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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.

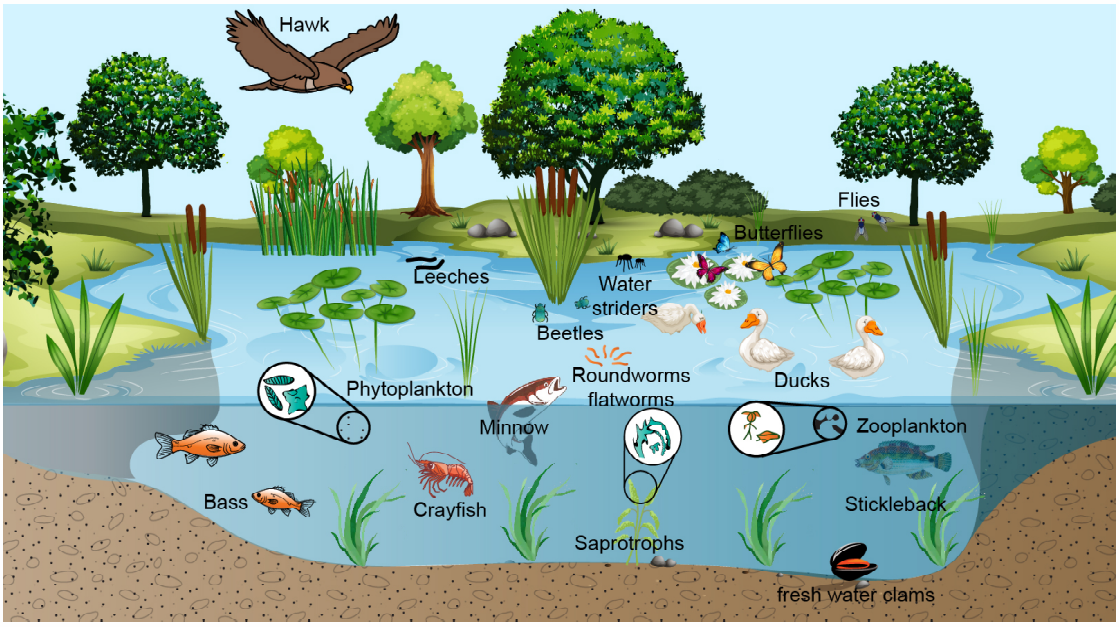

Fig. 1.1: Environment of a Carp in a Pond.

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.

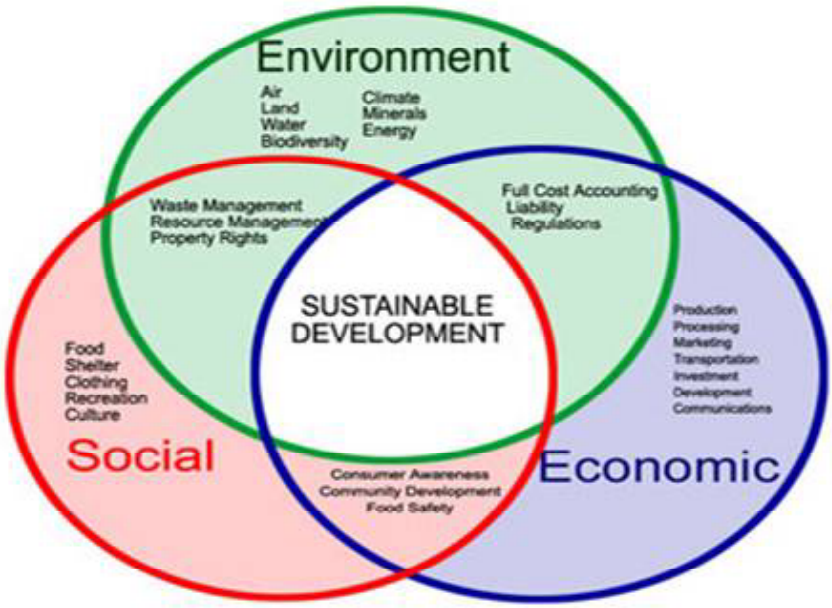

Fig. 1.3: Three Pillars of Sustainable Development.

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.

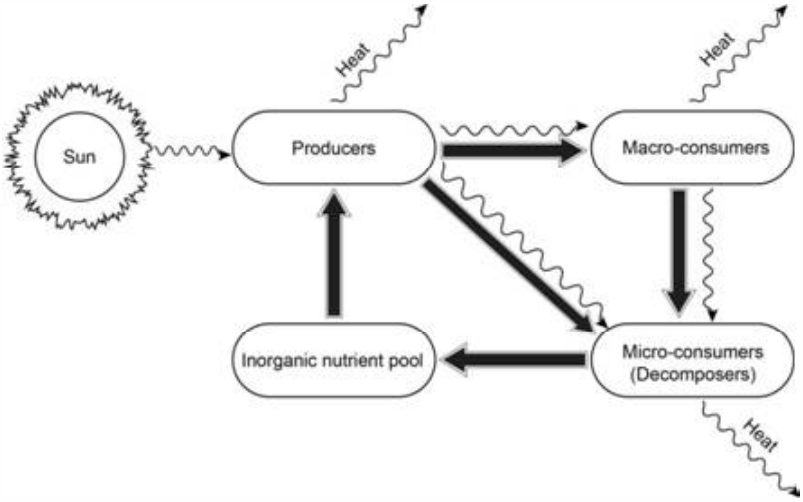


Fig. 2.1: Schematic representation of an ecosystem. The dotted lines represent the boundary of the system. The three major components are the producers, the consumers, and the abiotic elements. The arrows indicate interactions within the system and with the enviroment. Energy does not cycle because all 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).

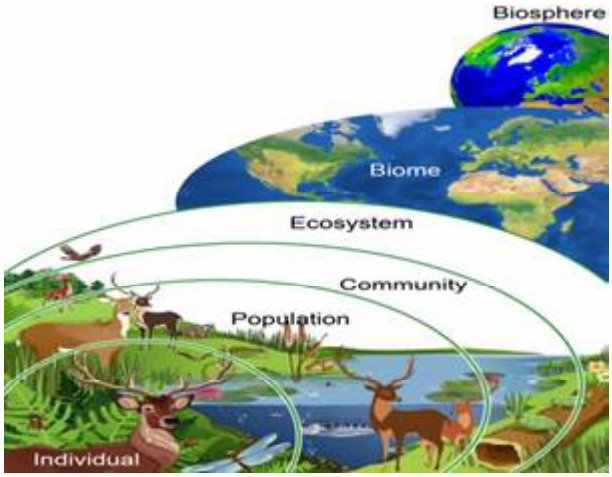


Fig. 2.2 : Size of ecosystem in decreasing order: Biosphere, biome, landscape, ecosystem, community, population, individual.

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.

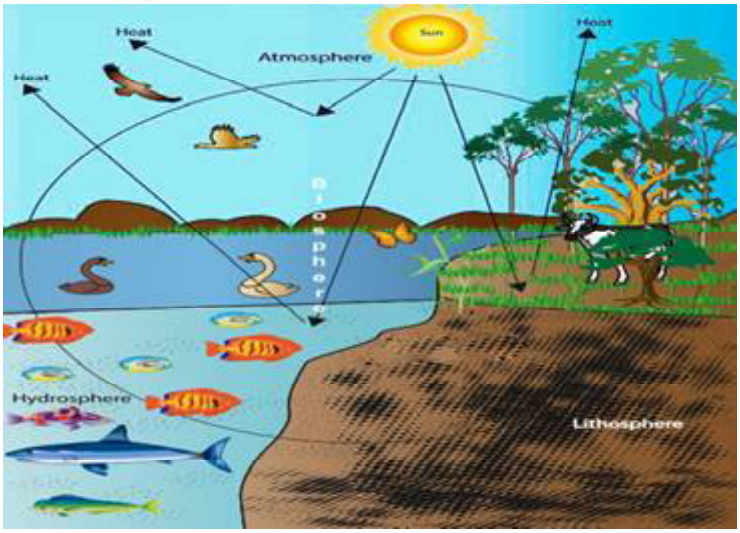


Fig 2.3: Idealised scheme of a biosphere in relation to hydrosphere, atmosphere and lithosphere.

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. ( )

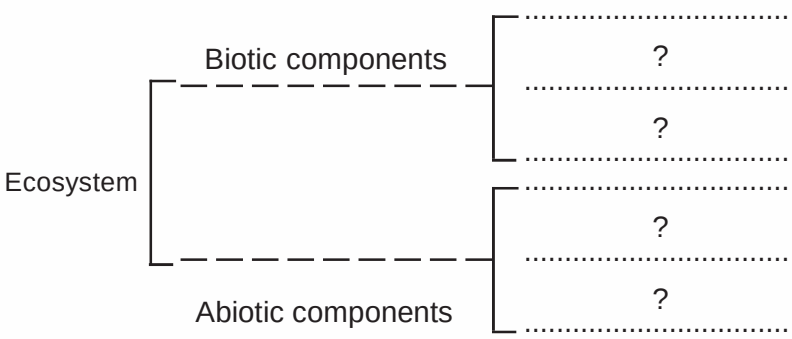
   iii) Ecosystems represent enormous contrast in size and complexity. ( )

   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

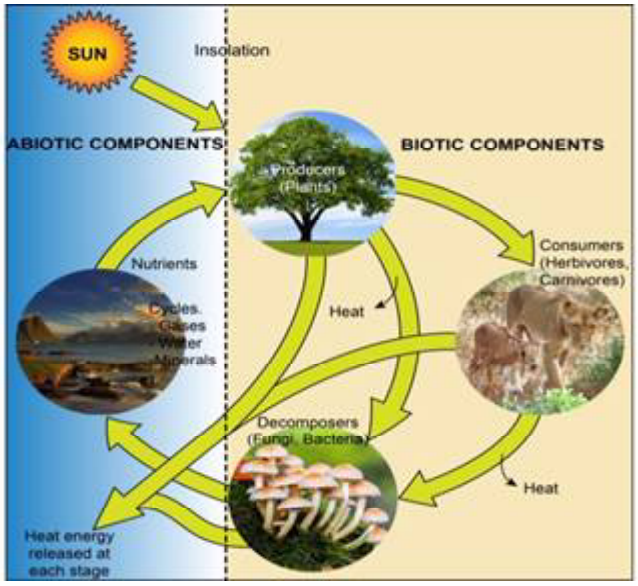


Fig. 2.4: Biotic factors are dependent on abiotic factors. Light and heat energy from the sun are the main key components that biota depend on. Biomass of producers is used by consumers who obtain energy by ingesting food. The assimilated energy is used for various functions of the body like respiration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

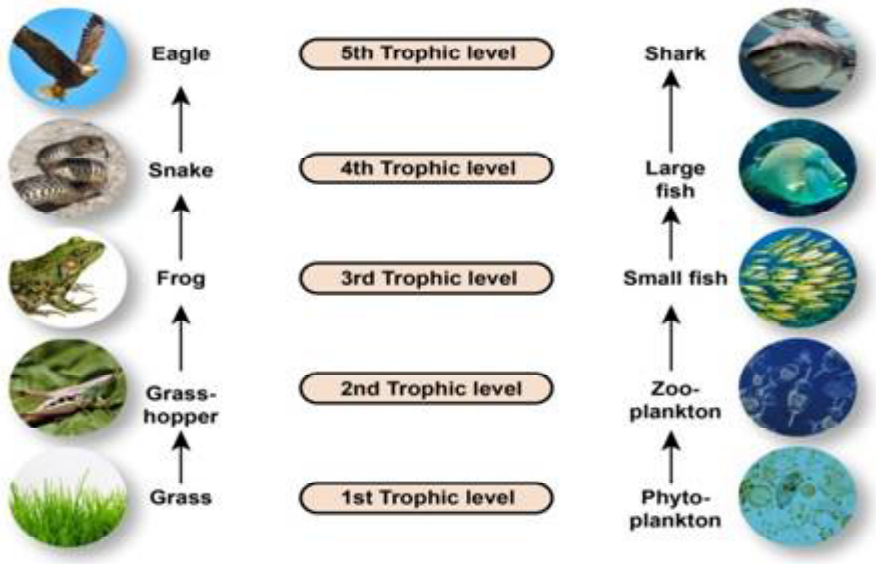


Fig. 2.5: Trophic levels in a food chain in: i) a terrestrial and an ii) aquatic environment.

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):

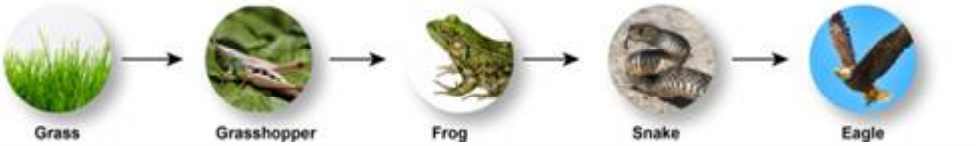


Fig. 2.6: A grazing food chain designated as follows: Grass→ grasshopper → frog → snake→ eagle.

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):

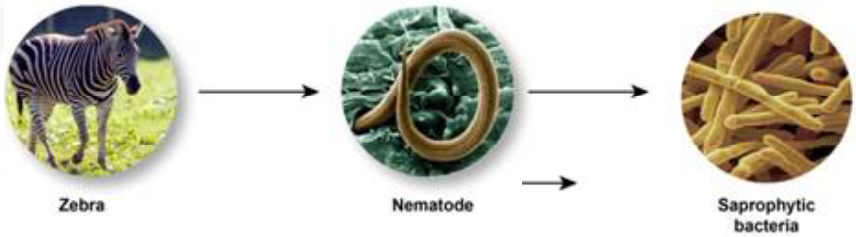


Fig. 2.8: A parasitic food chain designated as follows-zebra→nematode→bacteria.

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).

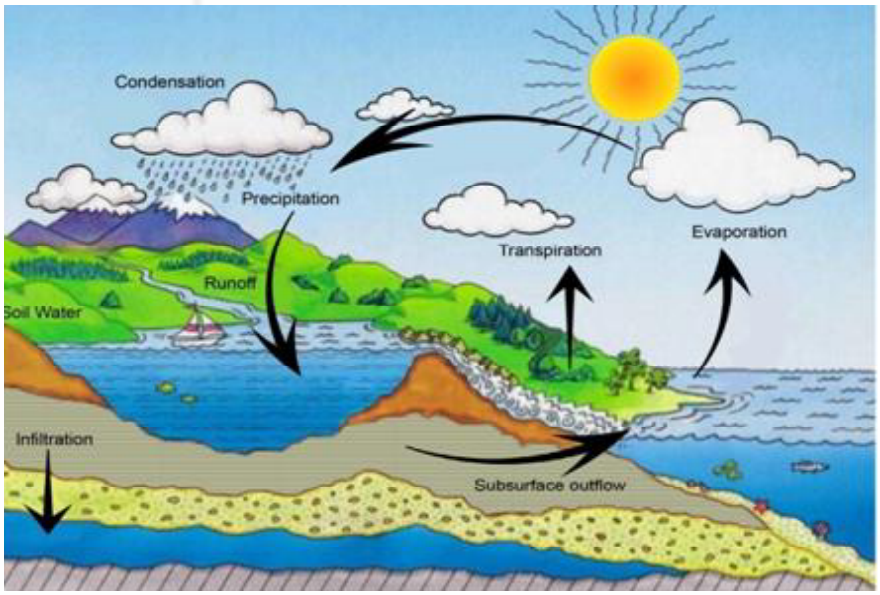


Fig. 2.9: The water or hydrological cycle depicting the major pathway of water movement through the ecosystem.

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

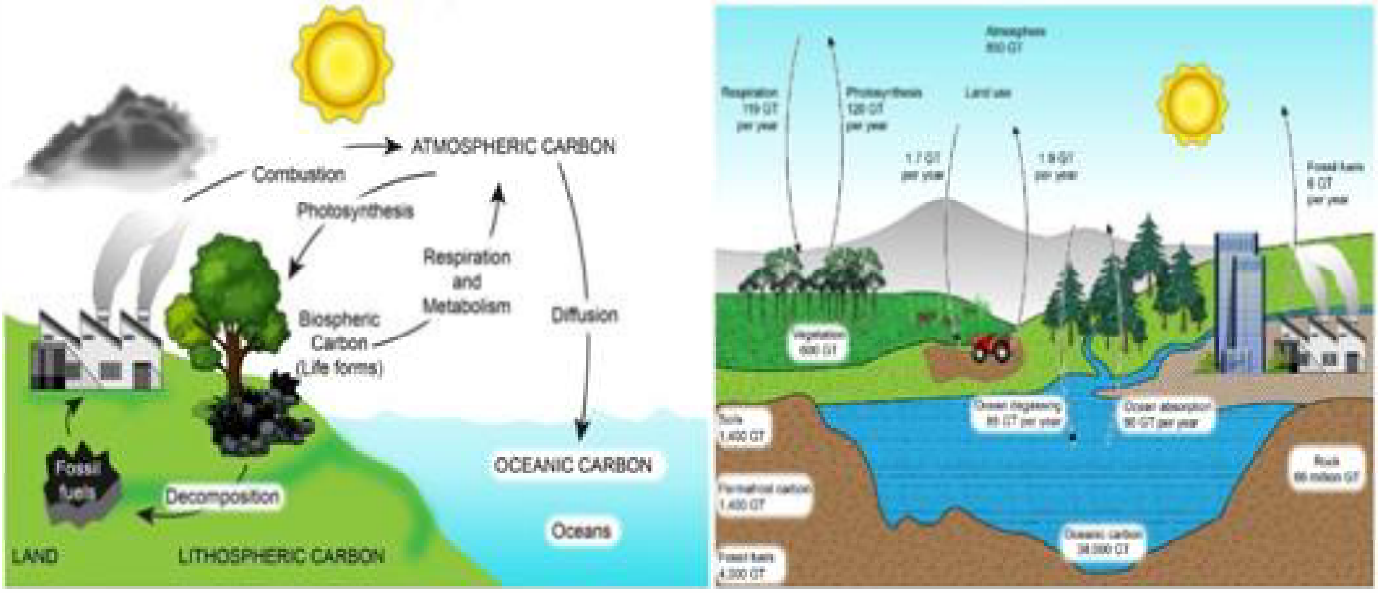


Fig. 2.10: a) Atmospheric carbon is fixed by plants in their biomass and gets transferred plants to the animals feeding on them, and so further moves up the food chain. Respiration, digestion, and metabolism of plants and animals result in some transfer of carbon back to the atmosphere. Some carbon also 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.

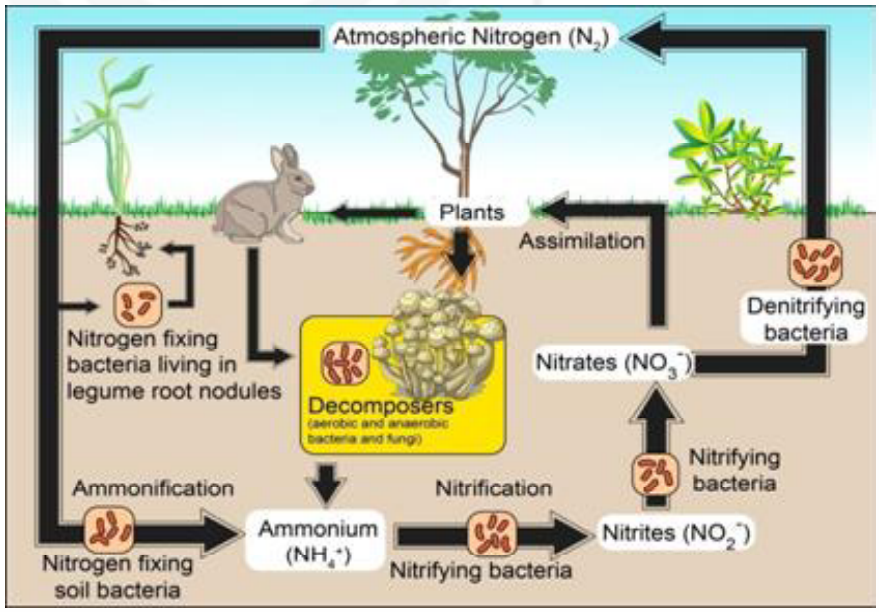


Fig. 2.11: A schematic nitrogen cycle showing the flow of nitrogen through the land environment. Presence of bacteria is a key elements in the cycle as it provides different forms of nitrogen compounds that can be assimilated by higher organisms.

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.

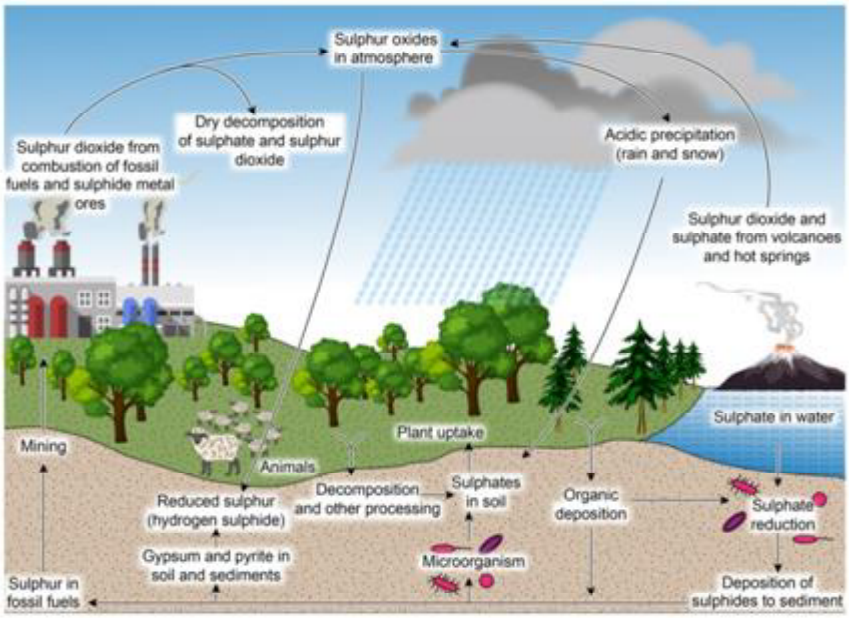


Fig. 2.12: The sulphur cycle, showing the two reservoirs namely, sedimentary and gaseous.

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.

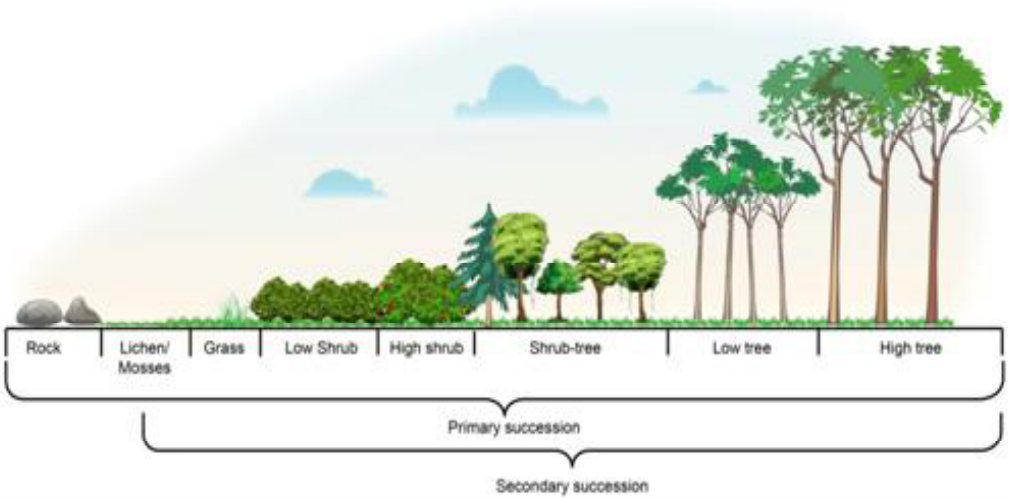


Fig. 2.13: Stages of primary succession in a terrestrial community. The orderly series of species replacement during succession can be seen in this sequence — from a bare exposed rock to a fir-birch-spruce community. Pioneer species of lichens and mosses begin the soil-building process, followed by the 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.

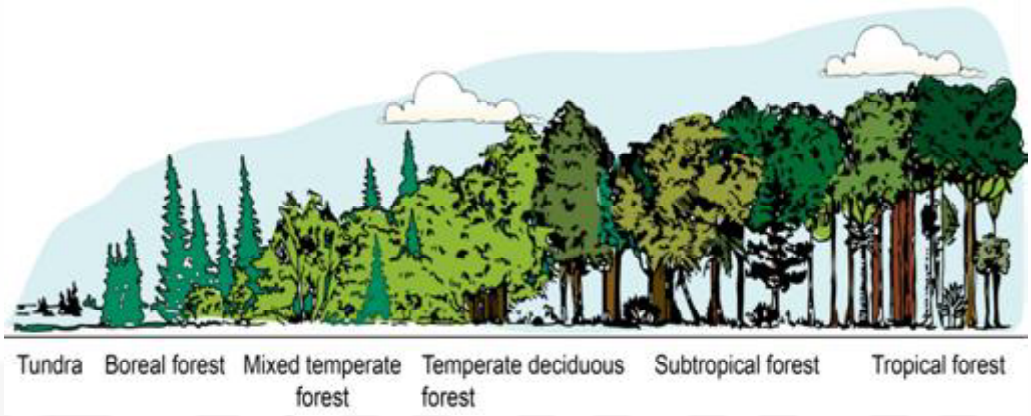

Fig. 3.1: Types of forests

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:

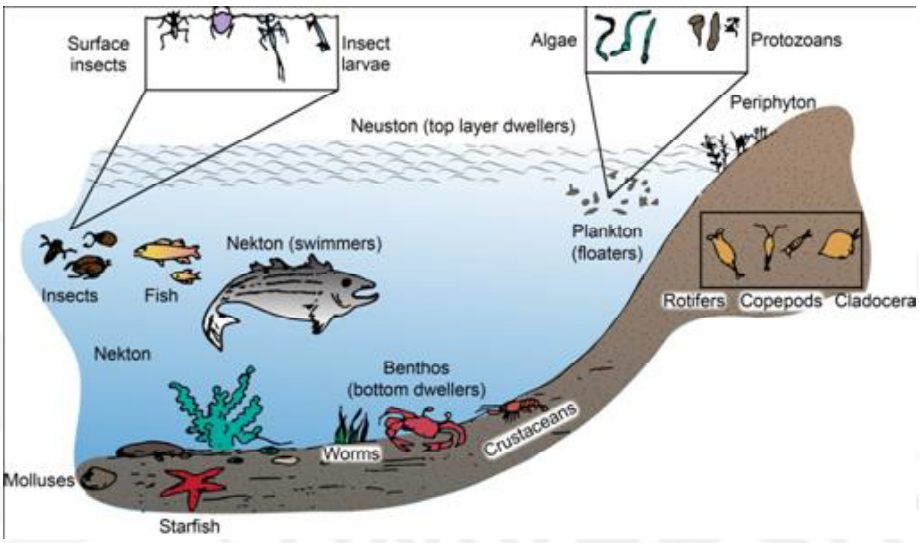

Fig 3.3: Life Styles of Aquatic Organisms

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.

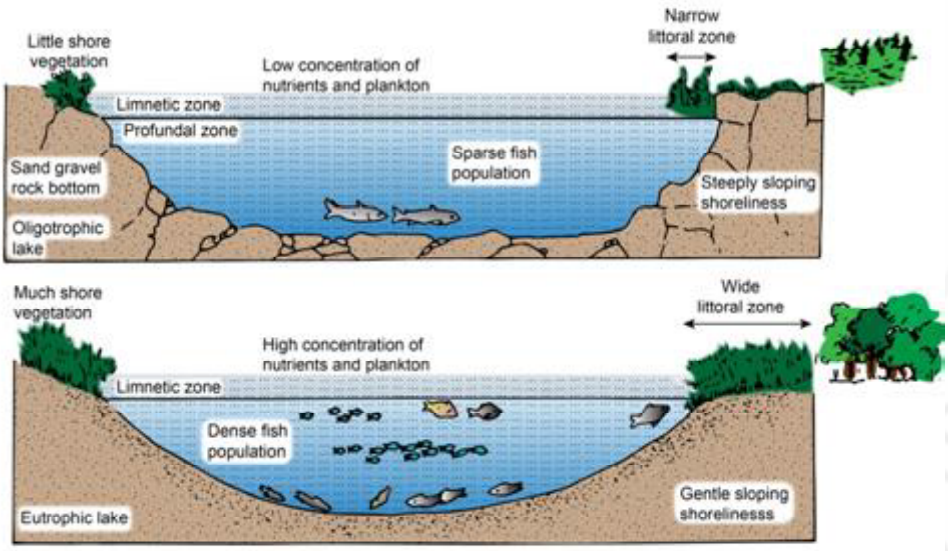

Fig. 3.4: Lake and its biota.

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.

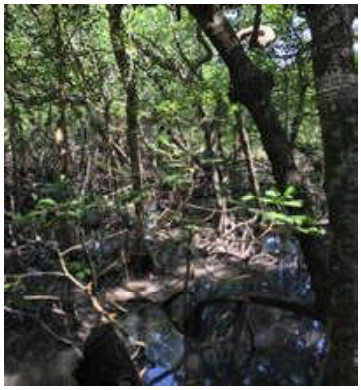

Fig. 3.6: Wetland.

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).

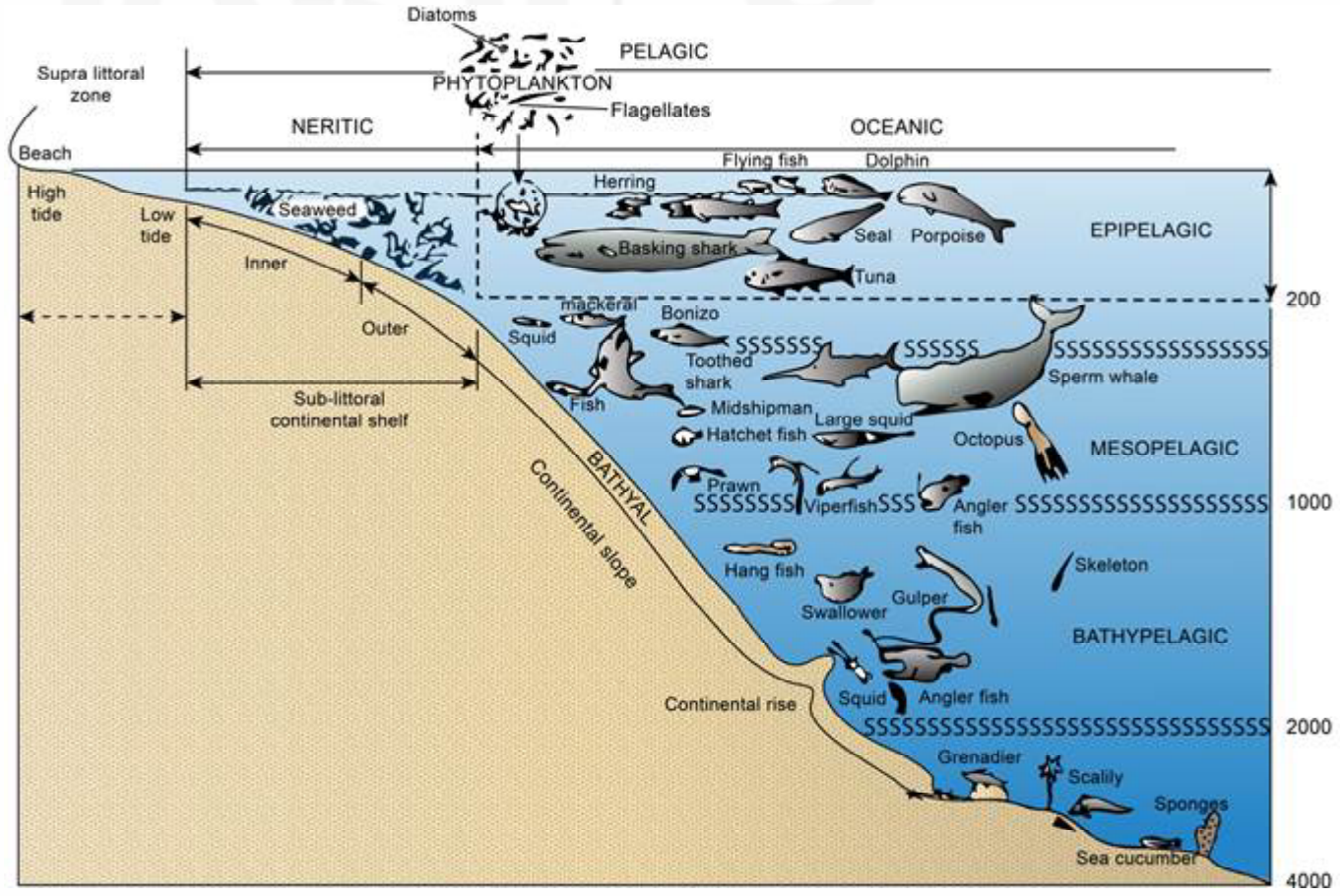

Fig 3.7: Major regions of the ocean.

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