low stretch of loess, dryland formed by wind

Ecofeminism : A pluralistic, nonhierarchical, relationship oriented philosophy suggests that humans could reconsider their relationship to nature in non-dominanting ways

Ecological approach : It emphasizes on wise and restrained use of natural resources and application of appropriate environmental management programmes, policies and strategies keeping in view certain basic principles of ecology so that already depleted natural resources are replenished, and health and productivity of the nature is restored.

Ecological succession: The orderly process of change or replacement of some inhabitants or species of the community in an area, through time is known as community development or more traditionally as ecological succession.

Ecosystem : Any unit that includes all the organisms that function together (the biotic community) in a given area, interacting with the physical environment so that the flow of energy clearly leads to defined biotic structures and cycling of materials between living and non-living parts.

Ecosystem diversity : The variation between different types of ecosystems.

Emergency preparedness : A programme of long term development activity whose goal is to strengthen the overall capacity and capability of a country to manage efficiently all types of emergencies and bring about an orderly transition from relief through recovery and back to sustainable development.

Environment : The sum total of living and non-living components; influences and events surrounding an organism.

Environmental equity: An ideal of equal treatment and protection for various racial, ethnic and income groups under environmental statutes, regulations and practices are applied in a manner that yields no differential impacts relative to the dominant groups and the conditions so created.

Environmental justice: The pursuit of equal justice and protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity and / or socio-economic status.

Environmental racism: Racial discrimination in environmental policy making, enforcement of regulations and laws and targeting of communities of colour for toxic waste diasporas and setting up of polluting industries.

Estuary	:	A coastal region such as inlets or mouths of river where fresh water and saltwater mix
Evaporation	:	It is the process by which liquid water changes into vapour at ambient temperature.
Evapotranspiration	:	It refers to the loss of water in vapour form from plant leaves.
Flood	:	A flood is the discharge of water that exceeds the canal capacity of the river.
Flora	:	A collective term for all the plant types that grow in a region
Food chain	:	A linear sequence of links of organisms in which an organism becomes food for the next organism.
Food web	:	The complex interlocking pattern of food chains in a biotic community
Fuel cells	:	These are electrochemical devices that convert the chemical energy of a fuel directly efficiently into electricity and heat, thus doing away with combustion.
Genetic diversity	:	Diversity of basic units of hereditary information which are passed down generations found within a species (e.g. different varieties of the same species).
Geothermal energy	:	Volcanoes, hot springs, and geysers, and methane under the water in the oceans and seas are sources of geothermal energy. Heat generated from the earth.
Global warming	:	Heating of earth's atmosphere due to increasing concentration of carbon dioxide and other green house gases
Green house effects	:	The situation is analogous to a greenhouse which traps heat and its glass walls do not allow the heat to go out thereby increasing the inside temperature. Therefore, this effect is called greenhouse effect.
Grit	:	Particles of coarse sand
Habitat	:	A specific site or place where a plant or animal naturally or normally lives or grow
Hazardous waste	:	A waste is considered as hazardous if it has any one of the following characteristics: ignitability, corrosiveness, reactivity, radioactivity and toxicity
Health	:	A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
Herbivore	:	Organism that feeds on plants
Heterotrophs	:	Organisms that cannot synthesize its own food and derives its nourishments by feeding on others.
Joint forest	:	Partnerships in forest movement involving both the

management : state forest departments and local communities.

Land degradation : It refers to the process of deterioration in the quality of land.

Mangrove : A tidal forest vegetation in saline swampy sea shore areas in the tropics

Most probable number (MPN) : MPN test both *E.coli* and coliforms can be detected and statistically enumerated the number of these organisms present in the water body.

Non-renewable resources : Sources that will run out or will not be replenished in our life times or even in many life times.

Nutrient cycles : Elements or mineral nutrients are always in circulation moving from non-living to living and then back to the non-living components of the ecosystem in a more or less circular fashion.

Oxymoron : It is a figure of speech that combines two usually contradictory terms into a compressed paradox (e.g. bitter sweet, pretty ugly).

Ozone hole : Depletion of ozone or *thinning of ozone layer.*

Photosynthesis : The process by which chlorophyll containing cells of plants utilize energy of the sun to synthesise simple carbohydrates from carbon dioxide and water.

Plankton : Microscopic floating, aquatic plants (phytoplankton) and animals (zooplankton) in marine and fresh water situation which float freely in water.

Pollutant : The agent that contaminates the environmental component is called the pollutant.

Pollution : Any undesirable change in the physical, chemical or biological characteristics of environmental components i.e., air, water and soil that adversely affect the life forms and life support systems of the biosphere.

Possibilism : It indicates that the physical environment is passive and human being is the active agent at liberty to choose between wide ranges of environmental possibilities. Ecological his approach emphasizes on wise.

Prairie : Wide area of level land with grass but no trees

Precipitation : It includes all forms in which atmospheric moisture descends to earth: rain, snow, hail, sleet and dew.

Range of tolerance : The organisms can tolerate changes in environment within a certain range.

Renewable resources: Some of the resources of the earth are replaced from time to time by natural multiplication.

Savanna : Grassy plain with few or no trees in tropical and sub-tropical regions

Social carrying capacity : Social carrying capacity is the sustainable biophysical carrying capacity within a given social organisation, including patterns of consumption and trade.

Social forestry : The management and protection of forest and afforestation of barren and deforested lands with the purpose of helping environmental, social and rural development.

Social inequity : This issue addresses the questions of fair treatment: the extent that governing rules, regulations, and evaluation criteria are applied uniformly.

Species diversity : This means the differences between species (both domesticated and wild).

Steppes : Level grassy plain devoid of forest

Stewardship : The job of supervising or taking care of something such as an organisation or property.

Sublimation : It is the process by which solid water changes directly to vapour phase without passing through the intervening liquid phase.

Sustainability : It refers to a process which can be continued indefinitely without depleting the resource base on which it depends.

Sustainable Development : Meeting the need of present generation without compromising the ability of future generation to meet their own needs.

Total dissolved solids (TDS) : The amount of salts and solids dissolved in water is measured by testing the TDS.

Trophic level : It refers to a position or a level in a food chain or ecological pyramid. It is occupied by a group of organisms that have a similar feeding mode.

Tsunami : A tsunami is a wave in the ocean or in a lake that is created by a geological event. They are also known as tidal waves or seismic sea waves

Wasteland : Land not producing its potential of biomass due to ecological degradation, over exploitation or the absence of a clear management system.

Weathering : The sum total of natural processes resulting in the disintegration of parent rocks is collectively known as 'weathering', and it involves physical, chemical and biological agencies.

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