Uttar Pradesh Rajarshi Tandon
Open University

Bachelor of Science

SBSBY-02

Ecology

COURSE INTRODUCTION

Ecology is the study of the interrelationship between the living organism with their environment. The term oekologie (ecology) was coined by the German biologist Ernst Haeckel in 1866. Taylor defined ecology as the science of all the relations of all organisms to all their environments in 1936.

"The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem".

The concept of ecosystem was first put forth by A.G. Tansley (1935). Ecosystem is the major ecological unit. It has both structure and functions. The structure is related to species diversity and functions are related to the flow of energy and cycling of materials.

The awareness for ecology is essential for the younger as well as older generation. It also needs to cover urban and rural population. The basic aim of ecological education is to make aware the people regarding the abiotic and biotic environment and their resources. The abiotic environment includes light, temperature, pressure, humidity and precipitation. The biotic environment includes all living organisms present in the environmental system. Forest is a very good example as well as natural resource composed of trees, shrubs and woody vegetation. The forest ecology helps in reducing global warming, ecological balance, pollution etc.

There are two major subdivisions of ecology in particular reference to animals or to plants, hence animal ecology and plant ecology. Further ecology is often broadly divided into autecology and synecology. Autecology is the study of individual organism or individual species whereas synecology is community ecology.

This course is divided into 2 blocks in which block-I and II deals with Ecology I and II respectively.

Ecology

Block I- Ecology I

Block II- Ecology II

Block I- has 4 units in which you will be introduced by ecology with structure and function of ecosystem, ecological succession and pollution.

Block II- has 4 units in which you will study the ecological adaptation in plants, edaphic factors, phytogeography and environmental education.

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Ecology

BLOCK

1

ECOLOGY-I

UNIT-1

Introduction to Ecology

UNIT-2

Structure and Function of Ecosystem

UNIT-3

Ecological Succession

UNIT-4

Pollution

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BLOCK INTRODUCTION

Ecology-I

This block is divided into four units 1, 2, 3 and 4. Unit 1 deals with introduction, scope, history, branches and major divisions of ecology as well as ecological levels of organization. In unit 2 you will study biotic and abiotic components of ecosystem, food chain, food web, pyramids, energy flow and biogeochemical cycle of ecosystem. The unit 3 tells you about causes and process of succession, types of succession like hydrosere and xerosere. In the unit four you will study about types of pollution and their control measures.

Objectives :

After studying this block you will be able to-

- Know about ecology and it's scope with their different branches and divisions.
- Understand structure and function of ecosystem in detail.
- Know what is ecologi succession and cal how it occurs?

Identify pollution hazards and apply various measures to control it.

UNIT –1 INTRODUCTION TO ECOLOGY

1.1 INTRODUCTION

The term ecology (oekologie) derived form two Greek words oikos means 'house' or place to live and logus means study. Ecology is the study of the inter-relationship between in the living organisms with their environment. Which includes both biotic and abiotic components, include the biodiversity, distribution, biomass and population of organisms, as well as cooperation and competition on within and between species.

The term ecology was first of all introduced by Reiter in 1868, but the German biologist Ernest Haeckel (1869) defined ecology refers to the "Surrounding outer world" which we now call the environment of an organism. "His Organic and inorganic condition" we call biotic and abiotic environmental factors, respectively. A.G. Tansley (1935), The philosopher

ecologist visualized a holistic approach of the study recognizing the fact that the biotic (living) and abiotic (non-living) components of nature are not only interrelated but also function in an orderly manner as a definite system.

He proposed the term ecosystem for the set of organisms interacting with each other and their surrounding physical and chemical factors extant in a given space.

Objectives :

After studying this unit you would be able to :

- **know history and scope of ecology**
- **explain the specialized branches of ecology**
- **discuss the major division of ecology**
- **discuss the ecological levels of organisation**

1.2 SCOPE OF ECOLOGY

The scope of ecology contains a wide array of interacting levels of organization, Spanning micro level (eg; cells) to a planetary scale (eg;biosphere) phenomena. To structure the study of ecology into a conceptually manageable framework, the biological world of organized into a nested hierarchy , ranging in scale from genes, to cell, to tissues, to organs, to organisms, to species, to populations, to communities, to ecosystems, to biomes, and up to the level of the biosphere.

In ecology, ecosystems are composed of dynamically interacting parts, which include organisms the communities, they comprise and the non living (abiotic) components of their environment. Ecosystem processes, such as primary production, pedogenesis (the formation of soil), nutrient cycling, regulates the flow of energy and matter through an environment. These processes are sustained by organisms with specific life history traits. The variety of organisms called biodiversity, which refer to the different species, genes, and ecosystem.

Biodiversity (an abbreviation of "biological diversity") describe the diversity of life from genes to ecosystems and spans every level of biological organization Biodiversity includes species diversity, ecosystem diversity, and genetic diversity. Biodiversity plays an important role in ecosystem, which maintain and improve human quality of life.

Biodiversity within ecosystem can be organized into trophic pyramids, in which the vertical dimension represent feeding relations that become further removed from the base of the food chain upto world top predators, and the horizontal dimension represents the abundance or biomass at each level.

When the relative abundance or biomass of each species is sorted into its respective trophic level, they naturally sort into a pyramid of numbers.

Ecologist study within several biological levels of organization, which include organism, population, community and ecosystem. There are many practical applications of ecology in conservation biology, wetland management, natural resource management (agriculture, forestry, agroforestry, fisheries), city planning (urban ecology), community health, human social interaction (human ecology). Ecosystem sustain life supporting functions and produce natural capital, such as biomass production (food, fuel, fiber and medicine), the regulation of climate, global biogeochemical cycles, water filtration, soil formation, erosion control and flood protection.

1.3 HISTORY OF ECOLOGY

The branch of science studying the interaction among living things and their environment.

Science of relationship between plants, animals and their environments.

Ernst Haeckel (1886) in his definition of ecology, refers the "surrounding outer world" which we now call the environment of an organism " His organic and inorganic conditions" we call biotic and abiotic environment at factor respectively.

A.G. Tansly (1935), the philosopher ecologist visualized a holistic approach of the study recognizing the fact that biotic (living) and abiotic (non living) components of nature are not only interrelated but also function in an orderly manner as a definite system. He proposed the term ecosystem for the set of organisms interacting with each other and their surrounding physical and chemical factors extant in a given space.

During the first third of 20^{th} century, there started developing specialized area of ecology like paleo-ecology, zoogeography, oceanography, limnology etc. And then was introduced the population concept on which statistical studies and sampling techniques were employed for solving the community problems. This era is popularly called as era of population and community ecologists.

Modern ecology become a much more regorous science in the late 19^{th} century. Evolutionary concepts relating to adaptation and natural selection become the cornerstones of modern ecological theory.

Ecosystem simply means "ecological system". Ecology is defined as the study of ecosystems. Ecologist study the interaction of all the organisms in an ecosystem. The study includes complex interactions between thousands of plants and animals to the role of microbes living under the soil to the effects of tropical rainforest on the earth's atmosphere. The study done by ecologists can help us to better understand the world around us and can influence our lives in a positive way by improving the environment, managing our natural resources and protecting the public health.

Ecologists also study how temperature influences the ecology and evolution of species. Organisms generally slow down or freeze when conditions are cold, but overheat and lose function as temperature rise. At the community level, community ecologist study how resource availability influences ecosystem characteristics, including the number and types of species present. For example, The amount of carbon and energy fixed in photosynthesis by plant and other producers (e.g. productivity) constrains the amount of consumers an ecosystem may support. Because of this limit it's lost at each transmission step through a food web. A low productivity ecosystem generally supports less consumer biomass than higher productivity systems.

The product of organic evolution is the origin of species or evolution of old species into new species. For example, during organic evolution under certain environmental stresses, certain autotrophic, heterotrophic, anaerobic and aerobic prokaryotic cells of kingdom. Monera started symbiotic relationship and evolved into eukaryotic plant, and animal cells to form kingdom protista (Margulis 1970). Later on, Kingdom Protista Evolved and gave origin to three kingdom Plantae (Metaphyta), Fungi and Animals (Metazoa).

1.4 SPECIALIZED BRANCHES OF ECOLOGY

Besides these major ecological subdivisions, there are following specialized branches of ecology.

There are also many subcategories of ecology, such as ecosystem ecology, animal ecology and plant ecology, which look at the differences and similarities of various plants in various climates and habitats.

In addition, physiological ecology, studies the responses of the individual organism to the environment, while population ecology looks at the similarities and dissimilarities of populations and how they replace each other overtime.

Finally, it is important to note that ecology is not synonymous with environment. It is also different from, through closely related to the studies of evolutionary biology, genetics, and ethnology.

Adaptation is the central unifying concept in behavioural ecology. Behavioural ecology is the study of an organism′s behaviour in its environment and its ecological and evolutionary implications. Predator-prey interactions are an introductory concept into food web studies as well as behavioural ecology.

Social ecological behaviours are notable in the social insects, slime moulds, etc. Ecological interactions can be classified into a host and an associate relationship. A host is any entity that harbours another that is called the associate. Relationships within a species that are mutually or reciprocally beneficial are called mutualisms. Example of mutualisms include fungus-growing agricultural symbiotic bacteria living in the guts of insect and other organisms. Lichens with fungi and photosynthetic algae and corals with photosynthetic algae are also examples of mutualism.

Branches of Ecology :

There are various specific and detailed approaches in ecology which are as follows:

1. **Habit ecology – This includes studies on habitat, e.g. Fresh water ecology, Marine ecology, Forest ecology, Grassland ecology.**
2. **Population Ecology- This deals with population dynamics in pure or mixed strands. Population ecology is the branch of ecology that studies the structure and dynamics of populations.**
3. **Human Ecology- This study concerns the environment with man as main theme.**
4. **Palaeoecology- A branch of ecology that is concerned with the characteristics of ancient environment and with their relationship to ancient plants and animals.**
5. **Ecosystem Ecology- It deals with the analysis of components of ecosystem and the interrelationship of biotic and abiotic components.**
6. **Radiation Ecology- It deals with the study of radioactive substances and radiations in the environment.**
7. **Space Ecology- This is concerned with a possible visit to and return from neighbouring planets.**
8. **Statistical Ecology- It deals with the statistical studies on populations, sampling techniques and community problems.**
9. **Applied Ecology- It deals with the soil erosion, environmental pollution, wild life management etc.**
10. **Zoogeography- It deals with geographic distribution of animals.**
11. **Phytogeography- It deals with geographic distribution of plants.**

1.5 MAJOR DIVISION OF ECOLOGY

Early ecologist has recognized two major subdivision of ecology in particular reference to animals or to plants, hence animal ecology and plant ecology. Furher, ecology is often broadly divided into autecology and synecology.

Depending upen the levels of organisation synecology may deal with population, community, biome, and ecosystem.

1.5.1 ANIMAL ECOLOGY

Animal ecology concerns the relationships of individuals to their environments, including physical factors and other organisms and the consequences of these relationships for evolution, population growth and regulation, interactions between species, the composition of biological communities and energy flow.

1.5.2 PLANT ECOLOGY

Plant ecology is the study of the relationship of plants with the biotic (living organisms such as animals and other plants, bacteria and fungi) and abiotic factors such as moisture, temperature, sunlight, soil (nutrients and salinity) and water surrounding them.

1.5.3 AUTECOLOGY

Autecology is the study of individual organism or individual species. It is also called as population ecology. Autecology study of interrelationship between individual species of organism or its population and its environment. In autecology we study in details the morphology of individual affected by its prevailing environment. Its geographical distribution based on the surrounding influence of environment on the life cycle and growth of organism. Its taxonomical position and several factors including those which effects different developmental stages of individuals life cycle.

In autecology we study in details of their geographic distribution, morphology, taxonomic position and life cycle etc.

1.5.4 SYNECOLOGY

Also called the community ecology. Synecology is the study of group of organisms of different species, which are associated together as a unit, in form of community. Synecology can be divided into population, community ecology, biome and ecosystem ecology.

Ecological Factor

Biotic Factor:-

The biotic factors include the influence of all living organisms which interact with each other and with a abiotic components.

Abiotic Factor:-

Abiotic factors are all of the non living chemical and physical factors present in the atmosphere. Sunlight, air, minerals, water, salts, and soil are some examples of abiotics factors.

The abiotic components are characterized by physical and chemical factors such as light, temperature, rain fall, pressure, P^H, the content of oxygen and other gases.

SAQ - 1

(i) The term ecology was proposed by
.....

(ii) Synecology is the study of
.....

(iii) Pedology is the study of
.....

(iv) The term ecosystem was first used in
.....by.....

1.6 ECOLOGICAL LEVEL OF ORGANISATION

It includes Species, Population ecology, Community ecology, Biome ecology & Ecosystem.

1.6.1 SPECIES

Species is a group of individuals that are genetically linked with each other. They can interbreed to produce fertile young ones.

1.6.2 POPULATION ECOLOGY

Population is a group of organisms belonging to the same species that live in the same area and interact with one another. Plant and animal populations are not the same in every environment, even when the kinds of organisms in the environment are the same. Population of size may be large or small, depending on such factors as food and water resources. Interactions of the organisms with each other may influence population size. The population ecology is the study of how biotic (living) and abiotic factors (non living) influence the density, dispersion, and size of population. Population ecology is also concerned with communities. A population ecologist also studies interactions between populations of different species in a community. The population has various group characteristics, which has statistical measures that can not be applied to individuals. These group characteristics are the three general types. The basic characteristics of a population is its size and density which is affected by four primary population parameters such as natality (births) mortality (deaths), immigration and emigration.

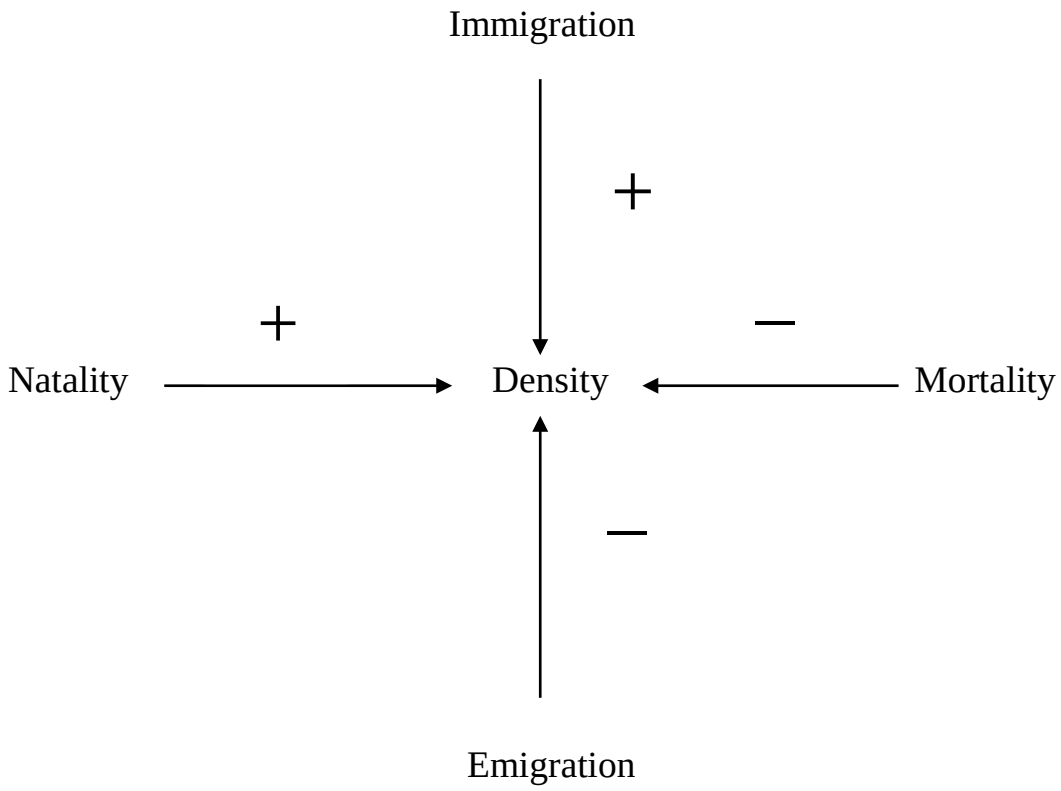

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Fig.1.1. Primary population parameters

The secondary characteristics of population, such as its age distribution, genetic composition and pattern of distribution (distribution of individuals in space) of these population parameters, results from a summation of individual characteristics.

Some ecologists recognized following two types of populations.

(1) Mono-specific population-is the population of individuals of only one species.

(2) Mixed or poly-specific population- is the population of individuals of more than one species, ecologists use the term community for the poly-specific population.

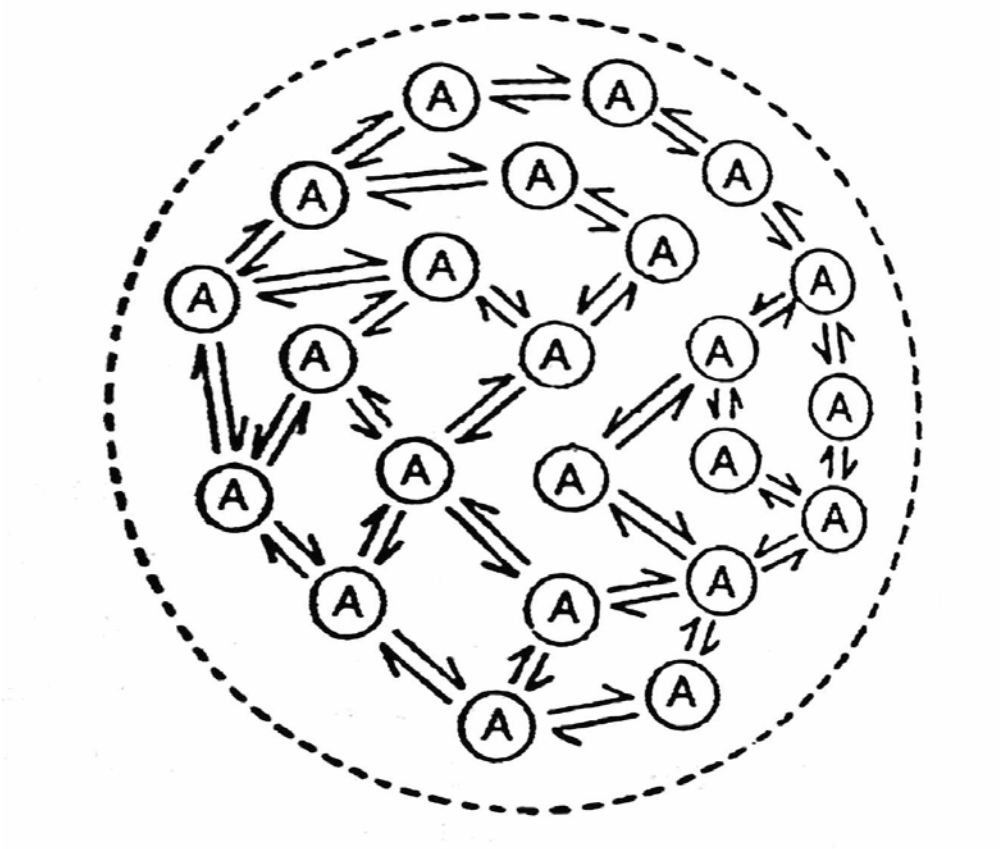


Fig. 1.2. Population ecology

1.6.3 COMMUNITY ECOLOGY

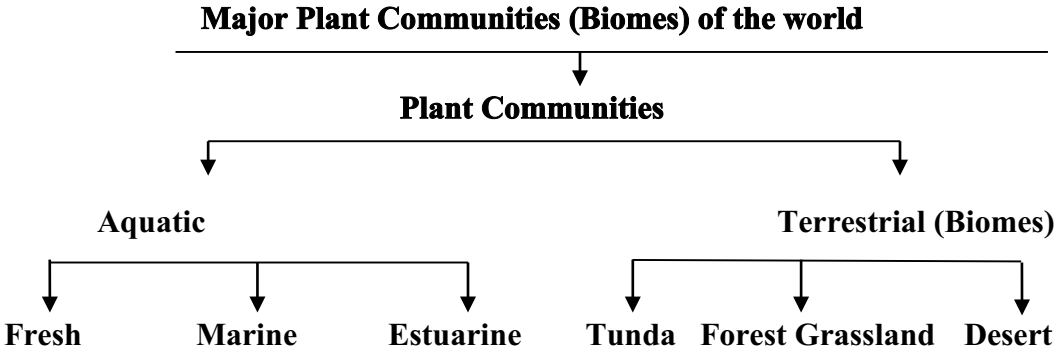
Community is the group of population of different species plants as well as animals, in a same area. Population of a community interact with one another, community is composed of all the biotic factors of an area.

Community ecology examines how interactions among species and their environment affect the abundance distribution and diversity of species within communities. (Community ecology is the study of the interactions among a collection of species that inhabit the same geographic area) community is a larger unit than the population.

Communities may be classified as forests, deserts, grasslands, tundra and so on. Communities may be divided as hydrophytic in pre-dominantly aquatic habitats, mesophytic in moderately moist soils and xerophytic in arid or dry conditions. Communities growing in condition of abundant light are called heliophytic and those growing in shade are called sciophytic.

The global community is an enormous mass of life, comprising all the plants and animals in the world.

The global community is further divided into continental communities and oceanic communities. Since due to great variability in climatic factors, an exhaustive study in such vast area is practically impossible, therefore, communities are often studied as biotic province.



Differences between Population and community

The main difference between population and community is that a population is a group of individuals of a particular species (single species living in a particular ecosystem at a particular time, whereas a community is a group of individuals belonging to different species plants as well as animals based on levels of organization.

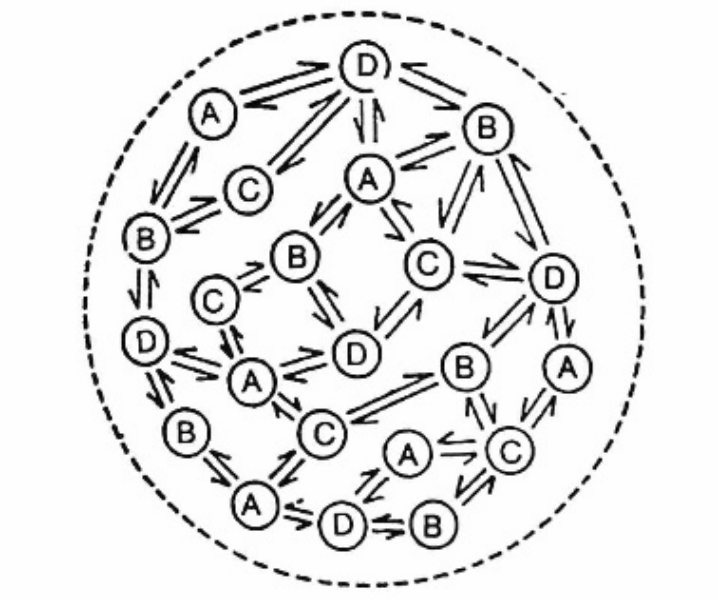


Fig. 1.3. Community ecology

1.6.4 BIOME ECOLOGY

Biomes, as unit of study there are interactions between different communities of area. Biomes are very large ecological areas on the earth′s surface, with fauna and flora (animals and plants) adapting to their environment. Biome is different from an ecosystem. An ecosystem is the interaction of living and nonliving things in an environment. A biome is a specific geographic area notable for the species living there. A biome can be made up of many ecosystems for example, classification and count as few as six biomes. These are forest, grassland, fresh water, marine, desert and tundra.

Biomes are larger units of organization that categorize region of the earth's ecosystem, mainly according to the structure and composition of vegetation.

Biosphere :

I. **The biosphere made up of the parts of earth where life exists. The biosphere is a global ecosystem composed of living organisms (biota) and the non living (abiotic) factors from which they derive energy and nutrients.**

II. **Biosphere is the narrow zone where the life exists on earth, In biosphere is everything about life on earth. It is the place where humans, animals, plants, Microorganism live and interact with each other.**

III. **The largest scale of ecological organization is the biosphere. Ecological relationships regulate the flux of energy, nutrients, and climate all the way up to the planetary scale.**

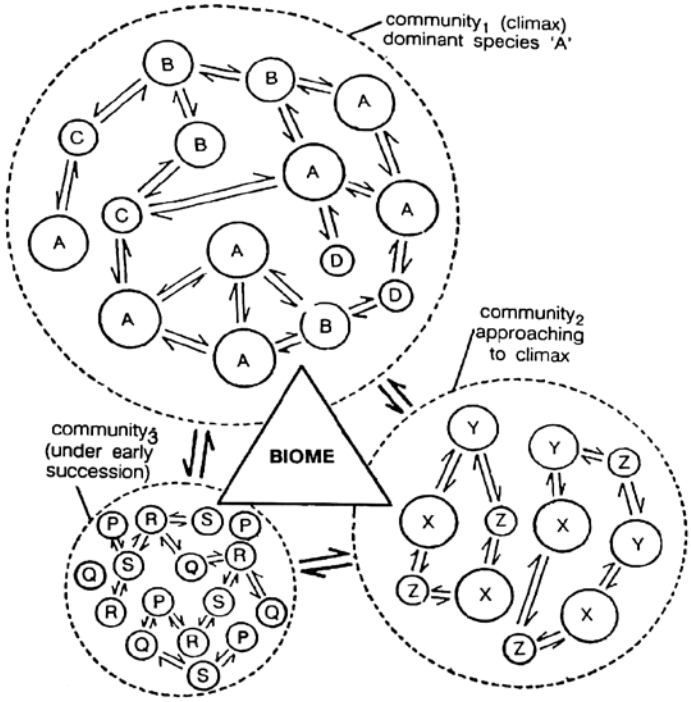


Fig. 1.4. : Biome ecology

1.6.5 ECOSYSTEM ECOLOGY

It consists of all the communities of an area. An ecosystem is made of the biotic and abiotic factors of the natural interact with each other. These interacting biotic and abiotic components then interact with each other to form an integrated system-ecosystem.

Ecosystem may be habitats within biomes that form an integrated whole and a dynamically responsive system having both physical and biological complexes.

Plants capture solar energy and use it to synthesize simple sugars during photosynthesis. As plants grow, they accumulate nutrients and are eaten by grazing herbivores, and the energy is transferred through a chain of organisms by consumption. The simplified linear feeding pathways that move from a basal trophic species to top consumers are called the food chain. The larger interlocking pattern of food chains in an ecological community creates complex food chains in an ecological community creates complex food web.

The food webs are composed of subgroups where members in a community are linked by strong interactions and weak interactions occur between these subgroups. These increases food web stability.

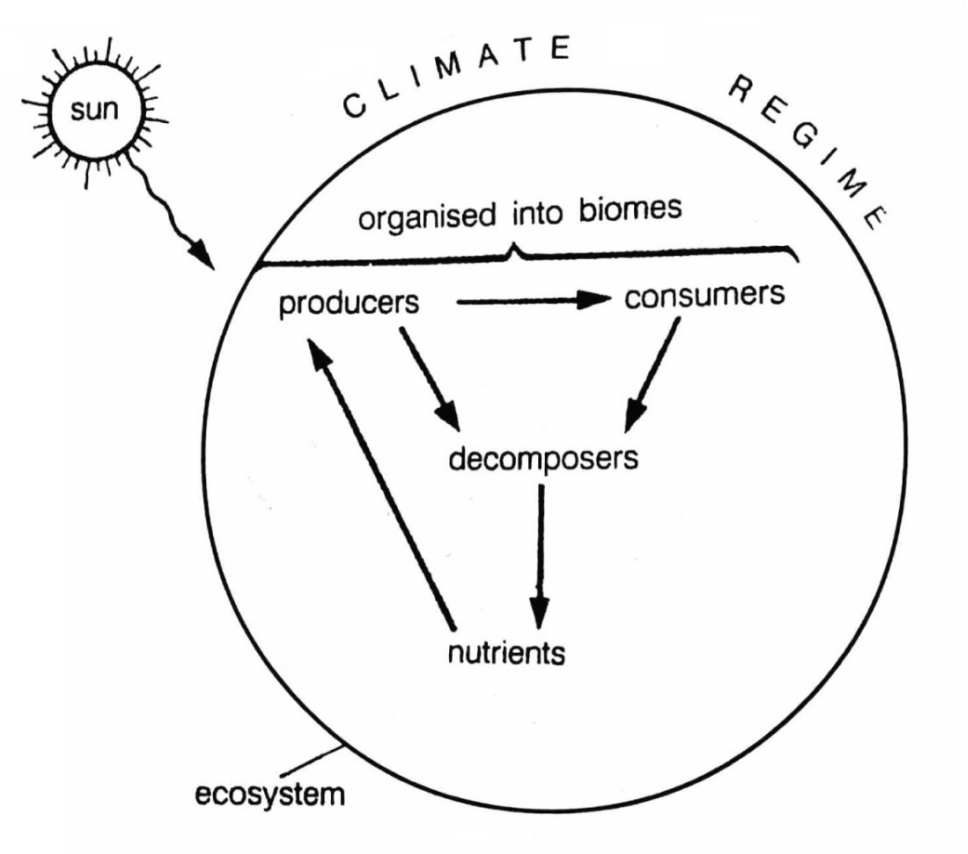


Fig. 1.5. Ecosystem ecology

The trophic pyramid roughly represents the biomass (usually measured as total dry - weight) at each level. Plants generally have the greatest biomass.

Ecological trophic pyramids are typically three kinds.

1. **pyramid of numbers**
2. **pyramid of biomass**
3. **pyramid of energy**

Ecological Pyraminds:-

There is a relationship between the numbers, biomass and energy constant of primary producers, consumers of first, second and third order to top carnivores in any ecosystem. These relationships are referred to as ecological pyramids. The trophic structure of an ecosystem can be summarized in the form of an ecological pyramid. There are three kinds of pyramid

1. **Pyramid of numbers- based on the number of organisms at each trophic level.**
2. **Pyramid of biomass- biomass in the weight of living material at some particular time.**
3. **Pyramid of Energy- Show the fact that each succeeding trophic level is small than the previous level.**

The shape of the first two may be upright or inverted but the third is always upright.

Biogeochemical Cycling :-

There are two types of cycle, the gaseous and the sedimentary. In gaseous cycles the main reservoir of nutrients is the atmosphere and the ocean. In sedimentary cycles the main reservoir is the soil and the sedimentary and other rocks of the earth's crust, both involved biotic and abiotic agents, both are driven by the flow of energy and both are tied to the water cycle. The flow of chemical elements and compounds between living organisms and the physical environment. Chemical absorbed or ingested by organisms are passed through the food chain and returned to the soil, air and water by such mechanisms as respiration, excretion and decomposition. As an element moves through this cycle, it often forms compound with other elements as a result of metabolic processes in living tissues and of natural reactions in the atmosphere or lithosphere.

SAQ. 2

i. **…… is a group of individuals of a particular species.**

ii. **…….. is a group of individuals belonging to different species.**

iii. **…… are larger units of organization that categorize region of the earths.**

iv. **Pyramid of energy is always …… ……..**

v. **Pyramid of number and pyramid of biomass may be …….. or ……**

Biogeography (distribution of Animals and Plants)

Three aspects of the distribution of an organism are generally recognized

I. **Geographic Range – The specific extent of land or water area where the organism normally occurs.**

II. **Geologic range- or the distribution in time, past and present.**

III. **Ecological Distribution- or the major biotic communities (i.e. marine biome, fresh water biome, and terrestrial biome) of which the organism is a member, Some other important distinction between geographic distribution (horizontal or superficial distribution) and Bathymetric distribution (vertical or altitudinal distribution) Bathymetric distribution includes the following three realms :**

(i) Holobiotic or vertical distribution of organisms in marine (sea) habitat.

(ii) Limnobiotic or vertical distribution of organism in fresh water habitat.

(iii) Geobiotic or altitudinal distribution of organisms on land.

All the living organisms in a given region are termed the biota of the region. The animal of a given region are collectively termed the fauna and the plants of a given region, the flora (i.e. fauna + flora = biota)

1. **Natural Resource Ecology :-**

   Classification of nature resources

2. **Non renewable resources- These resources once gone, have very little chance of recovery or resynthesis. Non-renewable resources are not altered by use. For example, mineral deposit are formed slowly over millions of years and once used cannot be regenerated e.g. fossil fuels, such as petrol and coal.**

3. **Renewable resources:-**

   These resources are constantly regenerated or renewed. Plants (Crops, forest etc) and animals (milk and meat production) form another good example of renewable resources.

1.7 SUMMARY

- **Ecology is the study of the inter-relationship between the living organism with their environment.**
- **The term oekologie (ecology) was coined in 1866 by the German biologist. Ernst Haeckel.**

- **In 1936, Taylor defined ecology as the science of all the relations of all organisms to all their environments.**
- **The term ecosystem was first used in 1935 by A.G. Tansley.**
- **The major subdivision of ecology in particular reference to animal ecology and plant ecology.**
- **According to other divisions of ecology are autecology and synecology.**
- **Autecology also called as population ecology.**
- **Synecology also called community ecology.**
- **Population is a group of individuals of a particular species (single species), living in a particular ecosystem at a particular time.**
- **Community is a group of individuals belonging to different species plants as well as animals.**
- **Pyramid of number and pyramid of biomass may be upright or inverted but pyramid of energy is always upright.**

1.8 TERMINAL QUESTION

Q.1. Write short account of basic concepts of ecology?

……
……

Q.2. Explain the following

(i) Population ecology

(ii) Community ecology

……
……

Q.3. What is ecosystem ecology? Explain the based on levels of organisation?

……
……

Q.4. Explain the following

(i) Autecology

(ii) Synecology

……
……

Q.5. Explain the major division of ecology ?

……
……

1.9 ANSWER

SAQ.1.

(i) Reiter

(ii) Communities

(iii) Soil

(iv) 1935 A.G. Tansley

SAQ.2.

(i) Population

(ii) Community

(iii) Biomes

(iv) Upright

(v) Upright. Inverted

UNIT-2 STRUCTURE AND FUNCTION OF ECOSYSTEM

2.1 INTRODUCTION

An organism is always in the state of perfect balance with the environment. The environment literally means the surroundings. The environment refers to the things and conditions around the organisms which directly or indirectly influence the life and development of the organisms and their populations.

"Ecosystem is a complex in which habitat, plants and animals are considered as one interesting unit, the materials and energy of one passing in and out of the others" – Woodbury.

Organisms and environment are two non-separable factors. Organisms interact with each other and also with the physical conditions that are present in their habitats.

"The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem." (Clarke, 1954).

The concept of ecosystem was first put forth by A.G. Tansley (1935). Ecosystem is the major ecological unit. It has both structure and functions. The structure is related to species diversity. The more complex is the structure the greater is the diversity of the species in the ecosystem. The functions of ecosystem are related to the flow of energy and cycling of materials through structural components of the ecosystem. According to Woodbury (1954),

ecosystem is a complex in which habitat, plants and animals are considered as one interesting unit, the materials and energy of one passing in and out of the others.

According to E.P. Odum, the ecosystem is the basic functional unit of organisms and their environment interacting with each other and with their own components. An ecosystem may be conceived and studied in the habitats of various sizes, e.g., one square meter of grassland, a pool, a large lake, a large tract of forest, balanced aquarium, a certain area of river and ocean. All the ecosystems of the earth are connected to one another, e.g., river ecosystem is connected with the ecosystem of ocean, and a small ecosystem of dead logs is a part of large ecosystem of a forest. A complete self-sufficient ecosystem is rarely found in nature but situations approaching self-sufficiency may occur.

Ecosystem structure is a network of interactions between abiotic and biotic components of the system and ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (e.g., feeding, growing, moving, excreting waste) have on the physical and chemical conditions of their environment. The relationship between the abiotic components and the biotic components of the ecosystem is termed 'holocoenosis'.

Objectives: Students will be able to,

- **Define the details about ecosystem and its components.**
- **Understand the relationship or connection between living world and their surroundings.**
- **Understand the transfer of flow of energy in ecosystem.**
- **Distinguish between the biological and biogeochemical cycles of important elements.**
- **Describe the water cycle and the effects of water on the environment.**

2.2 ABIOTIC COMPONENTS OF ECOSYSTEM

The abiotic components of an ecosystem include the water, the air, the temperature and the rocks and minerals that make up the soil. The biotic components of the ecosystem both live on and interact with the abiotic components. Abiotic factors are classified as-

Climatic factors include the climatic regime of an area with physical factors in the environment such as light, atmospheric temperature, wind, humidity, etc (fig.2.1).

Edaphicfactors, which relate to the composition and structure of the soil like its chemical and physical properties – like the soil type, soil profile, organic matter, minerals, soil water, and soil organisms. Inorganic substances like water, carbon, sulfur, nitrogen, phosphorus and so on. Organic substances like proteins, lipids, carbohydrates, humid substances etc.

The atmosphere provides organisms found within ecosystems with carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle of water occurs between the atmosphere and the Earth's surface.

Solar radiation is used in ecosystems to heat the atmosphere and to evaporate and transpire water into the atmosphere. Sunlight is also necessary for photosynthesis. Photosynthesis provides the energy for plant growth and metabolism, and the organic food for other forms of life. Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%. The protoplasm of a very few cells can survive if their water content drops below 10%, and most are killed if it is less than 30-50%.

Water is the medium by which mineral nutrients enter and are trans-located in plants. It is also necessary for the maintenance of leaf turgidity and is required for photosynthetic chemical reactions. Plants and animals receive their water from the Earth's surface and soil. The original source of this water is precipitation from the atmosphere.

Soils provide nutrients, water a home, and structural growing medium for organisms. The vegetation found growing on top soil is closely linked to this component of an ecosystem through nutrient cycle

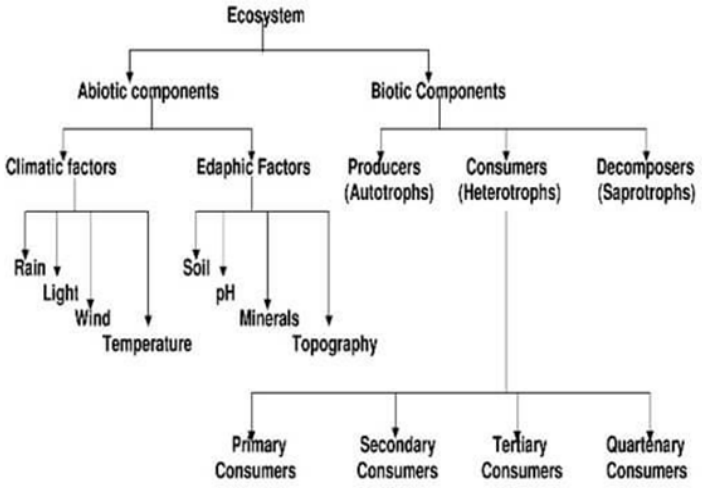


Fig 2.1 : Components of Ecosystem

2.3 BIOTIC COMPONENTS OF ECOSYSTEM

The biotic components include all living organisms present in the environmental system (fig.2.1).

From nutrition point of view, the biotic components can be grouped into three basic components :

(i) Autotrophic components-Autotrophs (from Greek: auto – self, trophos – feeder) are called producers, transducers or converters, as well. Those are photosynthetic plants; they normally bear chlorophyll, which synthesizes, a high-energy complex organic compound (or food)

from the inorganic raw materials utilizing the sunlight, by the process of photosynthesis. Autotrophs form the core of all biotic systems.

In terrestrial ecosystems, autotrophs are usually rooted plants. In the aquatic ecosystems, the floating plants referred to as phytoplankton and the shallow water rooted plants – macrophytes – are the main producers.

(ii) Heterotrophic components- Heterotrophs (from Greek: heteros – other; trophs – feeder) are the consumers. The consumers are also referred to as phagotrophs (phago – to swallow or ingest) while macro consumers are normally herbivores and carnivores.

(iii) Saprotrophs- Saprotrophs (from Greek again: sapros – rotten; trophies – feeder) are called the reducers or decomposers. They break the complex organic compounds in a dead matter (dead plants and animals). Decomposers don't ingest the food. Instead, they secrete a digestive enzyme into the dead, decaying plant or animal remains and digest this organic material. The enzymes act on the complex organic compounds in the dead matter. Decomposers absorb a bit of the decomposition products to provide themselves with nourishment. The remaining substance is added as minerals. The released minerals are utilized or reused as nutrients by plants – the producers.

So biotic components of an ecosystem can be described under the following three heads:

1. **Producers (Autotrophic components),**
2. **Consumers, and**
3. **Decomposers or reducers and transformers**

The amount of biomass at any time in an ecosystem is known as standing crop which is usually expressed as fresh weight, dry weight or as free energy in terms of calories/meter.

1. Producers (Autotrophic elements):

The producers are the autotrophic elements—chiefly green plants. They use radiant energy of sun in photosynthetic process, whereby carbon dioxide is assimilated and the light energy is converted into chemical energy. The chemical energy is actually locked up in the energy rich carbon compounds. Oxygen is evolved as by-product in the photosynthesis.

This is used in respiration by all living things. Algae and other hydrophytes of a pond, grasses of the field, trees of the forests are examples of producers. Chemosynthetic bacteria and carotenoid bearing purple bacteria that also assimilate CO_2 with the energy of

sunlight but only in the presence of organic compounds also belong to this category.

The term producer is misleading one because in an energy context, producers produce carbohydrate and not energy. Since they convert or transduce the radiant energy into chemical form, E.J. Kormondy suggests better alternative terms 'converters' or 'transducers'. Because of wide use the term producer is still retained.

2. Consumers :

Those living members of ecosystem which consume the food synthesized by producers are called consumers. Under this category are included all kinds of animals that are found in an ecosystem.

There are different classes or categories of consumers, such as:

(a) Consumers of the first order or primary consumers,

(b) Consumers of the second order or secondary consumer

(c) Consumers of the third order or tertiary consumers, and

(d) Quaternary consumers.

(a) Primary consumers:

These are purely herbivorous animals that are dependent for their food on producers or green plants. Insects, rodents, rabbit, deer, cow, buffalo, goat are some of the common herbivores in the terrestrial ecosystem, and small crustaceans, molluscs, etc. in the aquatic habitat. Elton (1939) named herbivores of ecosystem as "key industry animals". The herbivores serve as the chief food source for carnivores.

(b) Secondary consumers:

These are carnivores and omnivores. Carnivores are flesh eating animals and the omnivores are the animals that are adapted to consume herbivores as well as plants as their food. Examples of secondary consumers are sparrow, crow, fox, wolves, dogs, cats, snakes, etc.

(c) Tertiary consumers:

These are the top carnivores which prey upon other carnivores, omnivores and herbivores. Lions, tigers, hawk, vulture, etc. are considered as tertiary or top consumers.

(d) Quaternary consumers:

Quaternaryconsumers are often top predators within the environment, and they eat the tertiary consumers. Examples of

quaternary consumers include lions, wolves, polar bears, humans, and hawks.

3. **Decomposers and transformers:**

Decomposers and transformers are the living components of the ecosystem and they are fungi and bacteria. Decomposers attack the dead remains of producers and consumers and degrade the complex organic substances into simpler compounds. The simple organic matters are then attacked by another kind of bacteria, the transformers which change these organic compounds into the inorganic forms that are suitable for reuse by producers or green plants. The decomposers and transformers play very important role in maintaining the dynamic nature of ecosystems.

Q.1: What is the structure of ecosystem?

Answer: ----------

Q.2: What are the functions of ecosystem?

Answer: ----------

2.4 FOOD CHAIN

In ecosystem, every organism depends on other organisms for food material and all organisms are (herbivores to carnivores) arranged in a series in which food energy is transferred through a repeated series of eating and being eaten. It is called foodchain.

- **In the food chain, energy flow is in the form of food.**
- **In a food chain, food material or food energy transfer from one trophic level to the next trophic level.**
- **Four trophic levels are present in the ecosystem because level of energy decreases during the flow of energy from one trophic to another trophic level.**

1) **First trophic level [T_1] = Producers**
2) **Second trophic level [T_2] = Primary consumers**
3) **Third trophic level [T_3] = Secondary consumers**
4) **Fourth trophic level [T_4] = Top consumers**

There are five trophic levels found in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumers. Then the fifth trophic level (T_5) is formed by the top consumer.

- **Shorter food chains will provide greater energy.**
- **Generally the decomposers (bacteria and fungi) are not included in the food chain but when included then there are at as the last tropic level.**

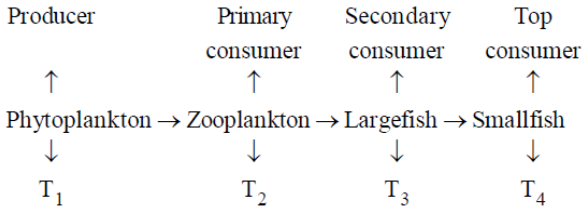
Types of Food Chains found in an Ecosystem

In nature, three types of food chains are present: Grazing food chain, parasitic food chain and detritus food chain.

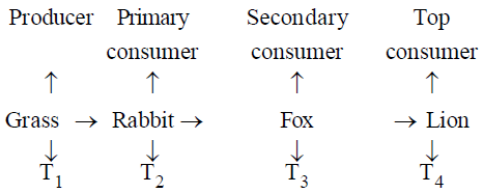
1. **Grazing Food Chains or Predatory Food Chain:**

   Most of the food chain in nature is of this type. This food chain begins with producers (plants) and in successive order it goes from small organism to large organism.

Aquatic ecosystem



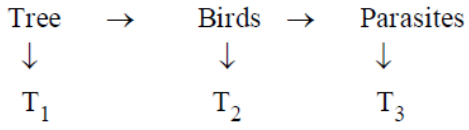
Grasslandecosystem



2. **Parasitic Food Chain**

   This food chain also starts from producers but in successive order it goes, from big organism to the smaller organism.

Tree ecosystem



Both grazing and parasitic food chains are directly dependent on solar radiation (as a primary source of energy) and have rapid energy flow.

3. **Detritus Food Chain or Saprophytic Food Chain**

- **This food chain begins with decomposition of dead organic matter by decomposers, so it is also known as saprophytic food chain.**
- **In this food chain, primary consumers are bacteria and fungi.**
- **In mangrove vegetation, this food chain goes up to big organism.**
- **Dead mangroves leaves Bacteria & fungi Amphipods, molluscs, crabs, nematodes Small fishes Fish eating birds.**

- **In detritus food chain, energy flow is rather very slow yet magnitude of energy is great because vast number of decomposers is involved.**
- **Detritus food chain does not depend on light.**

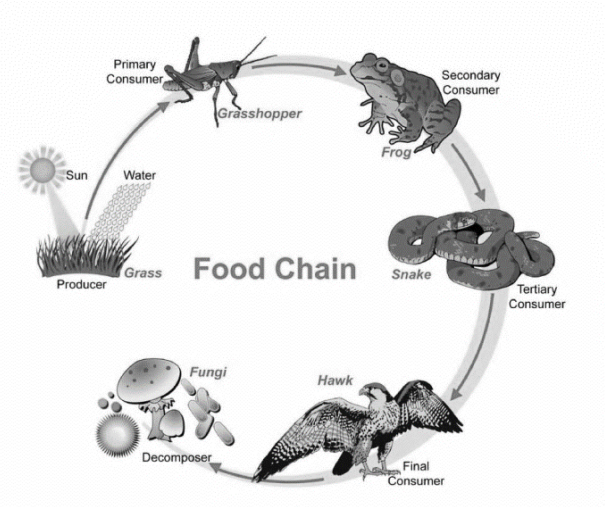


Fig. 2.2 : Food Chain

Significance of food chain:

1. **The studies of food chain help understand the feeding relationship and the interaction between organisms in any ecosystem.**
2. **They also help us to appreciate the energy flow mechanism and matter circulation in ecosystem and understand the movement of toxic substances in the ecosystem.**
3. **The study of food chain helps us to understand the problems of bio-magnifications.**

2.5 FOOD WEB

- **Food web is an important ecological concept. Basically, food web represents feeding relationships within a community (Smith and Smith 2009). It also implies the transfer of food energy from its source in plants through herbivores to carnivores (Krebs 2009).**
- **In a food web, transfer of food energy is unidirectional but from many different alternative pathways.**
- **In a food web, members of a particular trophic level obtain their food according to their choice and taste. It means they have more than one option or alternative for getting food.**
- **As much as food web in complex ecosystem is more permanent or stable, such type of ecosystem is not destroyed naturally and continues for a long time. This ecosystem is not affected by loss of any organism of any particular trophic level. Those ecosystems which have simple**

food web are not very stable it means that they can be finished at any time, if there is a change in any particular trophic level.

- **A food web (or food cycle) is the natural interconnection of food chains and a graphical representation (usually an image) of what-eats-what in an ecological community. Another name for food web is consumer-resource system. Ecologists can broadly lump all life forms into one of two categories called trophic levels: 1) Autotrophs, and 2) Heterotrophs.**
- **Many interconnected food chains make up a food web. When you look at the larger picture, a food web shows a realistic representation of the energy flow through different organisms in an ecosystem.**

Sometimes, a single organism gets eaten by many predators or it eats many other organisms. This is when a food chain doesn't represent the energy flow in a proper manner because there are many trophic levels that interconnect. This is where a food web comes into place. It shows the interactions between different organisms in an ecosystem.

The following diagram shows the energy flow between various organisms through a food web.

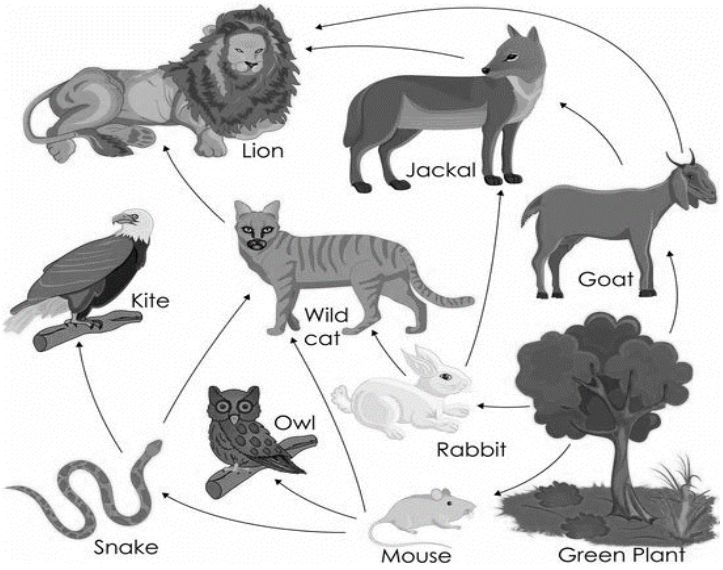


Fig.2.3 : Food Web

2.6 PYRAMID

An ecological pyramid is a graphical representation of the relationship between different organisms in an ecosystem. Each of the bars that make up the pyramid represents a different trophic level, and their order, which is based on who eats whom, represents the flow of energy.

It can be observed that these pyramids are in the shape of actual pyramids with the base being the broadest, which is covered by the lowest trophic level, i.e., producers. The next level is occupied by the next trophic level, i.e., the primary consumers and so on.

All the calculations for construction of these types of ecological pyramids must take into account all the organisms in a particular trophic level because a sample space of a few numbers or a few species will end up giving a huge level of errors.

Types of Ecological Pyramid

Three types of ecological pyramid exist. They are as follows:

A. **Pyramid of Numbers**
B. **Pyramid of Energy**
C. **Pyramid of Biomass**

A. Pyramid of Numbers:

In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal (Fig.2.4).

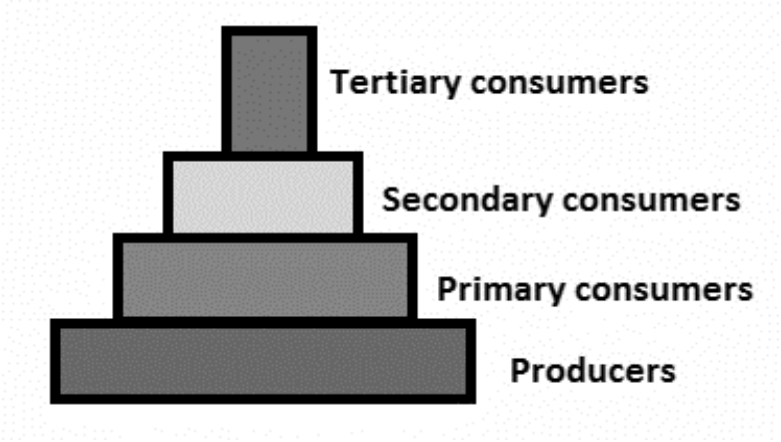


Fig. 2.4 : Pyramid of Numbers

B. Pyramid of Biomass:

In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons (Fig.2.5).

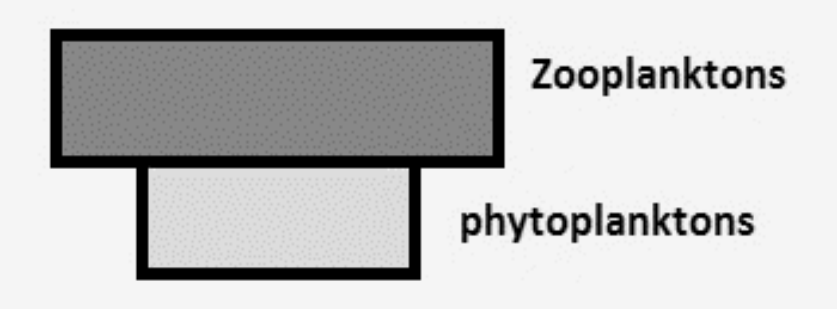


Fig. 2.5: Pyramid of Biomass (in ocean)

C. Pyramid of Energy :

Pyramid of energy is the only type of ecological pyramid, which is alwaysupright as the energy flow in a food chain is always unidirectional. Also, with every increasing trophic level, some energy is lost into the environment (Fig. 2.6).

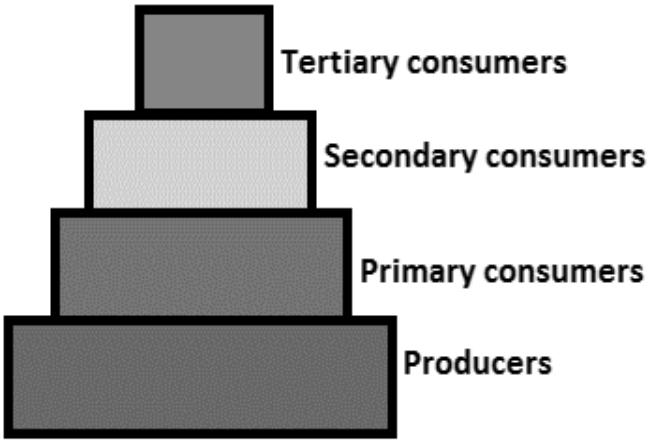


Fig. 2.6 : Pyramid of energy

Importance of Ecological Pyramid

The importance of ecological pyramid can be explained in the following points:

1. **They show the feeding of different organisms in different ecosystems.**
2. **It shows the efficiency of energy transfer.**
3. **The condition of the ecosystem can be monitored, and any further damage can be prevented.**

Limitations of the Ecological Pyramid

1. **More than one species may occupy multiple trophic levels as in case of the food web. Thus, this system does not take into account food webs.**
2. **The saprophytes are not considered in any of the pyramids even though they form an important part of the various ecosystems.**
3. **These pyramids are applicable only to simple food chains, which usually do not occur naturally.**
4. **These pyramids do not deliver any concept in relation to variations in season and climate.**
5. **They do not consider the possibility of the existence of the same species at different levels.**

2.7 ENERGY FLOW IN ECOSYSTEM

The flow of energy in ecosystems is vitally important to the thriving of life on Earth. Nearly all of the energy in Earth's ecosystems originates within

the Sun. Once this solar energy reaches Earth, it is distributed among ecosystems in an extremely complex manner. A simple way to analyze this distribution is through a food chain or food web.

Energy flow is the flow of energy through living things within an ecosystem. All living organisms can be organized into producers and consumers, and those producers and consumers can further be organized into a food chain. Each of the levels within the food chain is a trophic level.

How Organisms Acquire Energy in a Food Web

All living things require energy in one form or another since energy is required by most, complex, metabolic pathways (often in the form of ATP); life itself is an energy-driven process. Living organisms would not be able to assemble macromolecules (proteins, lipids, nucleic acids, and complex carbohydrates) from their monomeric subunits without a constant energy input.

It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through food webs and their constituent food chains. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of the food web. Energy is acquired by living things in three ways: photosynthesis, chemosynthesis, and the consumption and digestion of other living or previously-living organisms by heterotrophs.

Photosynthetic and chemosynthetic organisms are grouped into a category known as autotrophs: organisms capable of synthesizing their own food (more specifically, capable of using inorganic carbon as a carbon source). Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, whereas chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy source. Autotrophs act as producers and are critical for all ecosystems. Without these organisms, energy would not be available to other living organisms and life itself would not be possible.

Photoautotrophs, such as plants, algae, and photosynthetic bacteria, serve as the energy source for a majority of the world's ecosystems. These ecosystems are often described by grazing food webs. Photoautotrophs harness the solar energy of the sun by converting it to chemical energy in the form of ATP (and NADP). The energy stored in ATP is used to synthesize complex organic molecules, such as glucose.

Chemoautotrophs are primarily bacteria that are found in rare ecosystems where sunlight is not available, such as in those associated with dark caves or hydrothermal vents at the bottom of the ocean. Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H_2S), which is released from the vents, as a source of chemical energy. This allows chemoautotrophs to synthesize complex organic molecules, such as glucose, for their own energy and in turn supplies energy to the rest of the ecosystem.

Heterotrophs function as consumers in the food chain; they obtain energy in the form of organic carbon by eating autotrophs or other heterotrophs. They break down complex organic compounds produced by autotrophs into simpler

compounds, releasing energy by oxidizing carbon and hydrogen atoms into carbon dioxide and water, respectively. Unlike autotrophs, heterotrophs are unable to synthesize their own food. If they cannot eat other organisms, they will die.

Productivity within Trophic Levels

Productivity, measured by gross and net primary productivity, is defined as the amount of energy that is incorporated into a biomass.

Productivity within an ecosystem can be defined as the percentage of energy entering the ecosystem incorporated into biomass in a particular trophic level. Biomass is the total mass in a unit area (at the time of measurement) of living or previously-living organisms within a trophic level. Ecosystems have characteristic amounts of biomass at each trophic level.

The productivity of the primary producers is especially important in any ecosystem because these organisms bring energy to other living organisms by photoautotrophy or chemoautotrophy. Photoautotrophy is the process by which an organism (such as a green plant) synthesizes its own food from inorganic material using light as a source of energy; chemoautotrophy, on the other hand, is the process by which simple organisms (such as bacteria or archaea) derive energy from chemical processes rather than photosynthesis. The rate at which photosynthetic primary producers incorporate energy from the sun is called gross primary productivity (G.P.P.).

Because all organisms need to use some of this energy for their own functions (such as respiration and resulting metabolic heat loss), scientists often refer to the net primary productivity (N.P.P.) of an ecosystem. Net primary productivity is the energy that remains in the primary producers after accounting for the organisms' respiration and heat loss. The net productivity is then available to the primary consumers at the next trophic level.

Transfer of Energy between Trophic Levels

Energy is lost as it is transferred between trophic levels; the efficiency of this energy transfer is measured by TLTE and NPE.

Ecological efficiency: the transfer of energy between trophic levels

Large amounts of energy are lost from the ecosystem between one trophic level and the next level as energy flows, from the primary producers through the various trophic levels of consumers and decomposers. The main reason for this loss is the second law of thermodynamics, which states that whenever energy is converted from one form to another, there is a tendency toward disorder (entropy) in the system. In biologic systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level are consumed by the next level. The measurement of energy transfer efficiency between two successive trophic levels is termed the trophic level transfer efficiency (TLTE) and is defined by the formula:

$$TLTE = \frac{\text{Energy transferred to next level}}{\text{Energy received during transfer}} \times 100$$

The 10% Law of Energy Flow

In general, only about 10% of energy is transferred from one trophic level to the next, and this number can vary from 5-20% depending on the ecosystem. This means that 90% of obtained energy is lost at each trophic level, greatly affecting the maximum number of possible levels in the ecosystem. For example, if an ecosystem received 600,000 Kcal of solar energy from the sun, primary producers would pass on only 60,000 Kcal to herbivores, which would pass only 6,000 Kcal to secondary consumers, 600 Kcal to tertiary consumers and 60 Kcal to quaternary consumers at the top of the food chain. An apex predator like a wolf—needing an average of 2000 Kcal per day—would need to consume a very high quantity of secondary or tertiary consumers to meet its calorie quota per day (Fig.2.7).

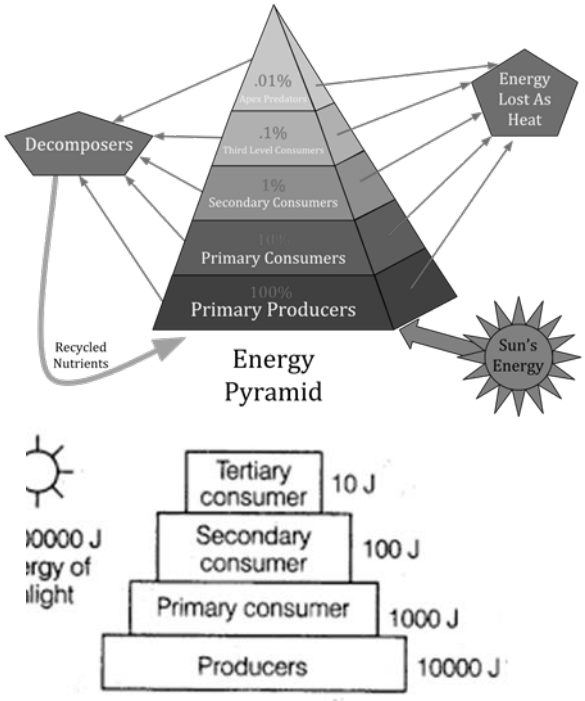


Fig. 2.7 : Ecological Pyramid

Net production efficiency

Another main parameter that is important in characterizing energy flow within an ecosystem is the net production efficiency. Net production efficiency (NPE) allows ecologists to quantify how efficiently organisms of a particular

trophic level incorporate the energy they receive into biomass. It is calculated using the following formula:

$$\text{N.P.E.} = \frac{\text{Net primary productivity}}{\text{G.P.P.}} \times 100$$

Net consumer productivity is the energy content available to the organisms of the next trophic level. Assimilation is the biomass (energy content generated per unit area) of the present trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste. Incomplete ingestion refers to the fact that some consumers eat only a part of their food. For example, when a lion kills an antelope, it will eat everything except the hide and bones. The lion is missing the energy-rich bone marrow inside the bone, so the lion does not make use of all the calories its prey could provide.

Thus, NPE measures how efficiently each trophic level uses and incorporates the energy from its food into biomass to fuel the next trophic level. In general, cold-blooded animals (ectotherms), such as invertebrates, fish, amphibians, and reptiles, use less of the energy they obtain for respiration and heat than warm-blooded animals (endotherms), such as birds and mammals. The extra heat generated in endotherms, although an advantage in terms of the activity of these organisms in colder environments is a major disadvantage in terms of NPE. Therefore, many endotherms have to eat more often than ectotherms to obtain the energy they need for survival. In general, NPE for ectotherms is an order of magnitude (10x) higher than for endotherms. For example, the NPE for a caterpillar eating leaves has been measured at 18 percent, whereas the NPE for a squirrel eating acorns may be as low as 1.6 percent.

The inefficiency of energy use by warm-blooded animals has broad implications for the world's food supply. It is widely accepted that the meat industry uses large amounts of crops to feed livestock. Because the NPE is low, much of the energy from animal feed is lost. For example, it costs about $0.01 to produce 1000 dietary calories (kcal) of corn or soybeans, but approximately $0.19 to produce a similar number of calories growing cattle for beef consumption. The same energy content of milk from cattle is also costly, at approximately $0.16 per 1000 kcal. Much of this difference is due to the low NPE of cattle. Thus, there has been a growing movement worldwide to promote the consumption of non-meat and non-dairy foods so that less energy is wasted feeding animals for the meat industry.

2.8 BIOGEOCHEMICAL CYCLE

The elemental components of organic matter are cycled through the biosphere in an interconnected process called the biogeochemical cycle.

Energy flows directionally through ecosystems, entering as sunlight (or inorganic molecules for chemoautotrophs) and leaving as heat during the many transfers between trophic levels. However, the matter that makes up living organisms is conserved and recycled. The six most common elements associated with organic molecules (carbon, nitrogen, hydrogen, oxygen,

phosphorus, and sulfur) take a variety of chemical forms and may exist for long periods in the atmosphere, on land, in water, or beneath the earth's surface. Geologic processes, such as weathering, erosion, water drainage, and the movement of the continental plates, all play a role in this recycling of materials. Because geology and chemistry have major roles in the study of this process, the recycling of inorganic matter between living organisms and their environment is called a biogeochemical cycle.

The components of organic molecules are constantly being stored and recycled as part of their biogeochemical cycle. Water, which contains hydrogen and oxygen, is essential to all living processes. The hydrosphere is the area of the earth where water movement and storage occurs. Water can be liquid on the surface and beneath the surface or frozen (rivers, lakes, oceans, groundwater, polar ice caps, and glaciers) or exist as water vapor in the atmosphere. Carbon, found in all organic macromolecules, is an important constituent of fossil fuels. Nitrogen, a major component of our nucleic acids and proteins, is critical to human agriculture. Phosphorus, a major component of nucleic acid (along with nitrogen), is one of the main ingredients in artificial fertilizers used in agriculture and their associated environmental impacts on our surface water. Sulfur, critical to the 3–D folding of proteins (as in disulfide binding), is released into the atmosphere by the burning of fossil fuels, such as coal.

The cycling of all of these elements is interconnected. For example, the movement of water is critical for the leaching of nitrogen and phosphate into rivers, lakes, and oceans. Furthermore, the ocean itself is a major reservoir for carbon. Thus, mineral nutrients are cycled, either rapidly or slowly, through the entire biosphere, from one living organism to another, and between the biotic and abiotic world.

The Water (Hydrologic) Cycle

Water has a large effect on climate, ecosystems, and living organisms and is continuously cycled through the environment. Water is the basis of all living processes. More than half of the human body is made up of water, while human cells are more than 70 percent water. Thus, most land animals need a supply of fresh water to survive. However, when examining the stores of water on earth, 97.5percent of it is non-potablesalt water. Of the remaining water, 99 percent is locked underground as water or as ice. Thus, less than 1 percent of fresh water is easily accessible from lakes and rivers. Many living things, such as plants, animals, and fungi, are dependent on the small amount of fresh surface water supply, a lack of which can have massive effects on ecosystem dynamics. Humans, of course, have developed technologies to increase water availability, such as digging wells to harvest groundwater, storing rainwater, and using desalination to obtain drinkable water from the ocean. Although this pursuit of drinkable water has been ongoing throughout human history, the supply of fresh water is still a major issue in modern times.

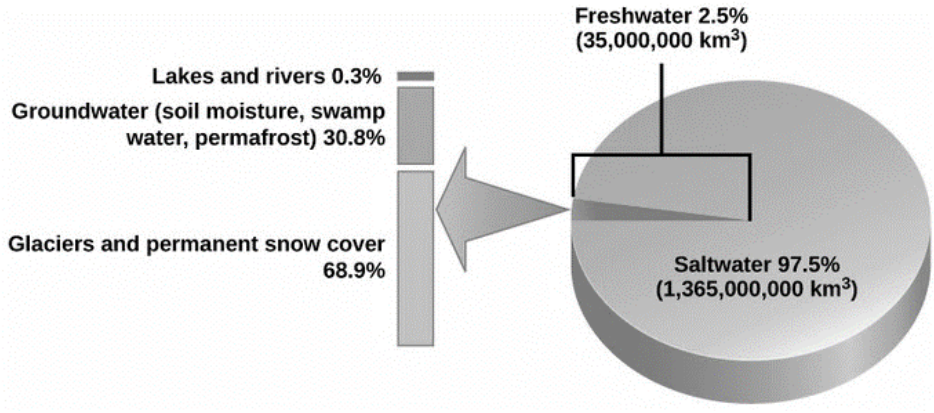


Fig. 2.8 : Water availability : Only 2.5 percent of water on earth is fresh water. Less than 1 percent of fresh water is easily accessible to living things.

Water cycling is extremely important to ecosystem dynamics as it has a major influence on climate and, thus, on the environments of ecosystems. For example, when water evaporates, it takes up energy from its surroundings, cooling the environment. When it condenses, it releases energy, warming the environment. The evaporation phase of the cycle purifies water, which then replenishes the land with fresh water. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the earth through processes including erosion and sedimentation. The water cycle is also essential for the maintenance of most life and ecosystems on the planet. Most of the water on earth is stored for long periods in the oceans, underground, and as ice. Residence time is a measure of the average time an individual water molecule stays in a particular reservoir. A large amount of the earth's water is locked in place in these reservoirs as ice, beneath the ground, and in the ocean, and, thus, is unavailable for short-term cycling (only surface water can evaporate).

There are various processes that occur during the cycling of water, which include the following:

- **evaporation / sublimation**
- **condensation /precipitation**
- **subsurface water flow**
- **surface runoff /snowmelt**
- **stream flow**

The water cycle is driven by the sun's energy as it warms the oceans and other surface waters. This leads to the evaporation (water to water vapor) of liquid surface water and the sublimation (ice to water vapor) of frozen water, which deposits large amounts of water vapor into the atmosphere. Over time, this water vapor condenses into clouds as liquid or frozen droplets, which is eventually followed by precipitation (rain or snow), returning water to the earth's surface. Rain eventually percolates into the ground, where it may evaporate again (if it is near the surface), flow beneath the surface, or be stored for long periods. More easily observed is surface runoff: the flow of fresh water either from rain or melting ice. Runoff can then make its way through streams

and lakes to the oceans or flow directly to the oceans themselves. Rain and surface runoff are major ways in which minerals, including carbon, nitrogen, phosphorus, and sulfur, are cycled from land to water.

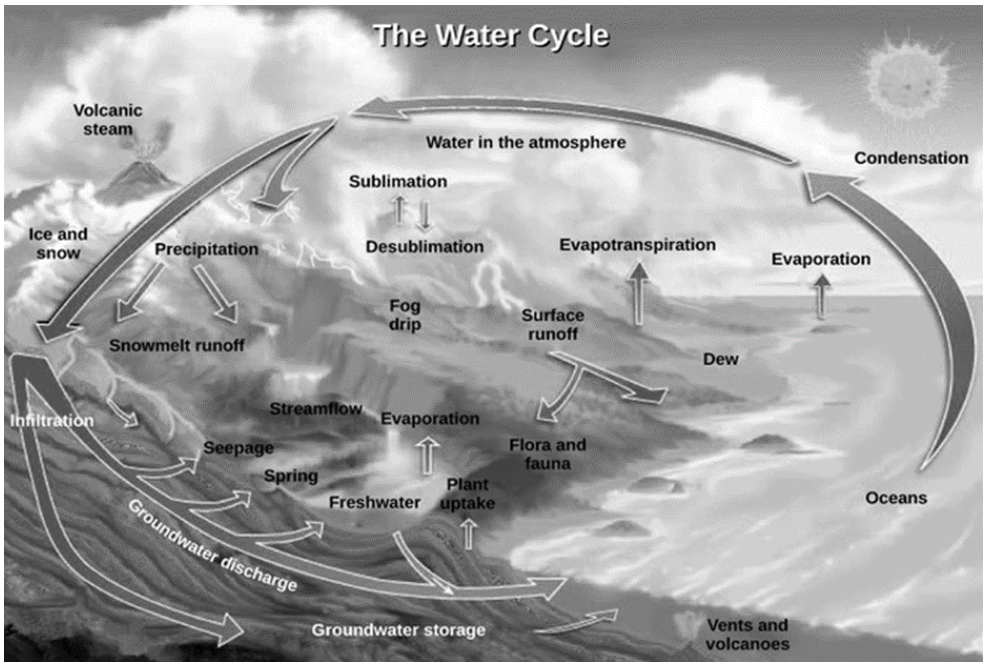


Fig. 2.9 : Cyclingofwater

Water from the land and oceans enters the atmosphere by evaporation or sublimation, where it condenses into clouds and falls as rain or snow. Precipitated water may enter freshwater bodies or infiltrate the soil. The cycle is complete when surface or groundwater reenters the ocean.

The Carbon Cycle

Carbon enters the atmosphere in the form of carbondioxide via the carbon cycle and returns to organic carbon via photosynthesis. Carbon, the secondmostabundantelement in living organisms, is present in all organic molecules. Its role in the structure of macromolecules is of primary importance to living organisms. Carbon compounds contain especially- high forms of energy, which humans use as, fuel. Since the 1800s (the beginning of the Industrial Revolution), the number of countries using massive amounts of fossil fuels increased, which raised the levels of carbon dioxide in the atmosphere. This increase in carbon dioxide has been associated with climate change and other disturbances of the earth's ecosystems. It is a major environmental concern worldwide.

The carbon cycle is most easily studied as two interconnected sub-cycles: one, dealing with rapid carbon exchange among living organisms and the other dealing with the long-term cycling of carbon through geologic processes.

The Biological Carbon Cycle

Living organisms are connected in many ways, even between ecosystems. A good example of this connection is the exchange of carbon between autotrophs and heterotrophs. Carbon dioxide is the basic building block that most

autotrophs use to build multi-carbon, high-energy compounds, such as glucose.

The energy harnessed from the sun is used by these organisms to form the covalent bonds that link carbon atoms together. These chemical bonds store this energy for later use in the process of respiration. Most terrestrial autotrophs obtain their carbon dioxide directly from the atmosphere, while marine autotrophs acquire it in the dissolved form (carbonic acid, H_2CO_3). However carbon dioxide is acquired, a by-product of the process is oxygen. The photosynthetic organisms are responsible for depositing approximately 21 percent of the oxygen content in the atmosphere that we observe today.

Heterotrophs acquire the high-energy carbon compounds from the autotrophs by consuming them and breaking them down by respiration to obtain cellular energy, such as ATP. The most efficient type of respiration, aerobic respiration, requires oxygen obtained from the atmosphere or dissolved in water. Thus, there is a constant exchange of oxygen and carbon dioxide between the autotrophs (which need the carbon) and the heterotrophs (which need the oxygen). Gas exchange through the atmosphere and water is one way that the carbon cycle connects all living organisms on Earth.

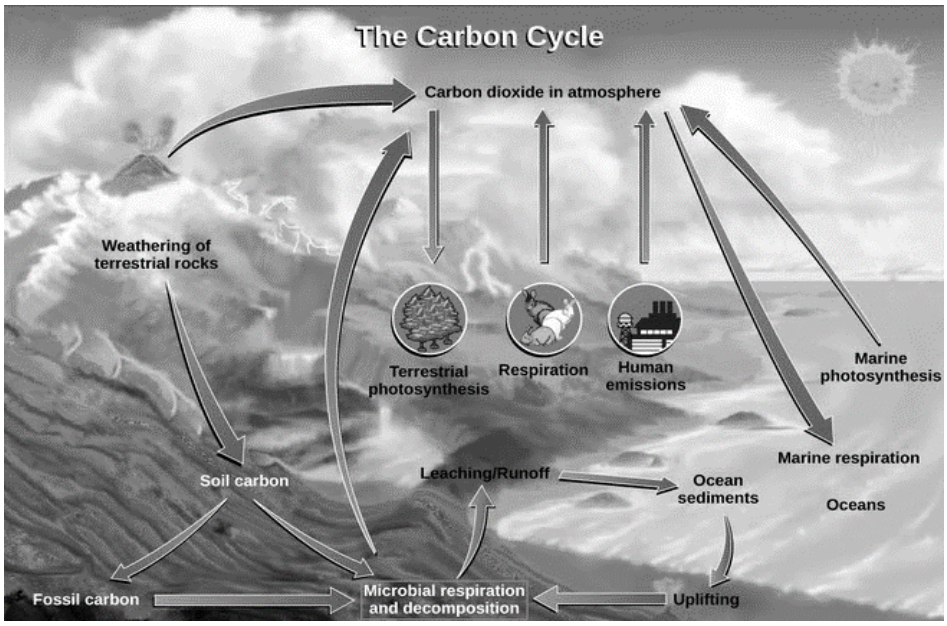


Fig. 2.10 : Carboncycle

Carbon dioxide gas exists in the atmosphere and is dissolved in water. Photosynthesis converts carbon dioxide gas to organic carbon, while respiration cycles the organic carbon back into carbon dioxide gas. Long-term storage of organic carbon occurs when matter from living organisms is buried deep underground and becomes fossilized. Volcanic activity and human emissions bring this stored carbon back into the carbon cycle.

The Biogeochemical Carbon Cycle

The movement of carbon through the land, water, and air is complex and, in many cases, it occurs much more slowly than the biological carbon cycle. Carbon is stored for long periods in what are known as carbon reservoirs,

which include the atmosphere, bodies of liquid water (mostly oceans), ocean sediment, soil, land sediments (including fossil fuels), and the earth's interior.

As stated, the atmosphere, a major reservoir of carbon in the form of carbon dioxide, is essential to the process of photosynthesis. The level of carbon dioxide in the atmosphere is greatly influenced by the reservoir of carbon in the oceans. The exchange of carbon between the atmosphere and water reservoirs influences how much carbon is found in each location; each affects the other reciprocally. Carbon dioxide (CO_2) from the atmosphere dissolves in water, combining with water molecules to form carbonic acid. It then ionizes to carbonate and bicarbonate ions.

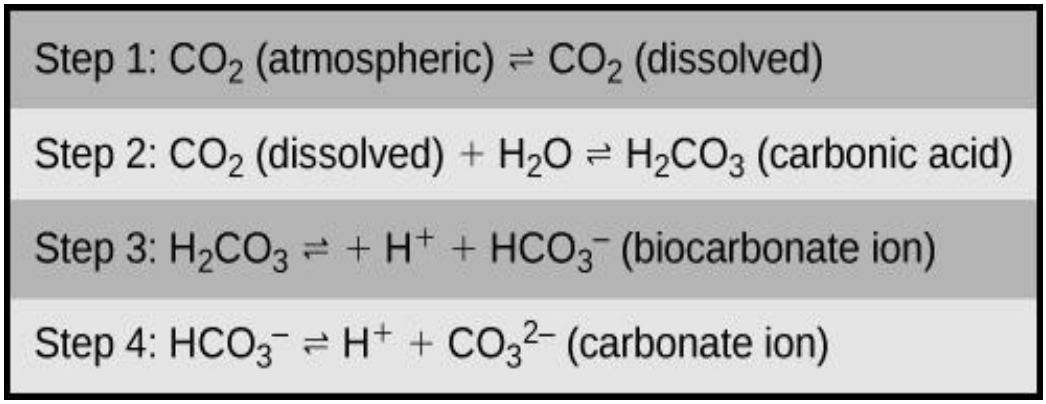


Fig. 2.11 : Formation of bicarbonate : Carbon dioxide reacts with water to form bicarbonate and carbonate ions.

More than 90 percent of the carbon in the ocean is found as bicarbonate ions. Some of these ions combine with seawater calcium to form calcium carbonate ($CaCO_3$), a major component of marine organism shells. These organisms eventually form sediments on the ocean floor. Over geologic time, the calcium carbonate forms limestone, which comprises the largest carbon reservoir on earth.

On land, carbon is stored in soil as a result of the decomposition of living organisms or the weathering of terrestrial rock and minerals. This carbon can be leached into the water reservoirs by surface runoff. Deeper underground, on land and at sea, are fossil fuels: the anaerobically-decomposed remains of plants that take millions of years to form. Fossil fuels are considered a non-renewable resource because their use far exceeds their rate of formation. A non-renewable resource is either regenerated very slowly or not at all. Another way for carbon to enter the atmosphere is from land by the eruption of volcanoes and other geothermal systems. Carbon sediments from the ocean floor are taken deep within the earth by the process of subduction: the movement of one tectonic plate beneath another. Carbon is released as carbon dioxide when a volcano erupts or from volcanic hydrothermal vents.

The Nitrogen Cycle

Nitrogen, the most abundant gas in the atmosphore, is cycled through the biosphere via the multi-step process of nitrogen fixation, which is carried out by bacteria.

Getting nitrogen into the living world is difficult. Plants and phytoplankton are not equipped to incorporate nitrogen from the atmosphere (which exists as tightly-bonded, triple-covalent N_2), even though this molecule comprises approximately 78 percent of the atmosphere. Nitrogen enters the living world via free-living and symbiotic bacteria, which incorporate nitrogen into their macromolecules through nitrogen fixation (conversion of N_2). Cyanobacteria live in most aquatic ecosystems where sunlight is present; they play a key role in nitrogen fixation. Cyanobacteria are able to use inorganic sources of nitrogen to "fix" nitrogen. Rhizobium bacteria live symbiotically in the root nodules of legumes (such as peas, beans, and peanuts), providing them with the organic nitrogen they need. Free-living bacteria, such as Azotobacter, are also important nitrogen fixers.

Organic nitrogen is especially important to the study of ecosystem dynamics as many ecosystem processes, such as primary production and decomposition, are limited by the available supply of nitrogen. The nitrogen that enters living systems by nitrogen fixation is successively converted from organic nitrogen back into nitrogen gas by bacteria. This process occurs in three steps in terrestrial systems: ammonification, nitrification, and denitrification. First, the ammonification process converts nitrogenous waste from living animals or from the remains of dead animals into ammonium (NH_4^+) by certain bacteria and fungi. Second, the ammonium is converted to nitrites (NO_2) by nitrifying bacteria, such as Nitrosomonas, through nitrification. Subsequently, nitrites are converted to nitrates (NO3) by similar organisms. Third, the process of denitrification occurs, whereby bacteria, such as Pseudomonas and Clostridium, convert the nitrates into nitrogen gas, allowing it to re-enter the atmosphere.

Human activity can release nitrogen into the environment by two primary means: the combustion of fossil fuels, which releases different nitrogen oxides, and the use of artificial fertilizers in agriculture, which are then washed into lakes, streams, and rivers by surface runoff. Atmospheric nitrogen is associated with several effects on earth's ecosystems, including the production of acid rain (as nitric acid, HNO_3) and greenhouse gas (as nitrous oxide, N_2O), potentially causing climate change. A major effect from fertilizer runoff is saltwater and freshwater eutrophication: a process whereby nutrient runoff causes the excess growth of microorganisms, depleting dissolved oxygen levels and killing ecosystem fauna.

A similar process occurs in the marine nitrogen cycle, where the ammonification, nitrification, and denitrification processes are performed by marine bacteria. Some of this nitrogen falls to the ocean floor as sediment, which can then be moved to land in geologic time by uplift of the earth's surface, becoming incorporated into terrestrial rock. Although the movement of nitrogen from rock directly into living systems has been traditionally seen as insignificant compared with nitrogen fixed from the atmosphere, a recent study showed that this process may indeed be significant and should be includedin any study of the global nitrogen cycle.

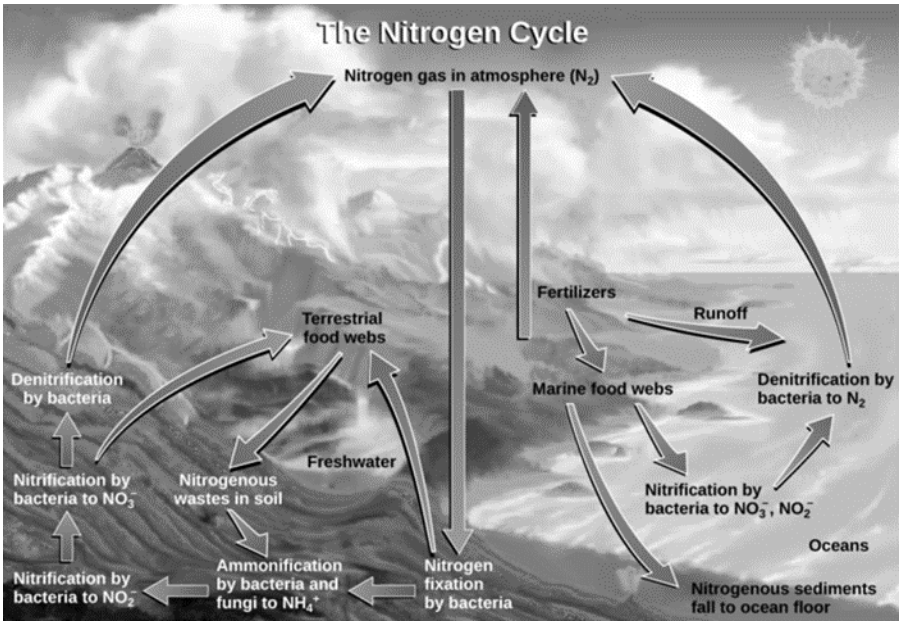


Fig. 2.12: Nitrogen fixation

Nitrogen enters the living world from the atmosphere via nitrogen-fixing bacteria. This nitrogen and nitrogenous waste from animals is then processed back into gaseous nitrogen by soil bacteria, which also supply terrestrial food webs with the organic nitrogen they need.

The Phosphorus Cycle

Phosphorus is an essential element of living things, but, in excess, it can cause damage to ecosystems.

Phosphorus is an essential nutrient for living processes. It is a major component of nucleic acid, both DNA and RNA; of phospholipids, the major component of cell membranes; and, as calcium phosphate, makes up the supportive components of our bones. Phosphorus is often the limiting nutrient (necessary for growth) in aquatic ecosystems.

Phosphorus occurs in nature as the phosphate ion PO_3^{4-}In addition to phosphate runoff as a result of human activity, natural surface runoff occurs when it is leached from phosphate-containing rock by weathering, thus sending phosphates into rivers, lakes, and the ocean. This rock has its origins in the ocean. Phosphate-containing ocean sediments form primarily from the bodies of ocean organisms and from their excretions. However, in remote regions, volcanic ash, aerosols, and mineral dust may also be significant phosphate sources. This sediment then is moved to land over geologic time by the uplifting of areas of the earth's surface.

Phosphorus is also reciprocally exchanged between phosphate dissolved in the ocean and marine ecosystems. The movement of phosphate from the ocean to the land and through the soil is extremely slow, with the average phosphate ion having an oceanic residence time between 20,000 and 100,000 years.

Excess phosphorus and nitrogen that enters these ecosystems from fertilizer runoff and from sewage causes excessive growth of microorganisms and

depletes the dissolved oxygen, which leads to the death of many ecosystem fauna, such as shellfish and finfish. This process is responsible for dead zones in lakes and at the mouths of many major rivers.

A dead zone is an area within a freshwater or marine ecosystem where large areas are depleted of their normal flora and fauna. These zones can be caused by eutrophication, oil spills, dumping of toxic chemicals, and other human activities. The number of dead zones has been increasing for several years.

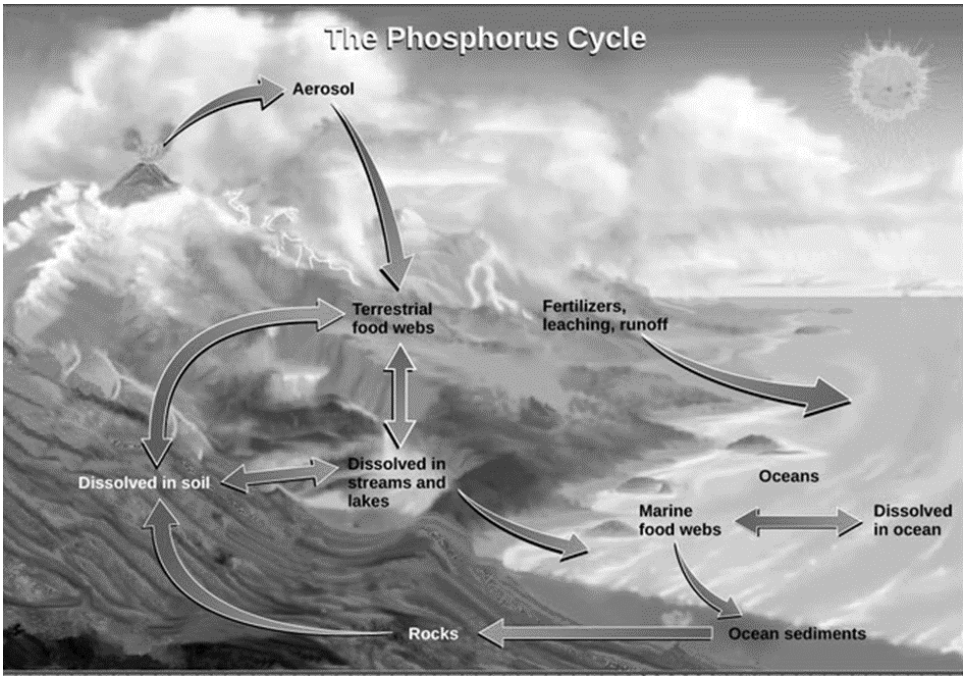


Fig. 2.13 : Phosphorus cycle

In nature, phosphorus exists as the phosphate ion(PO_4^{3-}). Weathering of rocks and volcanic activity releases phosphate into the soil, water, and air, where it becomes available to terrestrial food webs. Phosphate enters the oceans via surface runoff, groundwater flow, and river flow. Phosphate dissolved in ocean water cycles into marine food webs. Some phosphate from the marine food webs falls to the ocean floor, where it forms sediment.

The Sulfur Cycle

Sulfur is deposited on land as precipitation, fallout, and rock weathering, and reintroduced when organisms decompose. Sulfur is an essential element for the macromolecules of living things. As a part of the amino acid cysteine, it is involved in the formation of disulfide bonds within proteins, which help to determine their 3-D folding patterns and, hence, their functions. Sulfur cycles exist between the oceans, land, and atmosphere.

On land, sulfur is deposited in four major ways: precipitation, direct fallout from the atmosphere, rock weathering, and decomposition of organic materials. Atmospheric sulfur is found in the form of sulfur dioxide (SO_2). As rain falls through the atmosphere, sulfur is dissolved in the form of weak sulfuric acid (H_2SO_4), creating acid rain. Sulfur can also fall directly from the atmosphere in a process called fallout. The weathering of sulfur-containing rocks also releases sulfur into the soil. These rocks originate from ocean

sediments that are moved to land by the geologic uplift. Terrestrial ecosystems can then make use of these soil sulfates (SO_4^2). Upon the death and decomposition of these organisms, sulfur is released back into the atmosphere as hydrogen sulfide (H_2S) gas. Sulfur may also enter the atmosphere through geothermal vents.

Human activities have played a major role in altering the balance of the global sulfur cycle. The burning of large quantities of fossil fuels, especially from coal, releases large amounts of hydrogen sulfide gas into the atmosphere, creating acid rain. Acid rain is corrosive rain that causes damage to aquatic ecosystems and the natural environment by lowering the pH of lakes, which kills many of the resident fauna; it also affects the human-made environment through the chemical degradation of buildings. For example, many marble monuments, such as the Lincoln Memorial in Washington, DC, have suffered significant damage from acid rain over the years. These examples show the wide-ranging effects of human activities on our environment and the challenges that remain for our future.

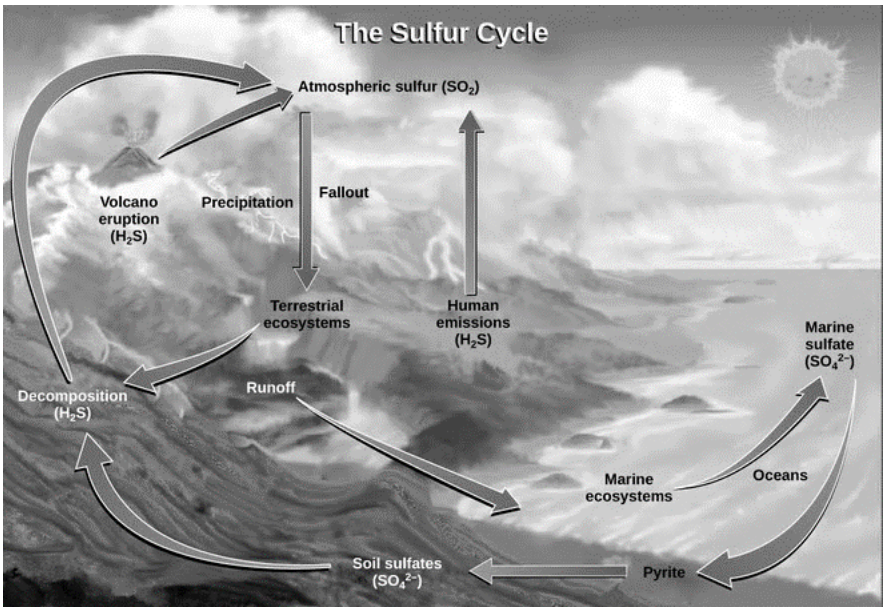


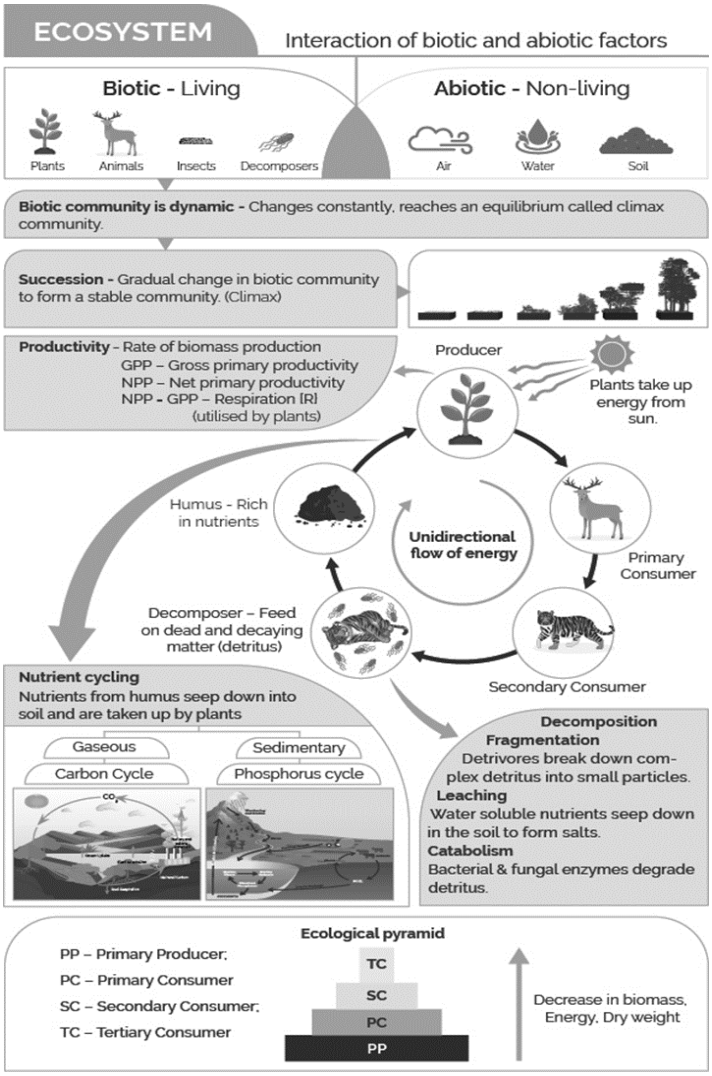
Fig. 2.14 : Sulfur cycle

Sulfur dioxide from the atmosphere becomes available to terrestrial and marine ecosystems when it is dissolved in precipitation as weak sulfuric acid or when it falls directly to the earth as fallout. Weathering of rocks also makes sulfates available to terrestrial ecosystems. Decomposition of living organisms returns sulfates to the ocean, soil, and atmosphere.

2.9 SUMMARY

- **An ecosystem is, therefore, defined as a natural functional ecological unit com-prising of living organisms (biotic community) and their non-living (abiotic or physio chemical) environment that interact to form a stable self-supporting sys-tem. A pond, lake, desert, grassland, meadow, forest etc. are common examples of ecosystems.**

- **Each ecosystem has two main components:1) Abiotic (2) Biotic**
- **A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. Food webs consist of many interconnected food chains and are more realistic representation of consumption relationships in ecosystems.**



2.10 TERMINAL QUESTIONS

Q.1: Define ecosystem.

Q.2: What is difference between a food chain and food web?

Q.3: What is in a food web?

Q.4: What is food chain and example?

Q.5: What are food chain types?

Q.6: What are consumers in a food web?

Q.7: What is the importance of food chain and food web?

Q.8: What are the three types of ecological pyramids?

Q.9: Explain the path of the hydrologic cycle and its importance.

Q.10: What are the three steps of the nitrogen cycle?

Q.11: Describe the interaction between heterotrophs and autotrophs in the carbon cycle.

Multiple Choice Questions:

Q.1: Who proposed the term ecosystem?

- **a)** Grinnel
- **b)** Turesson
- **c)** A.G. Tansley
- **d)** Lindeman

Q.2: Name the organisms that manufacture organic compounds from simple inorganic compounds without using sunlight?

- **a)** Detrivores
- **b)** Organotrophs
- **c)** Phototrophs
- **d)** Chemotrophs

Q.3: Which of the following organism eats feces?

- **a)** Fungus
- **b)** Bacteria
- **c)** Earthworm
- **d)** Dung beetle

Q.4: Which of the following type of productivity counts the total fixation of energy by photosynthesis?

- **a)** Secondary productivity
- **b)** Primary productivity
- **c)** NPP
- **d)** GPP

Q.5: Energy _____ in an Ecosystem.

- **a)** is released
- **b)** is absorbed
- **c)** flows
- **d)** None of the above

Q.6: Which of the following processes is not involved in the conversion of organic nitrogen to nitrogen gas?

a) nitrogen fixation

b) ammonification

c) nitrification

d) denitrification

Q.7: Which of the following processes produces hydrogen sulfide?

a) anoxygenic photosynthesis

b) oxygenic photosynthesis

c) anaerobic respiration

d) Chemoautrophy

Q.8: Terrestial biomes has a rapid exchange of-

a) Carbon dioxid

b) Oxygen

c) Water

d) All of the above

Q.9: Ecosystem is smallest unit of

a) Ionosphere

b) Lithosphere

c) Biosphere

d) Mesospher

Q.10: Into which two categories can the abiotic components of an ecosystem be divided?

a) Climatic and edaphic

b) Aquatic and edaphic

c) Climatic and aquatic

d) Terrestrial and aquatic

2.11 ANSWERS

1) c 2) d 3) d 4) d 5) c 6) a 7) c 8) d 9) c 10) a

UNIT-3 ECOLOGICAL SUCCESSION

3.1 INTRODUCTION

"The occurrence of relatively definite sequence of communities over a period of time in the same area is known as ecological succession."

The concept of succession was largely developed by Warming (1909) and Cowles (1899). It has been further elaborated by Clements (1916, 1936) who proposed a theory of plant succession and community development called the mono-climax. Later on Tansely (1939) and Daubenmire (1966) proposed the poly-climax hypothesis.

Ecological succession is a gradual process by which ecosystem change and develop overtime. Nothing remains the same and habitats are constantly changing. The species living in a particular place gradually change over time as does the physical and chemical environment with in that area. Succession take place because though the process of living, growing and reproducing organisms interact with and affect the environment within an area, gradually change it.

Objective :

After studying this unit you will be able to know-

1. **Causes and process of Succession.**
2. **Types of Succession.**
3. **Succession in water**
4. **Succession on land.**

3.2 CAUSES OF SUCCESSION

A succession always starts on a bare area which may be sand, clay-gravel, rock and water. The causes like physiographic processes, climatic factors and biotic agents are responsible for plant succession.

A number of causes induce together the process of succession which are as follows:

1. **Physiographic processes :**

   It mostly occurs in primary bare areas as-

   (a) Erosion- by water, wind, gravity or glaciers.

   (b) Deposition- by water, wind, gravity, glaciers, volcanoes.

   (c) Ecesis- The soil condition is also changing by the process of invasion, migration, competition and reaction of the population.

2. **Climatic factors : It includes temperature, rainfall, light intensity, gaseous composition, wind etc. The climatic factors mostly produce secondry bare are:**

   (a) Wind- It eliminates the previous vegetation.

   (b) Drought- It results in drying and killing of weaker species.

   (c) Snow- It kills the previous vegetation.

   (d) Lightning- It causes fire in the forest.

3. **Biotic agents : Producing mostly secondary bare areas :**

   (a) Man - Destroying natural vegetation.

   (b) Animals- By overgrazing.

   (c) Bacteria, Fungi, Insects- Eliminates species by disease or grazing.

4. **Stabilising Causes : Succession is taking place in order to attain the climax stage. Wind, water, glacier etc. brought soil erosion resulting in open bare land where plant succession can take place.**

   High velocity winds uproot trees and sometimes destroy even a climax vegetation. This causes a fresh succession of plant communities. Similarly drought, snow and fire results in open bare land for plant succession.

   In a community, there is competition amongst different members for their existence. In such a process, some of the members are not found suitable and thus are gradually replaced by new one.

3.3 GENERAL PROCESS OF SUCCESSION

The succession involves successive colonisation of a bare area by different plant communities in course of time. The process of succession is completed through the following sequential steps:

1. **Nudation**
2. **Invasion**
3. **Competition and Coaction.**
4. **Reaction**
5. **Stabilization (Climax)**

1. **Nudation - This is the development of bare area without any life form. Volcanic erruption, landslide, flooding, erosion, fire, disease etc. destroy the life completely and make the area bare. The succession starts in the bare area.**

2. **Invasion- It is arrival of propagule of various organism and their establishment in the new area. Invasion includes the following three steps.**

   (i) Migration- Seeds, propagules and spores of the species are brought to new area by the agency of air, water and animals. This is called migration.

   (ii) Ecesis (Establishment) - The successful establishment of species in the new area is known as ecesis. After migration the seed or propagules germinate, grow into seedlings and adults start to reproduce.

   (iii) Aggregation- It includes multiplication and aggregation of organism in a large population in the area.

3. **Competition and Co-action- The aggregation of individuals in an area leads to interspecific and intraspecific competition. The competition is for water, nutrients, heat, light, Co_2, O_2 and space. The intraspecific competition is more acute than interspecific competition because the needs of the individuals of the same species are very much similar. Individuals of a species affect each other's life in various ways and this is called coaction.**

4. **Reaction- The interaction and reaction among plant species as well as between habitat changes the soil, water, temperature, light etc. of the environment. As a result the environment is modified and less suited for the existing community which sooner or later is replaced by another community (Seral community). The whole sequence of communities that replaces on another in the given area is called a Sere and different communities constituting the sere are called seral communities.**

5. **Stabilization (Climax)- At last a final or terminal community is established. Which is stabilized for a longer period of time and maintain an equilibrium with the environment of that area. This final**

community is not replaced and is known as climax community and the stage as climax stage.

SAQ. 1

1. Erosion is the cause of .....
2. The final community in a succession is .....
3. The successful establishment of species in new area is known as .....
4. The arrival of propagule in the new area is known as .....

3.4 TYPES OF SUCCESSION

Some basic types of succession are as follows :-

1. **Primary Succession :-** This types of succession being in a sterile area or barren land or in an inorganic environment when, a bare or nude area is colonized by organisms for the first time and subsequently the communities are changed in a succession form. The process is known as primary succession.
2. **Secondary Succession-** The community development on area previously occupied by another well developed living community amidst the interruption due to adverse conditions like natural calamities, biotic intervention etc is designated as secondary succession. The natural calamities include forest fire, disease, flood, grazing etc.
3. **Autotrophic Succession-** When the population of autotrophs (plants) dominates the population of heterotrophs, the succession caused is known as autotrophic succession.
4. **Heterotrophic Succession -** It is characterized by early dominance of heterotrophs like bacteria, fungi and some animals in an organic environment. Since the environment is dominated by heterotrophs, the succession is called heterotrophic succession.
5. **Autogenic Succession-** Due to continuous interaction of community with environment, there happens a modification of environment causes the replacement of an old community by a new one, which is knows as autogenic succession.
6. **Allogenic Succession-** When the replacement of a community is caused by any other external condition and not by the existing organisms, the course of succession is known as allogenic succession.
7. **Habitat Succession-** Succession are also named differently basing upon the types of habitat from which the phasic replacement starts.
   (a) **Hydrosere-** The succession starting from aquatic habitat is known as "Hydrach" and the series of changes occuring in the vegetation of hydrarch are called Hydrosere.

(b) Mesarch- The succession starting from a habitat where adequate moisture condition are present.

(c) Halosere- The succession occuring at saline water or soil is known as holosere.

(d) Xerosere- Succession taking place in xeric habitat like sand or rocks where moisture is present at minimal amount is known as xerosere.

3.5 HYDROSERE- SUCCESSION IN WATER

Hydrosere may be studied in a freshly built deep reservoir or any other new water body which has very little or no nutrient in the substratum below the water and water itself does not contain any nutrients. Algal spores are brought by wind along with the soil particles and deposited on the water. Thus Unicellular and colonial phytoplankton invades first in the hydrosere. There are about six stages in this sere.

1. **Phytoplankton stage-** In the initial stage blue green algae, green algae (*Spirogyra, Oedogonium*) are the pioneer colonizers. If traces of phosphorous is present blooms of blue green algae appears. These are consumed by zooplankton (*Amoeba, Euglena, Paramecium* etc) and fish (sun fish, blue gillfish etc). Gradually this organism dies and increases the content of dead organic matter in the pond.

2. **Rooted submerged stage -** The above algae add large quantities of organic matter and nutrient in the pond. Thus the pond becomes lined with soft mud which is a suitable substratum for the growth of rooted submerged plants. The plants like *Hydrilla, Utricularia, Vallisneria* etc. appear there. The seeds of these plants are brought by birds and animals which frequently visit the water bodies. When these plants die they decomposed partly due to lack of oxygen. Their remains are, therefore, deposited at the bottom. The eroded soil particles brought by streams etc. are deposited within this dead mass of vegetation. All this results in building up of the substratum and shallowing of the water. Now the pond becomes unfavourable for the growth and development of these submerged species. The reduced depth of water and rich substratum favours colonisation of floating plants.

3. **Floating stage (Rooted and free-floating)-** When the water depth is about 2-8 feet, the rooted floating plants such as *Nymphaea, Ranunclulus, Trapa* etc. grow there. In a year or two, they increase in number and gradually spread over wide areas. Many free floating species like *Pistia, Azolla, Lemna, Wolffia, Eicchornia* etc also grow there. These plants cover the whole surface of water body due to which light does not reach to the submerged plants present deeper into water. As a result submerged plant die. These plants accelerate the loss of water through transpiration. Due to all above the water becomes shallow and rich in organic nutrients. In a few years, the rapid soil building process reduces the water depth to such an extent that it becomes too shallow for the survival of the floating species. The floating species migrate inwards, giving way to the swamp plants.

4. **Reed swamp stage (Amphibious stage)- In shallow water (upto 2 feet depth) the plants like *Typha, Pontederia, Sagittaria, Carex, Mariscus* etc. grow. These plants are slightly submerged and rooted by large much branched rhizomes. The vegetation is very dense therefore, it helps in accumulating sedimentary materials and plant remains. The water depth is further decreased due to which habitat becomes unfavourable for the growth of most of the species.**

6. **Sedge-meadow stage (Marginal mats)- The filling process finally results in a marshy soil which may be too dry for the plants of preexisting community. The plants of the sedge-meadow stage, therefore, gradually disappears and make way for a mesophytic vegetation depending upon the nature of the climate. In dry climates. The next stage may be grassland or some other xeric climax, but in more moist climate it is a woodland.**

6. **Woodland stage- Species of shrubs eg. *Slaix, Cephalanthus, Cornus* etc. and woody plants eg. *Alnus, Populus* etc grow in this stage. These plants can tolerate waterlogged conditions. Large amount of humus, bacteria, fungi and organism accumulate in the soil which favours entry of many other trees in the vegetation leading to the climax stage.**

7. **Climax forests - The nature of the climax depends upon the climate of the region. In tropical region dense rain forest develops due to high rainfall. In the temperate region mixed forest develops and in the region of moderate rainfall deciduous forest develops as climax. (Fig. 3.1)**

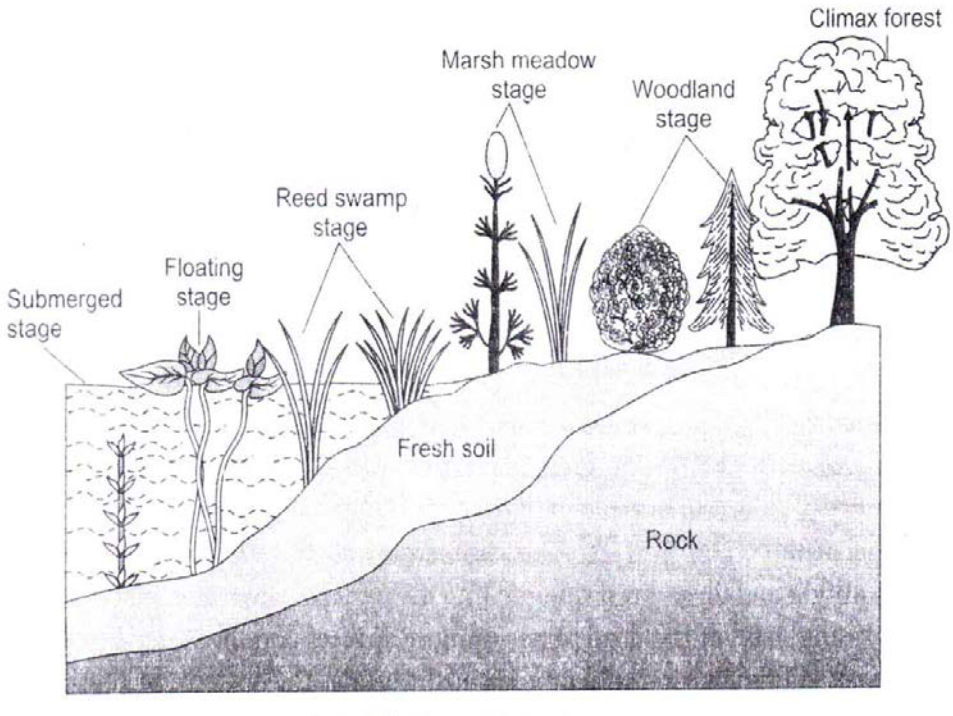


Fig. 3.1 Stage in hydrosere

SAQ-2

1. **The hydrosere occurs in .....**
2. **.....invades first in the hydrosere**
3. **Floating stage comes after .....**
4. **In the tropical region dense .....develops.**

3.6 XEROSERE-SUCCESSION ON LAND

The succession occur in dry condition is called xerosere (xerarch). A typical xerosere starts on rocks which are dry and hard. The soil is absent their for the perenation of roots and supply of nurients. In the extremes of temperature crustose lichens are supposed to be the pioneer plants to initiate succession on the bare rocks. The xerosere undergoes following stages.

1. **Crustose Lichen stage- The rocks have most adverse conditions for the growth of plants. In this hopless situation crustose lichens (*Rhizocarpon, Lecidia, Rhinodina, Lecanora*) appear as pioneer species. These lichens can live in extreme conditions. The carbonic acid produced by the metabolic activities of lichen help to corrode and decompose the rock supplementing the other forces of weathering. The dead remains of the lichens get mixed up with the rock particles. this soil formation facilitates the growth of other vegetation.**
2. **Foliose Lichen- Now habitat is suitable for foliose lichens. The foliose lichens are leaf like and remain attached to the rocks at one point. Their examples are *Parmelia* and *Dermaticarpo*. These lichens have large leaf like thalli, which overlap the crustose lichens. As a results the growth of crustose lichen is reduced or decreased. Acids are recreated by living and decaying plants. The weathering of rocks and addition of humus to it results in the formation of thin layer of soil above the surface of rocks. Thus the habitat becomes changed.**
3. **Moss Stage- The accumulation of soil in the rock crevices favours the growth of xerophytic mosses eg. *Polytrichum, Tortula* etc. The mosses compete with lichens for water. They penetrate much deeper in the soil as compared to the lichens. The lichens become dead. Thus more humus is added to the soil. Minerals combine with this humus. Now this environment is suitable for herbaceous plants.**
4. **Herbaceous Stage- Now the soil has large amount of humus and litter with increased water holding capacity. Therefore, herbaceous plants like *Poa, Adiantum, Tridex* etc. established there. These plants increase the process of weathering. Evaporation or transpiration takes place. It reduces the temperature. The bacteria, fungi and other organisms increase in the soil. The changed habitat do not favour the survival of mosses, therefore, they die and disappear.**
5. **Shrub stage- Now the soil conditions are favourable for shrubs therefore, they start growing. The shrubs become dense and cast**

shadow on the herbs so the herbs die. The roots of shrubs penetrate into soil and process of soil formation continues.

6. **Climax stage-** The much improved soil allows the growth and establishment of woody plants which are densely rooted. These plants inhibits the growth of most plants and dominate. It is a stable stage in succession. Thus the woody forest is the climax stage in a xerosere. (Fig. 3.2)

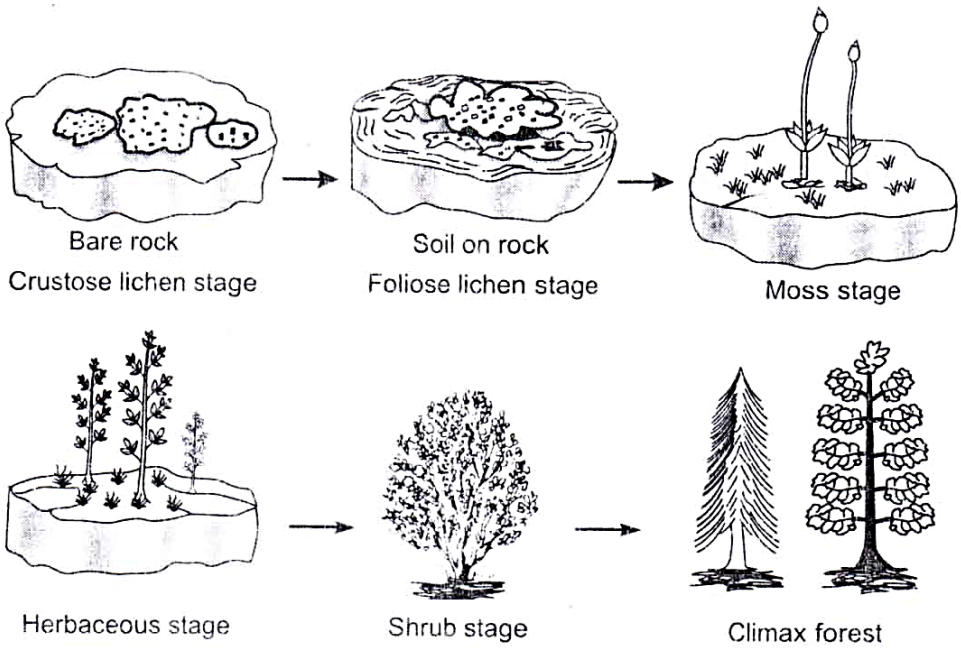


Fig. 3.2 Stages in xerosere

SAQ.-3

1. **The xerosere starts on .....**
2. **.....appear as pioneer species.**
3. **After lichens .....stage comes in xerosere.**
4. **The climax stage in a xerosere is .....**

3.7 SUMMARY

- **The causes of succession are physiographic processes, climatic factors, Biotic agents and stabilising causes.**
- **Nudation, Invasion, competition and coaction, Reaction and stabilization are various steps involved in succession.**
- **There are seven basic types of succession.**
- **The hydrosere starts in water and phytoplanktons are the pioneer colonizers.**

- **The xerosere starts on bare rock and crustose lichens are pioneer colonizers.**

3.8 TERMINAL QUESTIONS

Long Questions

1. **Describe hydrosere.**
2. **Describe succession in a pond or water.**
3. **Describe succession on land or xerosere.**

Short Questions

Write short notes on

(a) **Causes of succession**

(b) **General process of succession**

(c) **Types of succession**

7.9 ANSWERS

SAQ.1

1. Succession, 2. Climax stage, 3. Ecesis, 4. Invasion

SAQ.2

1.Water, 2. Phytoplankton, 3. Rooted submerged stage

4. Rainforest

SAQ.3

1. Rocks, 2. Crustose lichen, 3. Moss, 4. Woody forest.

UNIT-4 POLLUTION

4.1 INTRODUCTION

Pollution of the environment is one of the most horrible ecological crisis to which we are subjected today. We know that three basic amenities for living organisms are air, land or soil and water. Sometimes in the past, these amenities were pure, virgin, undisturbed, uncontaminated and basically most hospitable for living organisms. But the situation is just the reverse today, because progress in science and technology is also leading to pollution of environment and serious ecological imbalance which in the long run, may prove disastrous for mankind. "Environmental pollution is the result of urban-industrial technological revolution and speedy exploitation of every bit of natural resources."The craze of progress in industry, transportation, agriculture, infrastructure and technology is taken as the general criterion of development of any nation. Such activities of man have created adverse effects on all living organisms in the biosphere. Rapid industrialization has left with us polluted rivers, contaminated soil, depleted wild life and exhausted natural resources, and therefore, harmful for the health. The splendid, plentifulness of nature is a heritage that should never be spoiled. But the unlimited rapacious exploitation of nature by man has disturbed the delicate ecological balance existing between living and non- living components on the earth.The root cause of environmental pollution has been the man's misbehavior with the nature under the false ego that is the master of nature. This undesirable situation created by man has threatened the man himself and other living biota on the earth. The term environment, as far as pollution is concerned, includes air, water, the soil, noise, buildings, landscapes, oceans, lakes, river, vehicles and many other things. Thus

Pollution is generally defined as "The addition of the constituents to water or land, which adversely alter the natural quality of the environment." Today India is provided with a good industrial infra-structure in several industries like chemicals, power, nuclear energy, food petroleum, pesticides and plastics etc. The rapid progress in atomic and nuclear energy has added a huge amount of radioactive substances in the atmosphere. A number of industrial effluents and emissions, especially toxic gases are spewed into the air daily. Thus the environment is deteriorated to such an extent that it has crossed the critical limit and has become lethal to all organisms, including man.

Objectives: Students will be able to:

- **Understand and explain what pollution is.**
- **Know about pollutants and can differentiate primary and secondary pollutants.**
- **Identify and describe factors contributing to different kinds of pollution.**
- **Understand different sources and impact of pollution.**
- **Understand and describe why we need to control air, water and noise pollution.**

4.2 DEFINITION

Pollution is the introduction of harmful materials into the environment.

Pollution, also called environmental pollution, the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form.

The word pollution is derived from the Latin word pollutionem (meaning to defile or make dirty) is the act of polluting the environment. The term Pollution is defined in various ways. For example,

1) **Pollution is the unfavorable alteration of our environment, largely because of human activities.**
2) **Pollution – The Nuisance or Nemesis: is the deliberate or accidental contamination of the environment with the animal's waste.**
3) **Pollution is defined as a deviation from the natural composition of a part of the environment, resulting in adverse effects on life.**
4) **Pollution is the accumulation of matter in the wrong place or anything released into the environment which degrades its quality.**
5) **Pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water (or basic amenities) causing harmful effect on our life or that of other desirable species and cultural assets.**

6) **Environmental Pollution is the unfavorable alteration of our surroundings, wholly or largely as a by-product of man's actions, through direct or indirect effects of changes in the energy pattern, radiation levels, chemical and physical constitution and abundance of organisms.**

7) **Pollution means the addition of any foreign material like inorganic, organic, biological or radiological or any physical change occurring in nature which may harm or effect living organisms directly or indirectly, immediately or after a long time.**

8) **Pollution is an undesirable change in physical, chemical or biological characteristics of water, air and soil that may harmfully affect human, animal and the plant life, industrial progress, living conditions and cultural assets.**

9) **Pollution is the introduction of surplus energy or waste matter into the environment by man's activities which directly or indirectly cause hazard to man and his environment.**

10) **Pollution is the release of harmful substances or energy into the environment by man in quantities that damage health and resources.**

Classification of Pollutants

The major kinds of pollution, usually classified by environment, are air pollution, water pollution, and land pollution. Modern society is also concerned about specific types of pollutants, such as noise pollution, light pollution, and plastic pollution. Pollution of all kinds can have negative effects on the environment and wildlife and often impacts human health and well-being.

Pollutants can be classified in a number of ways: For example,

a) **On the basis of their forms they exist in the environment after their release. On the basis, pollutants can be classified as primary and secondary pollutants.**

   1) **Primary Pollutants – Those substances emitted directly from an identifiable source. These pollutants exist as such after being added or released into the environment. Examples are sulphur dioxide, nitrogen oxides etc.**

   2) **Secondary pollutants – These are substances, derived from primary pollutants by chemical reactions. For example, primary pollutants such as hydrocarbons and nitrogen oxides, particularly in the environmental, react in presence of sunlight to form a group of nitrous compounds like peroxyacetyl nitrate (PAN) as the secondary pollutant.**

b) **From ecosystem point of view, the pollutants may be classified as biodegradable and non-biodegradable pollutant.**

   1) **Biodegradable Pollutants – Biodegradable pollutants are those which can be decomposed easily in their natural environment, that is, by the natural biological process and also in the engineered**

systems which enhance nature's great capacity to decompose and recycle. Such pollutants consist of animal and plant debris, domestic sewage etc, which on decomposition give out nutrients like carbonates, phosphates etc, that are released in the biosphere. Heat or thermal pollution also belongs to biodegradable pollutants because heat can be dispersed by natural means. If organic wastes drain out from residential buildings are easily degraded completely by microorganisms these become useful for the ecosystem. The domestic sewage can be readily decomposed by natural processes or by engineered systems (such as municipal sewage treatment plant) which enhance capacity of the nature to decompose and recycle. However, if these pollutants enter the environment in such large quantities that complete degradation of all cannot take place, and then these become biodegradable pollutants and thus pollute the environment.Problem gets enhanced if the input of biodegradable pollutants in the environment exceeds the rate at which they are decomposed.

2) **Non-biodegradable pollutants – Non-biodegradable pollutants are those which either do not degrade or degrade very slowly in their natural environment. Such pollutants are mostly inorganic compounds like mercury and lead salts, aluminum cans, iron, compounds like phenolic compounds and D.D.T etc. Such pollutants are harmful even in low concentration. These pollutants not only accumulate, but are often biologically magnified as they move in biochemical cycles and along food chains. They may also react with other compounds present in the environment to produce even more toxic additional products. Their high concentration may even prove fatal. These pollutants decrease the rate of photosynthesis by affecting planktons, thus disrupting the natural balance existing between oxygen and carbon dioxide.**

In general pollutants are residues of substances made by us, used by us and even thrown away by us as waste products which pollute the environment in one way or the other.

4.3 TYPES OF POLLUTION

Pollutants need not be material substances. Noise can be pollutant and even electromagnetic waves can be pollutants. However, today man is the principal source of pollution, because there is no way for nature to decompose many man made materials and return their elements to the cycle of nature. These substances will just remain and will cause whatever harmful effects they can, until they are somehow disperse or diluted so that their action is no longer harmful.

Thus pollution may be natural (which originates from natural processes such as forest fires, natural organic and inorganic decays, volcanic eruptions, etc.) or artificial which originates due to activities of man.

However, it is better to classify Pollution either according to the environment (air, water, soil, noise, radiation, thermal etc.) in which it occurs or according to the pollutants by which pollution is caused.

1) **Classified according to environment – When different spheres of the environment are affected by pollution, they can be categorized as, Air pollution, Water pollution and Soil or Land pollution.'**

2) **Classification According to the pollutant – The pollution caused by pollutants may be of a number of types. For example, radioactive pollution, Plastic pollution, sewage pollution, Acid rain Pollution etc.**

4.4 AIR POLLUTION

The earth is the only object known in the entire universe capable of supporting life. The supporting property of our planet is due to its unique atmosphere. Today there is overwhelming evidence that various pollutants do and will continue to affect life on this planet. The deleterious effects of various pollutants on human, animal, plant life and even on our climate have been well recognized.

It has become increasingly evident that air pollution is affecting the vegetation to same extent as it is affecting human and animal lives. For our better living standards we need clean air, pure water, nutritious foods, clothes and space etc. which are the basic amenities for life. But the quality of air and water is likely to deteriorate because of pollution explosions, rapid industrialization and urbanization.

The presence of one or more contaminant such as dust, gas, mist, odor, smoke, among or vapor in the outdoor atmosphere, in quantities, of characteristics, and of duration so as to be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property is known as air pollution.

Air pollution may be personal, occupational or community air pollution. Exposure of an individual to dust, fumes, smokes, smog and gases may be regarded as personal air pollution. The type of exposure of an individual to potentially hazardous concentration of aerosols, vapors and gases in his working environment is known as occupational air pollution. Community air pollution involves pollution from a variety of sources and contaminants and factors which cause adverse social, economic and health effects. The community air pollution not only affects many individuals, but it can also exert a significant impact on man's total environment including plants, animals, buildings, property and even wealth.

The most important gaseous air pollutants are carbon monoxide, chlorine, halogenated solvents, hydrocarbons, hydrogen sulphide, nitrous oxide and sulphur dioxide.

Various industrial installations such as asphalt plants, boiling and heating installations, cement manufacturing, fertilizer manufacturing, mineral acid manufacturing, paper and pulp manufacturing, thermal and nuclear power plants, sewage treatment plants, engineering workshops etc.

form the stationary sources of the urban air pollution. The automobiles such as cars, scooters, motors, trucks, busesmoving on the urban roads form the mobile sources of air pollution.

Two and three wheelers emit the highly toxic gases in quantities that are about twice the amount emitted by other sources.

Air pollution may broadly be defined as the presence of one or more contaminants like, dust, smoke, mist, odor in the atmosphere which are injurious to human beings, plants and animals or which unreasonably obstruct the comfortable enjoyment of life and property.

Air pollution may be described as "The imbalance in quality of air so as to cause adverse effects on the living organisms existing on earth".

Air may be regarded as polluted when it is changed in its quality and composition as a result of human activities. The release of low amounts of pollutants into the air does not lead to any serious effects because the atmosphere has a considerable absorptive capacity. When the concentration of pollutants in air becomes so high that they cannot be tolerated by atmosphere's regulating cycles, dangerous consequences arise as polluted air is not suitable for breathing.

The rapid industrialization, fast urbanization, rapid growth in population, drastic increase in vehicles on the roads and other activities of human beings have disturbed the balance of natural atmosphere.

The survival of any living organism is totally based on the breathing of pure natural air and if it gets polluted because of one reason or the other, various undesirable and serious effects may occur. Since air is universal as well as international, the effects of air pollution will be widespread and will have no boundaries.

Thus we cannot find clean air in any part of the world. The air which we breathe is not pure oxygen, but is contaminated with dust, smoke and several gases in harmful proportions. According to the latest view point, air pollution is defined as "Substances introduced into the air by the activity of mankind in such concentrations sufficient to cause serious effects on his health, vegetables, property or interference with the enjoyment of his property".

When the rate of pollution exceeds the self-purifying capacity of the nature, accumulation of pollutants occur causing severe public health problems.

Commonly air constitutes 80% of man's daily intake by weight. We breathe 22,000 times a day inhaling 16 kg of air.

The physiological requirements of an average adult are roughly 14kg of air, 1.5 kg of food and 2 kg of water per day. A man can survive without food for 5 weeks, without water for 5 days but without air for few minutes only. So one has to inhale airfor his survival even if he is not interested in inhaling it.

The mankind has no other choice except to keep the atmospheric air extremely pure and free from the effects of air pollution.

It is evident that air pollution is now affecting the vegetation to some extent as it is affecting human and animal lives. For this reason air pollution has become one of the vital and serious environmental problems of the modern society.

Combustion, fermentation, putrefaction, fog and respiratory processes of animal life are the various important factors that contribute CO_2 in the atmosphere.

The quantity of CO_2 content in the atmosphere leads to greenhouse effect and global warming. It also leads to nausea, headache, depression etc. if its percentage becomes 1.5. The presence of CO_2 to the extent of 5% may lead to fatal accidents.

Composition of Air

The earth's atmosphere is an envelope of gases exceeding to a height of 200 km. Atmosphere constitutes protective cover of gases surrounding the earth which sustains life and saves it from unfriendly environment of outer space. The lowest atmosphere i.e. the troposphere contains about 70% mass of the atmosphere. It has mainly three categories of gaseous components viz. major, minor and trace.

For major gases like N_2 and O_2, concentrations vary but to a very little extent with time, while for trace gases, the values tend to converge as the averaging time lengthens. For example, Methane (CH_4) occurs as a neutral part of carbon cycle. It is also generated by certain bacteria during their metabolic processes. N_2O and NO_2 are the constituents of N_2 cycle. Ozone-concentration arises by photochemical reaction in the upper atmosphere. It also comes from lightning and forest fires.

The average composition of air is: O_2 = 20.90%, N_2 = 78.10%, CO_2 = 0.04% and the rest 0.96% includes O_3, Ar, Kr, CO, He, NH_3, water vapor etc.

SOURCES OF AIR POLLUTION

Air is never found absolutely clean in nature. Atmosphere, i.e. air sector is continuous which diffuse and disperse the air pollutant at a greater rate with faster action. Air pollutants are substances causing damage to target or receptor. The target may be man, animal, plant, tree, building or material which is adversely affected by pollutants.

There is now a growing concern about the pollution of the atmosphere air by manmade activities. Though many of the gaseous pollutants are also emitted by nature (such as volcanic eruptions), anthropogenic activities do adversely affect the quality of air, particularly near dense urban areas and near large emission sources.

Major Sources of Air Pollution

1) **Natural Sources – The natural sources of air pollution are volcanic eruptions releasing poisonous gases (such as SO_2, H_2S and CO etc.), forest fires, natural organic and inorganic decays or vegetative decay, marsh gases, deflation of sands and dust, extraterrestrial bodies, cosmic dust, pollen grains of flowers, soil debris, comets and fungal spores. All these are produced naturally and released in the air, making it foul and**

injurious to health. Green plants through evapotranspiration release huge amount of CO_2. Forest fires and reaction between natural gas emissions also constitute a source of air pollution.

In the lower atmosphere, the natural chemical reactions lead to the conversion of gases or vapors into solids and liquids products by oxidation, reduction, combination, combustion, condensation or polymerization. In the upper atmosphere, the photochemical reactions may undergobreakdown to the more complex molecules by absorption of high energy UV solar radiations. The dust and aerosols of natural origin which are present in the atmosphere consist of salt particles from sea water, condensation nuclei, air borne particles from the soil and vegetation, bacteria, dust of meteoric origin etc. Micro-organisms such as algae, fungi, bacteria, yeasts, rusts, moulds, spores etc. present as viable particles in the atmosphere. All these micro-organisms, except algae can be transported to distant places by wind and as a result they can infect plants, animals and human beings. Pollens or aero allergens enter the atmosphere from weeds, grasses and trees. They are transported from one place to another by wind current. The radioactive minerals present in the earth crust and the action of cosmic rays from outer space on gaseous constituents of the atmosphere are mainly responsible for radioactivity of the atmosphere.

Man Made Sources – Man made sources such as increase in population, deforestation, burning of fossil fuels and fires, emissions from vehicles, rapid industrialization, and agricultural activities.

a) Increase in population – The rapid explosion of population is one of the most important factors of air pollution. An increase in pollution leads to Global warming and emission of greenhouse gases. This in turn causes rise in sea level. An increase in global warming brings with the prospect of reduced production of food grains. An increase in population also contributes to loss in forest cover and loss in wildlife species.

b) Deforestation – Plants maintain the balance of CO_2 and O_2 in the nature, because plants purify the air by taking in CO_2 for their use in photosynthesis and liberating O_2 to be used up by animals during respiratory activities, again liberating CO_2 used by the plants. Indiscriminate cutting of plants, trees and cleaning of the jungles and forests, i.e., deforestation, by man for his own need has disturbed the balance of CO_2 and O_2 in the nature.

c) Burning of Fossil Fuels and Fires – The conventional sources of energy are wood, coal and fossil fuels etc. About 97% of the energy we use in our homes and factories is generated by coal, oil and natural gas, which are called fossil fuels.

The industries need fossil fuels, such as coal, wood and petroleum for energy which is used to drive machines and for many other purposes. The imperfect mode of burning of this fuel; produces smoke which contains:

i) **Fine particles less than 100μin diameter. These are carbon particles, metallic dust particles, resins, tars, aerosols, solid oxides, sulphates and nitrates etc.**

ii) **Coarse particles which are over 200μ in diameter. These include carbon particles and heavy dust that is quickly removed from the air by gravity.**

iii) **Nitrogen compounds such as NO, NO_2, N_2O etc.**

iv) **Halogens**

v) **Radioactive substances**

d) **Emission from Vehicles – The automobile exhausts are responsible for more than 75% of total air pollution. The automobiles such as cars, scooters, motors, taxies, trucks etc. release huge amount of poisonous gases such as carbon monoxide, nitrogen oxides and hydrocarbons, in addition to leaded gas and particulate lead etc., as a result of incomplete combustion of petrol and diesel which react with oxides of nitrogen in presence of sunlight to form photochemical smog in the atmosphere. This smog is very toxic in nature.**

e) **Rapid industrialization – A large no. of industries such as chemical industries, paper and pulp mills, metallurgical plants and smelter, petroleum refineries, mining and synthetic rubber industries are responsible for about 20% of air pollution. The common pollutants of these industries are various types of inorganic and organic gases and materials in the smoke they produce. The most common pollutants are CO_2, CO, SO_2, H_2S, NO, NO_2 etc. In addition, the smoke coming out from their chimneys also contains small particles of dust, carbon, metals, other solids, liquids and even radioactive materials which get mixed in the smoke and pollute the air. All such gases and suspended particles in them are injurious to human health. Accidental release of poisonous gases due to carelessness of authorities and other faults, from the industries also pollute the air badly and some time fatal instantaneously.**

f) **Agricultural Activities – Different types of biocides such as pesticides, insecticides, herbicides etc. which are used in agricultural practices, also cause air pollution because some amount of these poisonous substances is carried away by wind to different places, during their spray over crops, and thus make the air foul for human health and other animals.**

Excessive use of mineral fertilizers and chemical pesticides has caused soil degradation, ground water pollution and the spread of pests resistant to pesticides in several green revolution areas. This has led to warnings of implementing food crisis in the coming years.

Quality of air, quality of life

It has been proven that air quality affects human health. Living in a pollution-free environment signifies a better quality of life, but do we really know how

air pollution affects us and which parts of our bodies are damaged by each kind of polluting particle?

Air pollution causes around seven million deaths a year worldwide. Growth and concentration of the population in cities, as well as the way in which we consume energy in urban areas through transport or heating and air conditioning systems, among others, result in the emission of huge quantities of gases that are harmful to our health.

Effect of Air Pollution on Human Health:

Our physical and psychological wellbeing is affected differently by the kind of air pollution we are exposed to. There are many organs and bodily functions that can be harmed, the consequences including:

- **Respiratory diseases**
- **Cardiovascular damage**
- **Fatigue, headaches and anxiety**
- **Irritation of the eyes, nose and throat**
- **Damage to the reproductive organs, harm to the liver-spleen, blood and Nervous system**
- **Urban populations are more exposed to suffer the effects of air pollution and, in this context; people who are already ill particularly vulnerable, as are children and the elderly.**

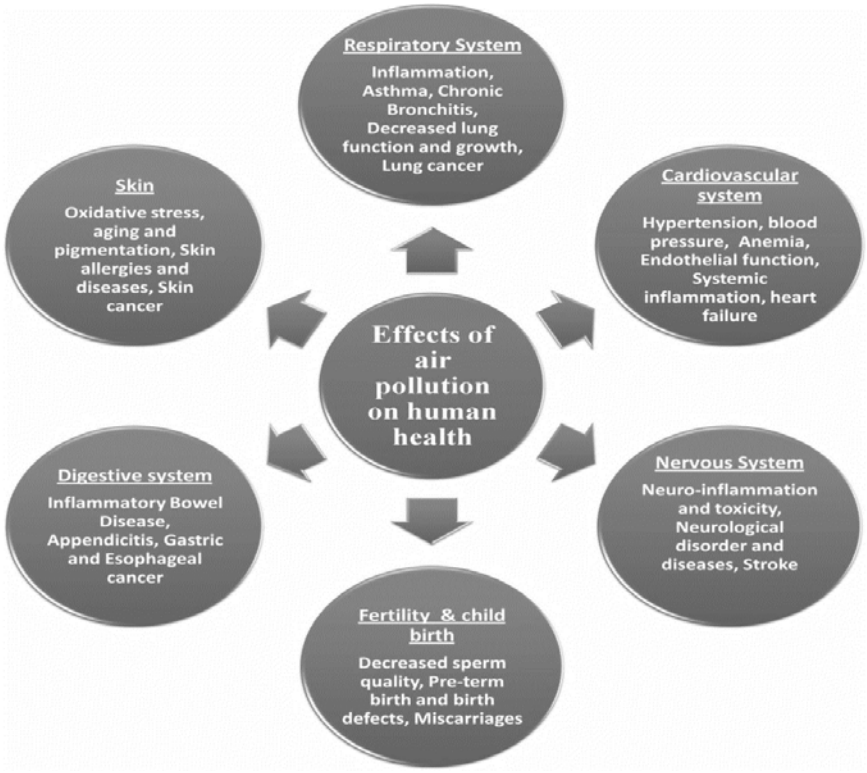


Fig. 4.1 : Effects of air pollution on human health

Effects of Air Pollution on Environment:

- **Global warming: According to estimates, at the current rate of increase, the average global temperature up by 3°C to 8°C in the next 100 years. This will affect the climate of different regions, distribution of plants and animals, disturbance in agriculture and food production, melting of snow caps and resultant increase in sea levels. This will submerge parts of coastal cities of Calcutta, New York, London and other major cities.**
- **Formation of photochemical smog: When pollutants like hydrocarbons and nitrogen oxides combine in the presence of sunlight, smog is formed. This is a mixture of gases and since it is formed by photochemical reactions, it is called the photochemical smog. The word 'smog' is derived from the two words-smoke and fog. It forms a yellowish brown haze especially during winter and hampers visibility. It also causes many respiratory disorders and allergies as it contains polluting gases.**
  - **Formation of acid rain: Sulphur dioxide and nitrogen oxides react with water in the atmosphere producing sulphuric acid and nitric acid. These acids come down along with the rain. This phenomenon is called acid rain. The pH of acid rain varies from 3-6. The composition of acid rain is sulphuric acid, nitric acid and weak carbonic acid. Its adverse effects on the environment include: causes respiratory and skin disorders, affects productivity of plants by damaging the leaves, enters the soil and affects the soil, pH and causes leaching, enters the ground and river waters which causes harm to the aquatic life, causes damage to marble and thus damages buildings and monuments (like TajMahal).**
  - **Aerosol formation: Aerosol is formed by the dispersion of solid or liquid matter in the atmosphere. If the aerosols form a thick layer in the troposphere, they affect the weather conditions by blocking the solar radiation. Aerosols are also deposited on the leaves and affect the photosynthesis. Aerosols disperse the organic metallic pollutants far and wide.**
  - **Depletion of Ozone: The stratosphere of the atmosphere has ozone (O_3). Ozone is known to absorb the Ultraviolet (UV) rays present in the sun's radiation and protects us from the harmful effects of the UV rays. However, hydrocarbons such as the chlorofluorocarbons (CFCs) destroy the ozone molecules which deplete the ozone layer. Ozone holes have been detected in the atmosphere which permits the UV rays to reach the earth's surface. The harmful effects of the UV rays are visible in the countries such as Australia and New Zealand where the rate of skin cancer is higher than the other regions of the world (www.tutorvista.com).**

Table 1. Harmful effects of the pollutants in air

S.No	Pollutant	Source/Cause	Effect
1.	Carbon monoxide	Automobile exhaust, photochemical reactions in the atmosphere, biological oxidation by marine organisms, etc.	Affects the respiratory activity as haemoglobin has more affinity for Co than for oxygen. Thus, CO combines with HB and thus reduces the oxygen-carrying capacity of blood. This results in blurred vision, headache, unconsciousness & death due to asphyxiation (lack of oxygen).
2.	Carbon dioxide	Carbon Burning of fossil fuels,depletion of forests (that remove excess carbon dioxide and help in maintaining the oxygen-carbon dioxide ratio).	Global warming as it is one of the greenhouse gases.
3.	Sulphur dioxide	Industries, burning of fossil fuels, forest fires, electric generation plants, smelting plants, industnal boilers, petroleum refineries and volcanic eruptions.	Respiratory problems, severe headache, reduced productivity of plants, yellowing and reduced storage time for paper, yellowing and damage to limestone and marble, damage to leather, increased rate of corrosion of iron, steel, zinc and aluminium.
4.	Hydrocarbons Polynuclear Aromatic Compounds (PAC) & Polynuclear Aromatic Hydrocarbons(PAH)	Automobile exhaust and industries, leaking fuel tanks, leaching from toxic waste dumping sites and coal tar lining of some water supply pipes.	Carcinogenic (may cause leukemia)
5.	Chlorofluoro carbons (CFCs)	Refngerators, air conditioners, foam shaving cream, spray cans and cleaning solvents.	Destroy ozone layer which then permits harmful UV rays to enter the atmosphere.
6.	Nitrogen Oxides	Automobile exhausts, burning of fossil fuels, forest fires, electric generation plants, smelting plants, industrial boilers, petroleum refineries and volcanic eruptions	Forms photochemical smog, at higher concentrations causes leaf damage or affects the photosynthetic activities of plants and causes respiratory problems in mammals.
7.	PAN - peroxylacetyl -nitrate	Photochemical reactions of hydrocarbons and nitrogen oxides.	Irritation of eye, throat and respiratory tract, damage to clothes, paint and rubber articles, damage to leaves and stomatal tissue in plants.
8.	Particulate matter Lead halides (lead pollution)	Combustion of leaded gasoline products	Toxic effect in man.
9.	Asbestos particles	Mining activities	Asbestosis - a cancerous disease of the lungs
10.	Silicon dioxide	Stone cutting, pottery, glass manufacturing and cement industries.	Silicosis, a cancerous disease.
11.	Biological matter like the pollen grains	Flowers	Allergy
12.	Fungal spores, bacteria, virus, etc	Microbes	Infectious diseases

Effects of Air Pollution on Animals :

When the animals feed upon the particulate coated plants (especially with Fluo-rine, Lead, Arsenic) they get affected with Arsenic poisoning (cattle and sheep) and Arsenic poisoning (cattle). Lead poisoning results in bronchitis and lack of appetite in pet animals.

Effects of Air Pollution on Plants :

Spraying of pesticides and other agricultural practices has exposed the plants to a large number of air pollutants, adversely affecting their growth and metabolism by destroying chlorophyll and disrupting photosynthesis.

(a) SO_2 bleaches the leaf surface and causes chlorosis (i.e. loss of chlorophyll and yellowing of the leaf) especially in leafy vegetables.

(b) NO_2 causes premature leaf fall (abscission) and suppressed growth of plants resulting in reduced yields of crop plants.

(c) **Ozone causes necrosis (dead areas on a leaf structure) and damages leaves.**

(d) **PAN (peroxyacylnitrate) damages leafy vegetables causing premature fall, discoloration and curling of sepals.**

Effects of Air Pollution on Materials:

Materials are affected by air pollutants in the following four ways:

(a) **Corrosion.**

(b) **Abrasion.**

(c) **Deposition and removal of materials.**

(d) **Chemical attack.**

The damages caused to various materials by air pollutants are:

(a) **SO_2, Acid rains and aerosols damage the building materials.**

(b) **Paints are discolored by SO_2, H_2S and particulates.**

(c) **Metals undergo corrosion and tarnishing by SO_2 and Acid gases.**

(d) **Paper becomes brittle and leather undergoes disintegration by SO_2 and Acid gases.**

(e) **Ozone, SO_2, NO_2 and acid gases discolor, deteriorate and reduce the ten-sile strength of textiles.**

4.5 WATER POLLUTION

British poet W. H. Auden once noted, "Thousands have lived without love, not one without water." Yet while we all know water is crucial for life, we trash it anyway. Some 80 percent of the world's wastewater is dumped—largely untreated—back into the environment, polluting rivers, lakes, and oceans.

This widespread problem of water pollution is jeopardizing our health. Unsafe water kills more people each year than war and all other forms of violence combined. Meanwhile, our drinkable water sources are finite: Less than 1 percent of the earths freshwater is actually accessible to us. Without action, the challenges will only increase by 2050, when global demand for freshwater is expected to be one-third greater than it is now.

Water pollution occurs when harmful substances often chemicals or microorganisms contaminated a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.

Causes of Water Pollution

Water is uniquely vulnerable to pollution. Known as a "universal solvent," water is able to dissolve more substances than any other liquid on earth. It's the reason we have Kool-Aid and brilliant blue waterfalls. It's also why water

is so easily polluted. Toxic substances from farms, towns, and factories readily dissolve into and mix with it, causing water pollution.

Categories of Water Pollution

Groundwater

When rain falls and seeps deep into the earth, filling the cracks, crevices, and porous spaces of an aquifer (basically an underground storehouse of water), it becomes groundwater—one of our least visible but most important natural resources. Nearly 40 percent of Americans rely on groundwater, pumped to the earth's surface, for drinking water. For some folks in rural areas, it's their only freshwater source. Groundwater gets polluted when contaminants—from pesticides and fertilizers to waste leached from landfills and septic systems—make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans.

Surface water

Covering about 70 percent of the earth, surface water is what fills our oceans, lakes, rivers, and all those other blue bits on the world map. Surface water from freshwater sources (that is, from sources other than the ocean) accounts for more than 60 percent of the water delivered to American homes. But a significant pool of that water is in peril. According to the most recent surveys on national water quality from the U.S. Environmental Protection Agency, nearly half of our rivers and streams and more than one-third of our lakes are polluted and unfit for swimming, fishing, and drinking. Nutrient pollution, which includes nitrates and phosphates, is the leading type of contamination in these freshwater sources. While plants and animals need these nutrients to grow, they have become a major pollutant due to farm waste and fertilizer runoff. Municipal and industrial waste discharges contribute their fair share of toxins as well. There's also all the random junk that industry and individuals dump directly into waterways.

Ocean water

Eighty percent of ocean pollution (also called marine pollution) originates on land whether along the coast or far inland. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities by streams and rivers into our bays and estuaries; from there they travel out to sea. Meanwhile, marine debris particularly plastic is blown in by the wind or washed in via storm drains and sewers. Our seas are also sometimes spoiled by oil spills and leaks big and small and consistently soaking up carbon pollution from the air. The ocean absorbs as much as a quarter of man-made carbon emissions.

Point source

When contamination originates from a single source, it's called point source pollution. Examples include wastewater (also called effluent) discharged legally or illegally by a manufacturer, oil refinery, or wastewater treatment

facility, as well as contamination from leaking septic systems, chemical and oil spills, and illegal dumping. The EPA regulates point source pollution by establishing limits on what can be discharged by a facility directly into a body of water. While point source pollution originates from a specific place, it can affect miles of waterways and ocean.

Nonpoint source

Nonpoint source pollution is contamination derived from diffuse sources. These may include agricultural or stormwater runoff or debris blown into waterways from land. Nonpoint source pollution is the leading cause of water pollution in U.S. waters, but it's difficult to regulate, since there's no single, identifiable culprit.

Trans-boundary

It goes without saying that water pollution can't be contained by a line on a map. Trans-boundary pollution is the result of contaminated water from one country spilling into the waters of another. Contamination can result from a disaster—like an oil spill—or the slow, downriver creep of industrial, agricultural, or municipal discharge.

The Most Common Types of Water Contamination

Agriculture

Not only is the agricultural sector the biggest consumer of global freshwater resources, with farming and livestock production using about 70 percent of the earth's surface water supplies, but it's also a serious water polluter. Around the world, agriculture is the leading cause of water degradation. In the United States, agricultural pollution is the top source of contamination in rivers and streams, the second-biggest source in wetlands, and the third main source in lakes. It's also a major contributor of contamination to estuaries and groundwater. Every time it rains, fertilizers, pesticides, and animal waste from farms and livestock operations wash nutrients and pathogens such bacteria and viruses into our waterways. Nutrient pollution, caused by excess nitrogen and phosphorus in water or air, is the number-one threat to water quality worldwide and can cause algal blooms, a toxic soup of blue-green algae that can be harmful to people and wildlife.

Sewage and wastewater

Used water is wastewater. It comes from our sinks, showers, and toilets (think sewage) and from commercial, industrial, and agricultural activities (think metals, solvents, and toxic sludge). The term also includes storm water runoff, which occurs when rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways.

More than 80 percent of the world's wastewater flows back into the environment without being treated or reused, according to the United Nations; in some least-developed countries, the figure tops 95 percent. In the United States, wastewater treatment facilities process about 34 billion gallons of wastewater per day. These facilities reduce the amount of pollutants such as pathogens, phosphorus, and nitrogen in sewage, as well as heavy metals and toxic chemicals in industrial waste, before discharging the treated waters back

into waterways. That's when all goes well. But according to EPA estimates, our nation's aging and easily overwhelmed sewage treatment systems also release more than 850 billion gallons of untreated wastewater each year.

Oil pollution

Big spills may dominate headlines, but consumers account for the vast majority of oil pollution in our seas, including oil and gasoline that drips from millions of cars and trucks every day. Moreover, nearly half of the estimated 1 million tons of oil that makes its way into marine environments each year comes not from tanker spills but from land-based sources such as factories, farms, and cities. At sea, tanker spills account for about 10 percent of the oil in waters around the world, while regular operations of the shipping industry through both legal and illegal discharges contribute about one-third. Oil is also naturally released from under the ocean floor through fractures known as seeps.

Radioactive substances

Radioactive waste is any pollution that emits radiation beyond what is naturally released by the environment. It's generated by uranium mining, nuclear power plants, and the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medicine. Radioactive waste can persist in the environment for thousands of years, making disposal a major challenge. Consider the decommissioned Hanford nuclear weapons production site in Washington, where the cleanup of 56 million gallons of radioactive waste is expected to cost more than $100 billion and last through 2060. Accidentally released or improperly disposed of contaminants threaten groundwater, surface water, and marine resources.

Effects of Water Pollution

On human health

To put it bluntly: Water pollution kills. In fact, it caused 1.8 million deaths in 2015, according to a study published in The Lancet. Contaminated water can also make you ill. Every year, unsafe water sickens about 1 billion people. And low-income communities are disproportionately at risk because their homes are often closest to the most polluting industries.

Waterborne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water. Diseases spread by unsafe water include cholera, giardia, and typhoid. Even in wealthy nations, accidental or illegal releases from sewage treatment facilities, as well as runoff from farms and urban areas, contribute harmful pathogens to waterways. Thousands of people across the United States are sickened every year by Legionnaires' disease (a severe form of pneumonia contracted from water sources like cooling towers and piped water), with cases cropping up from California's Disneyland to Manhattan's Upper East Side.

Meanwhile, the plight of residents in Flint, Michigan where cost-cutting measures and aging water infrastructure created the recent lead contamination crisis offers a stark look at how dangerous chemical and other

industrial pollutants in our water can be. The problem goes far beyond Flint and involves much more than lead, as a wide range of chemical pollutants from heavy metals such as arsenic and mercury to pesticides and nitrate fertilizers are getting into our water supplies. Once they're ingested, these toxins can cause health issues, from cancer to hormone disruption to altered brain function. Children and pregnant women are particularly at risk.

Even swimming can pose a risk. Every year, 3.5 million Americans contract health issues such as skin rashes, pinkeye, respiratory infections, and hepatitis from sewage-laden coastal waters, according to EPA estimates.

On the environment

In order to thrive, healthy ecosystems rely on a complex web of animals, plants, bacteria, and fungi all of which interact, directly or indirectly, with each other. Harm to any of these organisms can create a chain effect, imperiling entire aquatic environments.

When water pollution causes an algalbloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algal growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create "dead zones," where waters are essentially devoid of life. In certain cases, these harmful algal blooms can also produce neurotoxins that affect wildlife, from whales to sea turtles.

Chemicals and heavy metals from industrial and municipal wastewater contaminate waterways as well. These contaminants are toxic to aquatic life—most often reducing an organism's life span and ability to reproduce—and make their way up the food chain as predator eats prey. That's how tuna and other big fish accumulate high quantities of toxins, such as mercury.

Marine ecosystems are also threatened by marine debris, which can strangle, suffocate, and starve animals. Much of this solid debris, such as plastic bags and soda cans, gets swept into sewers and storm drains and eventually out to sea, turning our oceans into trash soup and sometimes consolidating to form floating garbage patches. Discarded fishing gear and other types of debris are responsible for harming more than 200 different species of marine life.

Meanwhile, ocean acidification is making it tougher for shellfish and coral to survive. Though they absorb about a quarter of the carbon pollution created each year by burning fossil fuels, oceans are becoming more acidic. This process makes it harder for shellfish and other species to build shells and may impact the nervous systems of sharks, clownfish, and other marine life.

4.6 NOISE POLLUTION

Atmospheric pollution is not the only type of contamination that is harming living beings on the planet. According to the World Health Organization (WHO), it is one of the most dangerous environmental threats to health. And according to the European Environment Agency (EEA), noise is

responsible for 16,600 premature deaths and more than 72,000 hospitalizations every year in Europe alone.

Not only does it hurt humans, it is bad for animals, too. According to the National Park Service (NPS) in the United States, noise pollution has an enormous environmental impact and does serious damage to wildlife. Experts say noise pollution can interfere with breeding cycles and rearing and is even hastening the extinction of some species.

What is noise pollution?

Noise pollution is unwanted or disturbing sound in the environment that affects the health and well-being of humans and other living organisms. It is an invisible danger. It cannot be seen, but it is present nonetheless, both on land and under the sea.

Noise pollution is unwanted or excessive sound that can have deleterious effects on human health, wildlife, and environmental quality. Noise pollution is commonly generated inside many industrial facilities and some other workplaces, but it also comes from highway, railway, and airplane traffic and from outdoor construction activities.

Not all sound is considered noise pollution. The World Health Organization (WHO) defines noise above 65 decibels (dB) as noise pollution. To be precise, noise becomes harmful when it exceeds 75 decibels (dB) and is painful above 120 dB. As a consequence, it is recommended noise levels be kept below 65 dB during the day and indicates that restful sleep is impossible with nighttime ambient noise levels in excess of 30 dB.

The energy in a sound wave can be measured using Decibels. The Decibel Meter shows examples of things that make noise and measurements in decibels. Sound energy travels in waves and is measured in frequency and amplitude.

Amplitude measures how forceful the wave is. It is measured in decibels or dBA of sound pressure. 0 dBA is the softest level that a person can hear. Normal speaking voices are around 65 dBA. A rock concert can be about 120 dBA.

Sounds that are 85 dBA or above can permanently damage your ears. The more sound pressure, a sound has the less time, it takes to cause damage. For example, a sound at 85 dBA may take as long at 8 hours to cause permanent damage, while a sound at 100 dBA can start damaging hair cells after only 30 minutes of listening.

Frequency is measured in the number of sound vibrations in one second. A healthy ear can hear sounds of very low frequency, 20 Hertz (or 20 cycles per second), to a very high frequency of 20,000 Hertz. The lowest A key on the piano is 27 Hertz. The middle C key on a piano creates a 262 Hertz tone. The highest key on the piano is 4186 Hertz.

Limits for Permissible Noise Exposure (According to OSHA)	
8 hours	90 dB
6 hours	92 dB
4 hours	95 dB
3 hours	97 dB
2 hours	100 dB
1.5 hours	102 dB
1 hour	105 dB
30 minutes	110 dB
15 minutes	115 dB

Table 2 : Decibel Exposure Time Guideline

Sources of Noise Pollution :

The sources of noise pollution are classified into two broad categories: Internal and external sources of noise pollution.

1. **External pollution sources of noise**

   There are the major sources of noise pollution in the environment. They are sources that are extremely difficult to control. They include:

   Industrial sources: The industrialization has resulted in the rise of noise pollution. The industries include textile mills, engineering plants, printing presses, and metal industries. Most industries use heavy machines capable of producing very high levels of noise. They have equipment such as compressors, exhaust fans, grinding mills, and generators which increase the overall noise levels in the environment. Workers in these environments are in great health risks in case they do not take proper measures like wearing earplugs to minimize the effect of the noise.

   Vehicles for transportation: The automobile revolution has turned out to be a big source of environmental noise in urban regions. In the modern age, there is an increase in traffic due to the growth in the number of vehicles such as buses, trains, and trucks. People caught in traffic jams are also often impatient and will continuously hoot their horns in an attempt to alert the driver in front of them to move. These acts produce unbearable noise to the people living in the neighboring areas, the commuters or passersby, and the environment as a whole. Airplanes also increase the problem of noise in major urban cities. Most airports are located near residential areas and for this reason, the jet-planes taking off and landing in such areas normally produce high sound levels.

   Poor urban planning: Developing nations habitually lack proper urban planning that leads to congested housing, small spaces, small industry proliferation, and lack of enough parking areas. Poor urban planning thus contributes to environmental noise through fights or social and basic amenities, noise from small manufacturing industries, wrangles over parking space, family quarrels from the neighboring houses, and noise from playing children.

Public address systems: Public functions such as rallies, strikes, elections, religious and secular events use addressing systems that are very loud. The organizers of such events normally flout the rules set against public noise pollution by the state. Loud noise from public address systems and music systems during social events such as parties and religious crusades are another source of noise pollution. Open markets also often produce high levels of noise pollution due to the activities of buying and selling, and the use of loudspeakers and megaphones in advertising merchandise or services.

Agriculture machine: Noise level of as high as 90 dB to 98 dB has been recorded in some farms using heavy types of machinery and equipment. These equipment include thrashers, tube wells, tractors, drillers, powered tillers, and harvesters.

Military equipment: Artillery tanks, rocket launching, military airplanes drills, explosions, and shooting practice are serious noise polluters. Deafening impacts are produced by the sounds of jet engines and in extreme cases, they cause the shattering of window panes and cracking of old dilapidates buildings located near their take-off and landing areas or when they fly past such structures.

2. **Indoor sources of noise**

They are noises associated with human activities within a household or building. They also occur due to operations of building services and office services.

Inside building services: Construction works, workshops and automobile repairs cause noise pollution. The equipment used in such jobs produces a lot of noise that causes nuisance and may hamper hearing ability.

Household activities: These are activities such as the loud banging of doors, noises from playing children, furniture movement, crying infants, loud arguments. Many households also own entertainment equipment such as Hi-Fi Systems, Television sets, and loudspeakers that may further contribute to the overall noise emanating from indoor household activities. Household equipment like pressure cookers, vacuum cleaners, washing machines, sewing machines, mix-grinders, desert coolers, exhaust fans, and air-conditioners equally produce a lot of noise.

Office equipment: In offices, there are printers, photocopiers, and typewriters among other equipment that contribute to noise pollution in the working places and its environs.

Effects on Noise Pollution on Human Health

1. **Noise pollution** – The second-largest Environmental Cause to Health Problems

According to a World Health Organization (WHO) finding, noise is the second largest environmental cause of health problems, just after the

impact of air pollution (particulate matter). As per the current data, it is estimated that environmental noise contributes to 48,000 new cases of ischaemic heart disease a year, as well as 12,000 premature deaths.

In addition, we estimate that 22 million people suffer chronic high annoyance, and 6.5 million people suffer chronic high sleep disturbance. As a result of aircraft noise, we estimate that 12,500 school children suffer from reading impairment in school.

2. Hearing Problems

Hearing is one of the five senses that human beings have. As such, it is an essential part of the life of any person. But as much as the ear serves the purpose of receiving sound waves, it can also do so to a certain limit. When it gets to the point termed as noise, it means it is undesirable because it interferes with one's hearing capacity.

This is the reason people cover their years when there is really loud noise. Such loud noise can cause hearing impairment, which can even result in permanent hearing loss. Hearing loss due to noise pollution is attributed to prolonged exposure of noise levels above 85 decibels.

3. Tinnitus

Tinnitus is defined as the sensation of sound in the absence of an external sound source. Tinnitus caused by excessive noise exposure has long been described; 50% to 90% of patients with chronic noise trauma report tinnitus.

In some people, tinnitus can cause sleep disturbance, cognitive effects, anxiety, psychological distress, depression, communication problems, frustration, irritability, tension, inability to work, reduced efficiency and restricted participation in social life.

4. Difficulty in Sleeping

Noise can deter sleep because of its psychological effect. Having noise around can distort peaceful sleep as it causes stress. Moreover, being in a noisy place means there is almost no chance of having any sleep. Inadequacy of sleep, in turn, interrupts the normal functioning of the body, leading to discomfort, fatigue, and general moodiness.

5. Reduced Cognitive Functioning

The ear is connected to the brain, which coordinates the body's stimulus responses. For this reason, all the sound waves that hit the ear are sent to the brain for interpretation. This means too much noise also gets to the brain, and according to scientific reports, such kind of noise dulls the brain and contributes to a lower response rate by the brain.

Due to this, cognitive functioning reduces, and so does the ability to solve problems normally. Individuals who live in areas with too much noise, for instance, adjacent to busy highways, railway lines, airports or near loud night clubs, tend to have lower cognitive power compared to those who live in quieter environments.

6. Cardiovascular Problems

Noise 'excites' the heart. Too much noise means the heart is also disturbed and ends up beating faster, increasing blood pressure. In loud noise, stress hormones such as adrenaline and cortisol are also released.

Therefore, blood pressure will definitely increase in noisy environments, thus prompting faster flow of blood, which in turn leads to the secretion of catecholamine, a hormone that further magnifies the number of times the heart pumps blood. As long as there is no harm in this, regular exposure will keep the body getting higher impulses leading to increased blood pressure.

If blood pressure keeps rising, it may open up chances for heart-related diseases such as high blood pressure and stroke. Other cardiovascular diseases include hypertension and arteriolosclerosis, which are caused by the dilation of the pupil and constriction of blood vessels.

7. Emotion and Behavioral Change

This is different from cognitive thinking. Too much noise means disturbance of peace, which may lead to annoyance or anger. People in this state tend to have constant headaches, which may even intensify if the noise is continuous.

This may lead to amplified stress levels, and thus, emotions take over, and violence may ensue. This type of behavior is reported to be due to anxiety. With such behavior, it becomes hard to concentrate on work and achieve set goals owing to reduced work efficiency.

8. Reproduction Problems

Varying studies have been conducted to estimate the effect of noise pollution on reproduction in human beings, and surprisingly, most of these studies have posited that pregnant women exposed to noise pollution during the course of their expectancy tend to give birth to children with less body weight. The stress levels experienced by the expectant mother equally disturbs the unborn child.

9. Trouble Communicating

High decibel noise can create inconvenience and may not allow two people to communicate clearly. This may lead to misunderstanding, and one may get difficult in understanding the other person. Constant sharp noise can cause severe headaches and disturb the emotional balance.

Effects of Noise Pollution on Animals

1. Reduction in Feeding Patterns

Some birds and animals like bats, whales and dolphins use their sharp hearing abilities – known as echolocation for movements, foraging, and

avoiding prey. Noise pollution has negated this since the noise monopolizes all the sounds present.

As a result, there is increased migration by animals from their natural habitats in search of quieter places where they can feed comfortably. Some animal species have slowly become extinct due to this. They migrate to other ecosystems that are not suitable for them and end up dying.

2. Hearing Problems

Dolphins and whales are frequent visitors to the shallow waters of large oceans. But because of the continuous loud noise caused by drilling machines in the oceans, some of these animal's hearing capabilities have been severely impacted, with some having a permanent hearing impairment.

3. Hinders Communication

Noise has the greatest impact on males with the most attractively colored resonators. For example, exposure to unwanted sounds and increasing levels of stress and immune suppression can cause aberrations in the coloration of vocal sacs, a flexible membrane that enhances sounds, in male tree frogs. This, in turn, affects sexual selection in these animals.Disturbances in reproduction and selection of a partner lead to significant disorders in the population in general.

4. Reproduction Problems

Animals use unique voices to know the locations of mates and stay away from danger. Birds also use low pitched sounds in order to attract mates. Some of the sounds made have been said to be too low, only audible to the animals that can pick up the sound at that wavelength but inaudible to the human ear.

A noisy environment would prevent this, leading to the near-extinction of various species of birds and animals as it makes it difficult for them to mate and breed. Without breeding, it means no new offspring.

5. Death

Bigger animals are able to survive in noisy areas. The case is different for smaller marine organisms, such as cephalopods – one of the many species of shellfish. These marine fish are heavily affected by the noise coming from moving vessels. The slow movement of large ships over areas where they call habitat can lead to their death.

During seismic surveys, compressed air 'bullets' are sent deep into the ocean at high speed to search for oil deposits at the bottom of the oceans, resulting in enormous noise in the aquatic environment.

Within an hour of a single shot, the amount of zooplankton, organisms at the very base of the oceanic food chain, decreases by an average of 64% in this area. It disturbs the whole ocean's trophic network.

The noisy underwater turbines and submarines also emit very high levels of noise decibels that end up disrupting and even destroying marine life.

6. Reduction in Production

Noise deters the productivity of animals both in the wild and domesticated. Cows produce less milk if there is any noise around them during milking. They get agitated and tend to withdraw the milk due to fear and discomfort. Chickens are also adversely affected by noise. There is a drastic drop in the production of eggs for layers in noisy environments.

7. Behavioral Change

Like human beings, wild animals also experience a change in behavior depending on the level of peace or noise present. The agitation caused by noise influences heightened aggression levels in all animals, and interestingly, irritation has even been reported for birds.

Noise makes them unable to communicate, which may change their behavior into aspects such as cannibalism. Beetles, as another example, are so disturbed by the noise that they end up killing each other.

8. Adaptation

Whereas some of the animals cannot make it in a noisy environment, the rest either die or bear a tough skin through to the end. It is up to the animals to survive in order to ensure the continuation of their species. As such, animals are slowly adapting to life in urban areas. Instead of the usual calling sounds between females and males, animals are using higher pitches to surpass the noise levels.

At times the rise in pitch may lead to confusion, but birds such as water birds and tits have been able to survive in urban settings despite chirping louder. Some birds, on the other hand, have had to change their singing from daytime to nighttime when there is reduced noise to survive.

9. Slow Reaction Time

Hermit crabs, tortoises and turtles are some of the animals that withdraw to their shells when trouble strikes. The presence of boats or human activity quickly warrants trouble leading to their withdrawal.

Noise pollution for long periods of time has distorted this pattern, especially in crabs. Their reaction time to danger has slowed, which puts them at a disadvantage when faced by predators.

10. Disturbs Echolocation in Sea Animals

The marine mammals, Cetaceans (including dolphins), rely on echolocation to communicate, navigate and find partners. They are particularly vulnerable to intensified noise. The excessive noise

interfering with echolocation, therefore, disturbs many of their key cognitive behaviors and functions.

Sonar devices are a special problem with sound intensity as high as 235 dbs. Such sounds can damage hearing organs of cetaceans.

4.7 CONTROL OF POLLUTION

Control of Air Pollution:

1. **Using public transports**

   Using public transport is a sure short way of contributing to less air pollution as it provides with less gas and energy, even carpools contribute to it. In addition to less release of fuels and gas, using a public transport can also help in saving money.

2. **Turn off the lights when not in use**

   The energy that the lights take also contribute to air pollution, thus less consumption of electricity can save energy. Use energy saving fluorescent lights to help the environment.

3. **Recycle and Reuse**

   The concept of recycle and reuse is not just conserve resources and use them judicially but also is helpful for air pollution as it helps in reducing pollution emissions. The recycled products also take less power to make other products.

4. **No to plastic bags**

   The use of plastic products could be very harmful to the environment as they take a very long time to decompose, due to their material made up of oil. The use of paper bags instead is a better alternative as they decompose easily and are recyclable.

5. **Reduction of forest fires and smoking**

   The collecting of garbage and getting it on fire in dry seasons or dry leaves catching fires is a huge factor for causing air pollution, moreover smoking also causes air pollution and causes the air quality to worsen along with obviously damaging one's health.

6. **Use of fans instead of Air Conditioner**

   The usage of AC's takes a lot of energy and emits a lot of heat which is bad for the environment. AC's also take a lot of power and energy to work as compared to fans.

7. **Use filters for chimneys**

   The gas that is emitted from fireplaces in homes and factories are extremely dangerous for air pollution and harms the air quality severely. The use of filters should be used at least if the consumption

couldn't be lessened, this will help to reduce the effect of harmful gases absorbing in the air.

8. **Avoid usage of crackers**

   The use of crackers during festivals and weddings is sadly one of the biggest contributors to air pollution, leading to a layer of smog which is extremely harmful for health. So, practice of no crackers should be implemented.

9. **Avoid using of products with chemicals**

   Products that use the chemicals in their usage or smell strongly, like paints or perfumes should be used less or outside the house. There can also be an alternative to use products with low chemical content and organic properties.

10. **Implement Aforestation**

    Last but not the least, plant and grow as many trees as possible. The practice of planting trees provides a lot of benefits to the environment and helps with the release of oxygen.

Control of Water Pollution:

Water pollution in natural water bodies can be identified and quantified on the basis of various parameters, such as, dissolved oxygen (DO), biochemical oxygen demand (BOD), coliform organisms, pH etc. As per the water quality criteria, the DO levels in drinking water should be 6 mg/L and BOD levels should be < 2 mg/L. Moreover coliforms level should not exceed 50 MPN/100 mL in water which is safe for drinking purpose. If the water quality of any source is not complying with these criteria, the water cannot be used for drinking purpose without undergoing complete treatment.

Water pollution can be controlled by diluting the water pollutants in a reservoir. The various methods for the control of water pollution can be summarized as follows:

1. **The sewage pollutants are required to be treated in sewage treatment plants before their discharge in natural water bodies.**
2. **Water pollution due to organic insecticides and pesticides can be reduced by the use of very specific and less stable chemicals in the manufacture of insecticides/pesticides. Moreover, use of bio-fertilizers needs to be promoted.**
3. **Oxidation ponds can be useful in removing low level of radioactive wastes.**
4. **Hot water should not be disposed directly into the river, as it adversely affects the life of aquatic organisms. Thermal pollution can be reduced by employing techniques such as cooling, cooling ponds, evaporative or wet cooling towers and dry cooling towers.**

5. **Domestic and industrial waste waters should be treated properly in waste water treatment plants, before discharge in the natural aquatic systems.**

6. **Strict implementation of legislations for water treatment should be done.**

7. **No solid waste should be dumped into water bodies.**

8. **Dead bodies of animals/human should not be floated in water sources.**

9. **Bathing, washing of clothes, and idol immersion should be strictly restricted in natural water bodies.**

Control of Noise Pollution:

Like all other pollutions, noise pollution needs to be controlled by measures which will maintain the acceptable levels of noise pollution for human beings and buildings as indicated.

Noise pollution can be effectively controlled by taking the following measures:

(1) Control at Receiver's End:

For people working in noisy installations, ear-protection aids like ear-plugs, ear-muffs, noise helmets, headphones etc. must be provided to reduce occupational exposure.

(2) Suppression of Noise at Source:

This is possible if working methods are improved by:

(a) Designing, fabricating and using quieter machines to replace the noisy ones.

(b) Proper lubrication and better maintenance of machines.

(c) Installing noisy machines in sound proof chambers.

(d) Covering noise-producing machine parts with sound-absorbing materials to check noise production.

(e) Reducing the noise produced from a vibrating machine by vibration damp-ing i.e. making a layer of damping material (rubber, neoprene, cork or plastic) beneath the machine.

(f) Using silencers to control noise from automobiles, ducts, exhausts etc. and convey systems with ends opening into the atmosphere.

(g) Using glass wool or mineral wool covered with a sheet of perforated metal for the purpose of mechanical protection.

(3) Acoustic Zoning :

Increased distance between source and receiver by zoning of noisy industrial areas, bus terminals and railway stations, aerodromes etc. away from the residential areas would go a long way in minimizing noise pollution. There should be silence zones near the residential areas, educational institutions and above all, near hospitals.

(4) Sound Insulation at Construction Stages:

(a) Sound travels through the cracks that get left between the door and the wall. For reducing noise, this space (jamb frame gap) should be packed with sound absorbing material.

(b) Sound insulation can be done by constructing windows with double or triple panes of glass and filling the gaps with sound absorbing materials.

(c) Acoustical tiles, hair felt, perforated plywood etc. can be fixed on walls, ceilings, floors etc. to reduce noise (especially for sound proof recording rooms etc.)

(5) Planting of Trees:

Planting green trees and shrubs along roads, hospitals, educational institutions etc. help in noise reduction to a considerable extent.

(6) Legislative Measures:

Strict legislative measures need to be enforced to curb the menace of noise pollution. Some of these measures could be:

(a) Minimum use of loudspeakers and amplifiers especially near silence zones.

(b) Banning pressure horns in automobiles.

(c) Framing a separate Noise Pollution Act.

4.8 SUMMERY

- **Pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water (or basic amenities) causing harmful effect on our life or that of other desirable species and cultural assets.**
- **Air pollution is the imbalance in quality of air so as to cause adverse effects on the living organisms existing on earth.**
- **The natural sources of air pollution are volcanic eruptions releasing poisonous gases (such as SO_2, H_2S and CO etc.), forest fires, natural organic and inorganic decays or vegetative decay, marsh gases, deflation of sands and dust, cosmic dust, pollen grains of flowers, soil debris, comets and fungal spores.**
- **Manmade sources of air pollution are increase in population, deforestation, burning of fossil fuels and fires, emissions from vehicles, rapid industrialization, and agricultural activities.**

- **Water pollution occurs when harmful substances—often chemicals or microorganisms contaminate a stream, river, lake, ocean, aquifer, or other body of water, degrading water quality and rendering it toxic to humans or the environment.**
- **Used water is waste water. It comes from our sinks, showers, and toilets (thick sewage) and from commercial, industrial, and agricultural activities (thick metals, solvents, and toxic sludge).**
- **Waterborne pathogens, in the form of disease-causing bacteria and viruses from human and animal waste, are a major cause of illness from contaminated drinking water.**
- **Amplitude measures how forceful the wave is. It is measured in decibels or dBA of sound pressure. 0 dBA is the softest level that a person can hear. Normal speaking voices are around 65 dBA. A rock concert can be about 120 dBA.**

4.9 TERMINAL QUESTIONS

Q.1: **What are the 5 examples of air pollution?**

Q.2: **What are the 3 main causes of air pollution?**

Q.3: **How can we prevent air pollution?**

Q.4: **Which disease is caused due to air pollution?**

Q.5: **What are the causes and solutions of air pollution?**

Q.6: **What is water pollution?**

Q.7: **Where does water pollution come from?**

Q.8: **How do we detect water pollution?**

Q.9: **What is eutrophication, what causes it and what are the dangers?**

Q.10: **What is acid rain and how does it develop?**

Q.11: **What's noise?**

Q.12: **Can noise cause damage to buildings?**

Q.13: **What are sound and noise?**

Q.14: **What are the major sources of noise pollution?**

Q.15: **What decibel level is considered noise pollution?**

Q.16: **What is the effect of noise pollution on human health?**

Q.17: **How can we reduce noise pollution?**

Q.18: **What are some examples of noise pollution?**

Multiple Choice Questions:

Q.1: **What is noise?**

a) **Desirable sound**

b) **Desirable and unwanted sound**

c) **Undesirable and unwanted sound**

d) **Undesirable and wanted sound**

2. **In which unit sound is measured?**

a) **Kilometer**

b) **Pascal**

c) **Kilogram**

d) **Decibel**

3. **Which pollution cause hearing loss in organisms?**

a) **Air pollution**

b) **Noise pollution**

c) **Water pollution**

d) **Soil pollution**

4. **What is the dB of a threshold of hearing?**

a) **0**

b) **10**

c) **50**

d) **100**

5. **What is the dB of a threshold of pain?**

a) **100**

b) **110**

c) **120**

d) **146**

6. **Which of the following is called the secondary air pollutant?**

(a) **PANs**

(b) **Ozone**

(c) **Carbon monoxide**

(d) **Nitrogen Dioxide**

7. **Which of the following particles is called the particulate pollutants?**

(a) **Ozone**

(b) **Radon**

(c) Fly Ash

(d) Ethylene

8. Which of the following agents is responsible for turning the TajMahal yellow?

(a) Sulphur

(b) Chlorine

(c) Sulphur dioxide

(d) Nitrogen dioxide

9. Which of the following rivers is called the world's most polluted river?

(a) Ganga River

(b) Chenab River

(c) Cauvery River

(d) Yamuna River

10. Which of the following are the primary causes of water pollution?

(a) Plants

(b) Animals

(c) Human activities

(d) None of these

11. Which of the following is not a waterborne disease?

(a) Measles

(b) Typhoid

(c) Cholera

(d) Hepatitis

4.10 ANSWERS

1) c 2) d 3) b 4) a 5) d 6) b

7) c 8) c 9) a 10) c 11) a

Uttar Pradesh Rajarshi Tandon
Open University

Bachelor of Science

SBSBY-02

Ecology

BLOCK

2

ECOLOGY-II

UNIT-5

Ecological Adaptations in Plants

UNIT-6

Edaphic Factors

UNIT-7

Phytogeography

UNIT-8

Environmental Education

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BLOCK INTRODUCTION

Ecology-II

Like previous block this block also has 4 units, 5, 6, 7 and 8. The unit 5 deals with adaptation of plants in water and xerophytic environment. In unit 6 you will study about definition and composition of soil along with soil profile. This study also helps you in understanding soil erosion methods of soil conservation. Unit 7 gives you knowledge about major plant communities of the world and country. The aim of Unit 8 is to aware you about environment and acquire knowledge, skills, values, experiences, which will enable you to act individually and collectively to solve present and future environmental problems.

Objectives :

After studying this block you will be able to know:-

- How plants have adapted them self according to the environment.
- About soil, their erosion and methods of their conservation.
- Major plant communities of the world and country.

Importance of environment in our life and to act individually and collectively to protect it.

UNIT-5 ECOLOGICAL ADAPTATIONS IN PLANTS

Structure

5.1 INTRODUCTION

The living organisms react with their environments and they bear full impression of the environments in which they grow.

In order to withstand adverse conditions of the environment and utilize to their maximum benefit the nutrients and other conditions prevailing therein, the organisms develop certain morphological, anatomical, physiological and reproductive features.

Organisms interact with the various environmental factors, be it the abiotic components or the biotic components, there comes a time when adaptations begin to form, for the better survival of the race.

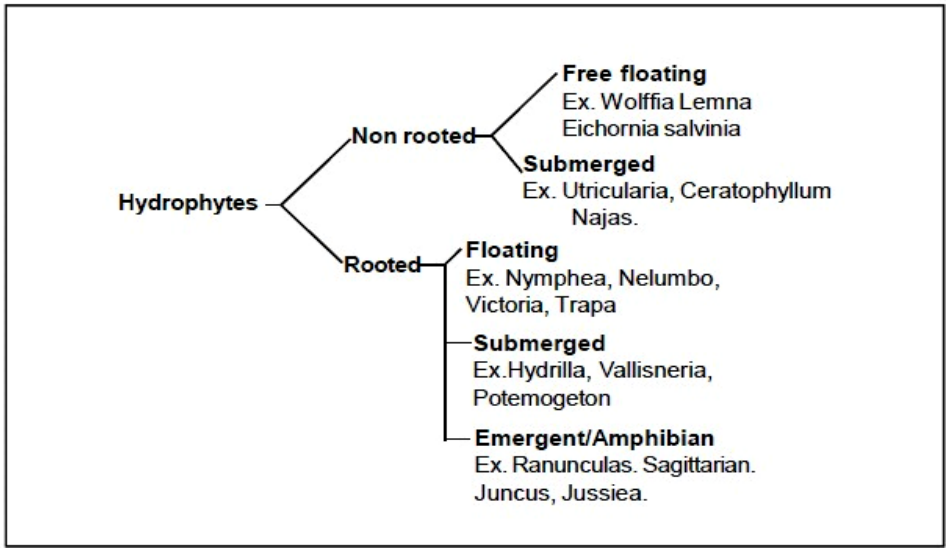
Any physiological, behavioural or morphological attribute of an organism that enables it to survive and reproduce in its respective habitat is called as an adaptation. Adaptations are very important for each and every organism. Otherwise, the rate of survival or continuing its progeny becomes diminished.

5.2 HYDROPHYTES

Hydrophytes grow in water or in soil which is saturated with water or is covered with water. Water may be fresh or saline.

Hydrophytes divide in following types –

Hydrophytes :



Rooted Hydrophytes

The hydrophytes which possess vascular tissue i.e. xylem and phloem are called vascular hydrophytes. The vascular hydrophytes may be arranged into 3 natural groups *viz.* submerged plants, floating plants and amphibious plants.

Non rooted hydrophytes

The hydrophytes which lacks the vascular tissue in them are called non rooted hydrophytes.

Submerged hydrophytes

These are rooted hydrophytes completely submerged in water. (5.1a)

The submerged hydrophytes can be of two types

a) **Plants with long stems eg. *Hydrilla***

b) **Plants with tuberous stem eg. *Vallisneria***

Floating forms

Floating hydrophytes are those plants which can float on the surface of water

a) **Free floating forms**

b) **Floating but rooted forms**

Free floating forms

These plants are not attached to soil but they can freely float on the surface of water eg. *Wolffia* (Fig 5.1b)

Floating but rooted forms

These aquatics are rooted in mud but their leaves are floating on the surface of water eg. *Nymphaea* (Fig 5.1c)

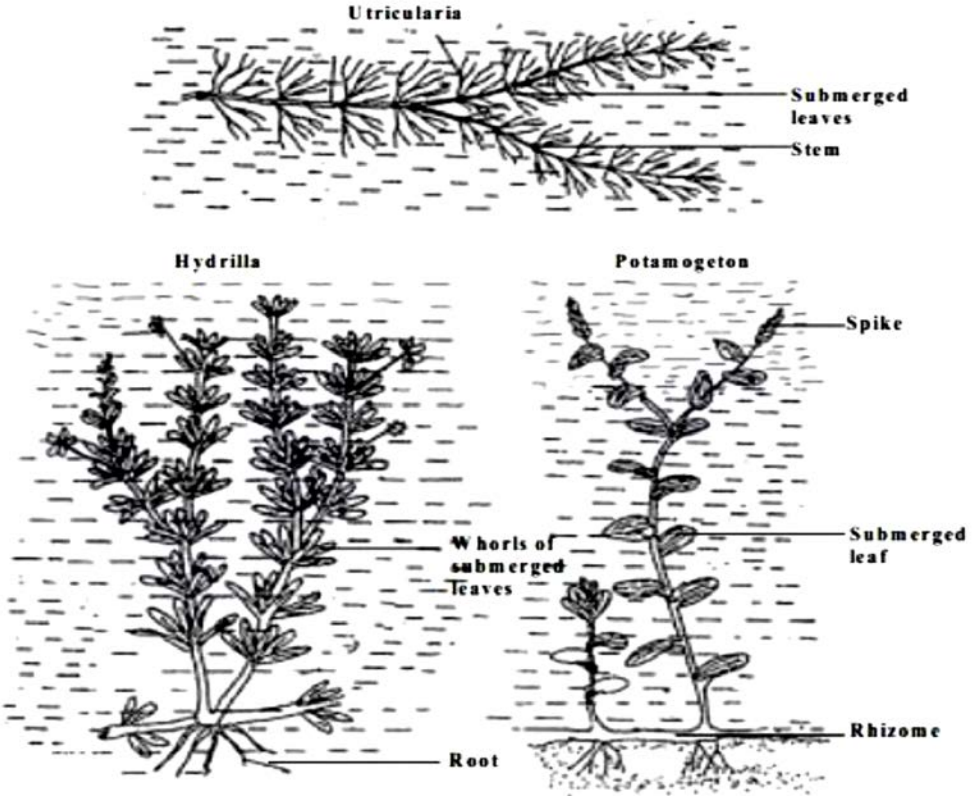


Fig 5.1a Submerged hydrophytes

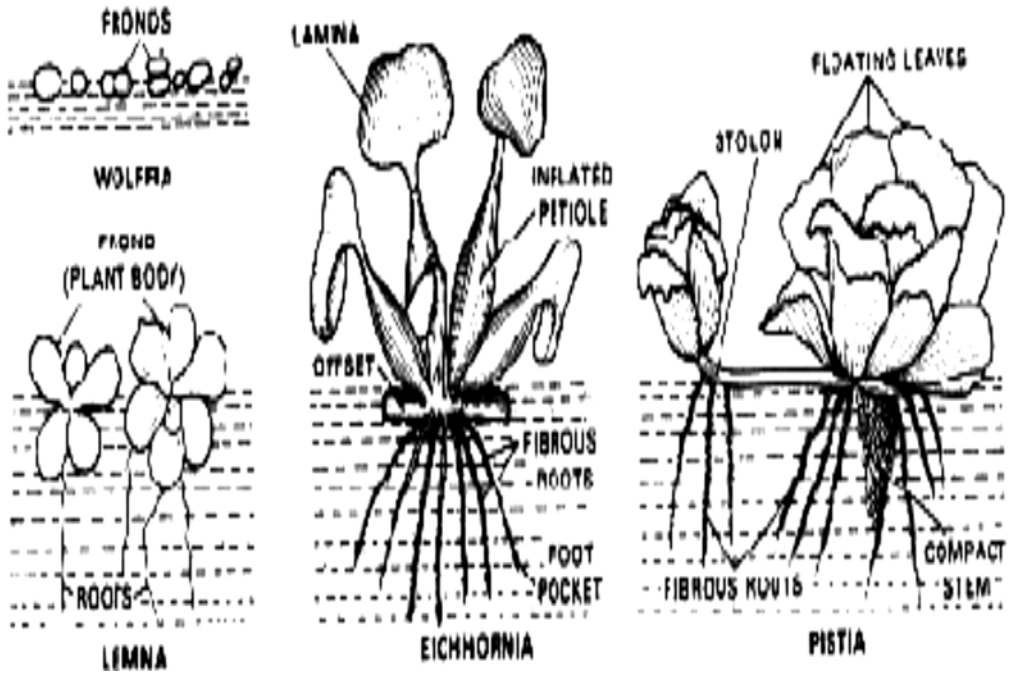


Fig 5.1b Free floating hydrophytes

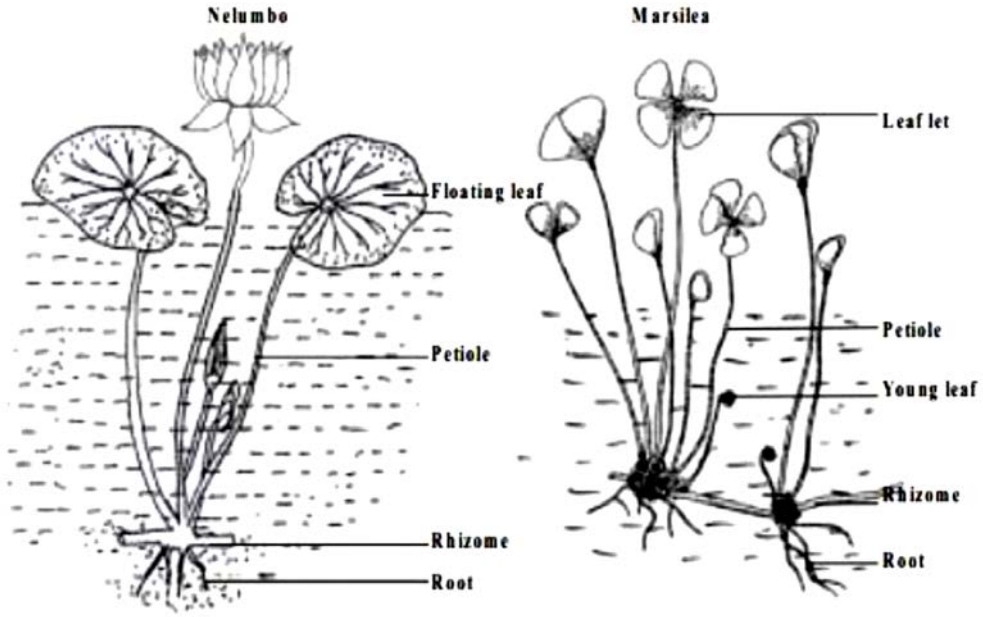


Fig 5.1c Floating but rooted hydrophytes

SAQ1

a) Absence of root, cuticle and stomata are the characteristics of……..

b) *Vallisneria* is a ……

c) Non-rooted hydrophytes…….

d) Submerged hydrophytes……

5.3 ADAPTATIONS IN HYDROPHYTES

Hydrophytic Adaptations:

As the aquatic environment is uniform throughout, the hydrophytes develop very few adaptive features.

Important features of these plants are described in the following heads:

(i) Roots :

Root system in hydrophytes are poorly developed which may or may not be branched in submerged hydrophytes. Roots are meaningless as body which is in direct contact with water acts as absorptive surface and absorbs water and minerals. This may probably be the reason why roots in hydrophytes are reduced or absent. Roots of floating hydrophytes show very poor development of root hairs. Roots in floating plants do not possess true root caps but very often they develop root pockets or root sheaths which protect their tips from injuries. Exact functions of these root pockets, however, are not fully understood. Some rooted hydrophytes like *Hydrilla*, they derive their

nourishments from water by their body surfaces, are partly dependent on their roots for minerals from the soil. Roots are totally absent in some plants, e g., *Ceratophyllum, Salvinia, Azolla, Utricularia,* etc. In *Jussiaea repens* two types of roots develop when the plants grow on the surface of water, some of them are floating roots which are negatively geotropic having spongy structures. The floating roots keep the plants afloat.

(ii) Stem:

In aquatic plants, stem is very delicate and green or yellow in colour. In some cases, it may be modified into rhizome or runner, etc.

(iii) Leaves:

(a) In floating plants leaves are generally peltate, long, circular, light or dark green in colour, thin and very smooth. Their upper surfaces are exposed in the air but lower leaves are generally in touch with water. In lotus plant petioles of leaves show indefinite power of growth and they keep the laminae of leaves always on the surface of water.

(b) Heterophylly:

Some aquatic plants develop two different types of leaves in them. This phenomenon is termed as heterophylly. Examples are *Sagittaria sagittaefolia, Ranunculus aquatilis, Limnophila heterophylla, Salvinia, Azolla* etc. In this phenomenon, generally the submerged leaves are linear ribbon shaped or highly dissected and the leaves that are found floating on or above the surface of water are broad circular or slightly lobed. The occurrence of heterophylly is associated probably with the physiological behaviours of these aquatic plants.

A. Submerged rooted hydrophytes (e.g *Hydrilla Fig. 5.2a*)

We can understand the adaptation of hydrophytes by a very good example of *Hydrilla*. Submerged plant *Hydrilla* is a rooted hydrophyte. It grows completely below the water.

It shows following adaptations

Morphological adaptations

1. **Roots are greatly reduced and root hairs are absent.**
2. **Stem is thin and delicate because mechanical tissue absent.**
3. **Leaves are reduced.**

Anatomical adaptations

T.S. of *Hydrilla* stem shows following anatomical adaptations

1. **Absence of cuticle.**
2. **Vascular bundles do not develop.**
3. **Extremely reduced xylem.**
4. **Cortical region become very large.**

5. **Presence of large number of air cavities in the cortex region for gas exchange.**
6. **Stem is soft and spongy.**
7. **Mesophyll is not differentiated.**

Hydrophytic characters of *Hydrilla*

1. **Epidermis is made up of thin walled cells.**
2. **Cuticle is absent.**
3. **Absence of mechanical tissue.**
4. **Arenchyma and air chambers present.**
5. **Extremely reduced xylem.**
6. **Comparatively well developed phloem.**

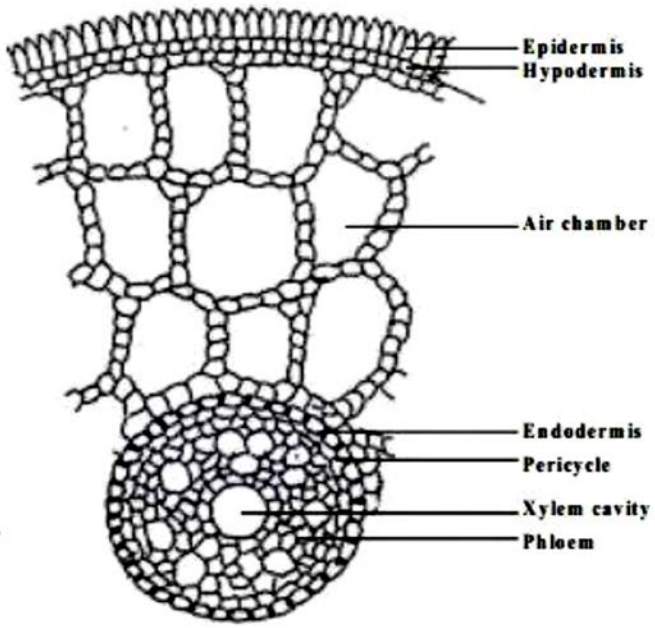


Fig 5.2 a : T.S. of *Hydrilla* stem

B. Floating but rooted hydrophytes (eg : *Nymphea Fig.5.2b*)

Morphological adaptations

1. **Roots are poorly developed**
2. **Roots are produced from horizontal stems, root stocks or tubers.**
3. **Petioles are very well developed and elongated.**
4. **Air cavities are well developed within a petiole.**
5. **Leaves are covered with wax to prevent the wetting of the upper surface.**

Anatomical adaptations

T.S. of petiole of *Nymphea* shows following anatomical adaptations

1. **Epidermis : It is the outermost layer made of parenchymatous cells.**
2. **Cuticle is absent**
3. **Hypodermis : It is present just below the epidermis. The cells are compactly arranged.**
4. **Ground tissue : Many large air chambers are distributed throughout this region.**
5. **Vascular tissue : Vascular bundles are distributed throughout the ground tissue.**
6. **Vascular bundles. are poorly developed.**
7. **Xylem is represented by a single large element.**
8. **Phloem is scattered all around the xylem.**

Hydrophytic characters

1. **Cells of epidermis are thin walled**
2. **Cuticle absent**
3. **Absence of mechanical tissue**
4. **Ground tissue parenchymatous**
5. **Presence of arenchyma.**
6. **Vascular tissues poorly developed.**

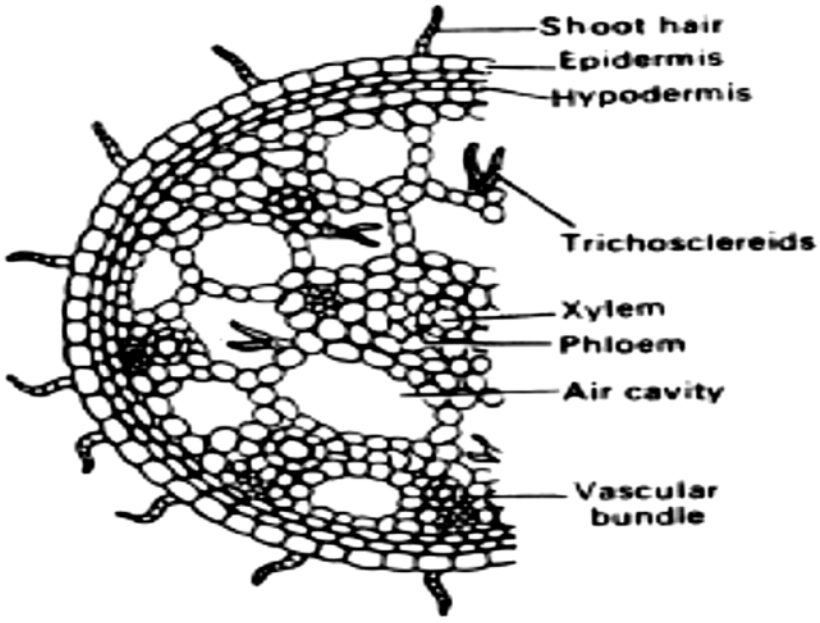


Fig 5.2b : T.S. of petiole of *Nymphea*

5.4 ADAPTATIONS IN XEROPHYTES

Plants which grow in places like deserts, sand hills and alpine region there is acute shortage of water and the rate of transpiration is often rapid. In such xeric habitats the plants are modified to withstand such unfavourable conditions such plants are called xerophytic plants or xerophytes.

Important xerophytic features are summarized under the following heads:

(1) Morphological (external) adaptations;

(2) Anatomical (internal) adaptations;

(3) Physiological adaptations.

1. External Morphology of Xerophytes:

(A) Root:

Xerophytes have well developed root systems which may be profusely branched. It is extensive and more elaborate than shoot system. Many desert plants develop superficial root system where the supply of water is restricted to surface layer of the earth. The roots of perennial xerophytes grow very deep in the earth and reach the layers where water is available in plenty. Root hairs are densely developed near the growing tips of the rootlets. These enable the roots to absorb sufficient quantity of water.

(B) Stem:

Some of the important characteristics of xerophytic stems are listed below:

(i) Stems of some xerophytes become very hard and woody. It may be either aerial or subterranean.

(ii) They are covered with thick coating of wax and silica as in *Equisetum*. Some may be covered with dense hairs as is *Calotropis*.

(iii) In some xerophytes, stems may be modified into thorns.

Morphological adaptations

1. The xerophytes have a very deep and extensive root system which reaches the deeper layer of soil water. The root system is several times larger than the aerial portions.

2. The stem is stunted in growth and its branching give the plants a bushy appearance.

3. Some plants have very hard and woody stems. They are covered with thick bark.

4. **In many xerophytic plants the leaves are reduced to spiny structures to reduce the rate of transpiration.**

5. **Certain xerophytic plants shed their leaves during the dry period.**

6. **In plants like *Nerium*, the leaf surfaces are shining to reflect away light.**

7. **In some plants leaves are very thick and leathery to reduce transpiration.**

8. **The leaves of many xerophytic plants have waxy coating on the upper surface. They are also covered with a dense mass of hairs.**

9. **Some of the grasses are folded in such a manner that the stomata are completely protected.**

Anatomical adaptations

1. **Leaves of many xerophytic plants have thick cuticle on the upper surface and sometimes even on lower surface to check transpiration.**

2. **The epidermal cells are thick walled to reduce transpiration. Some plants like Nerium have many layers of epidermis both on the upper as well as the lower surface of leaf.**

3. **The stomata are greatly reduced in number and mostly present on the lower surface of the leaf to avoid direct light.**

4. **The stomata are mostly located in deep pit. The pit cavities are filled with large number of hairs, such stomata are called sunken stomata.**

5. **In mesophyll tissue the palisade parenchyma is many layered and is well developed not only in the upper portion of the leaf but also in the lower portion to check evaporation of water. The spongy parenchyma cells are comparatively fewer in number and have very small intercellular spaces.**

6. **Many vascular bundles are present in the leaf.**

7. **The water conducting elements are well developed i.e xylem.**

Xerophytic character of *Nerium* leaf (Fig 5.2c)

1. **Presence of thick cuticle.**

2. **Both epidermal layers are multi-layered.**

3. **Stomata only in the lower epidermis and highly sunken.**

4. **Stomata covered with thick envelope of hairs.**

5. **Presence of palisade near both epidermal layers.**

6. **Well developed vascular tissues.**

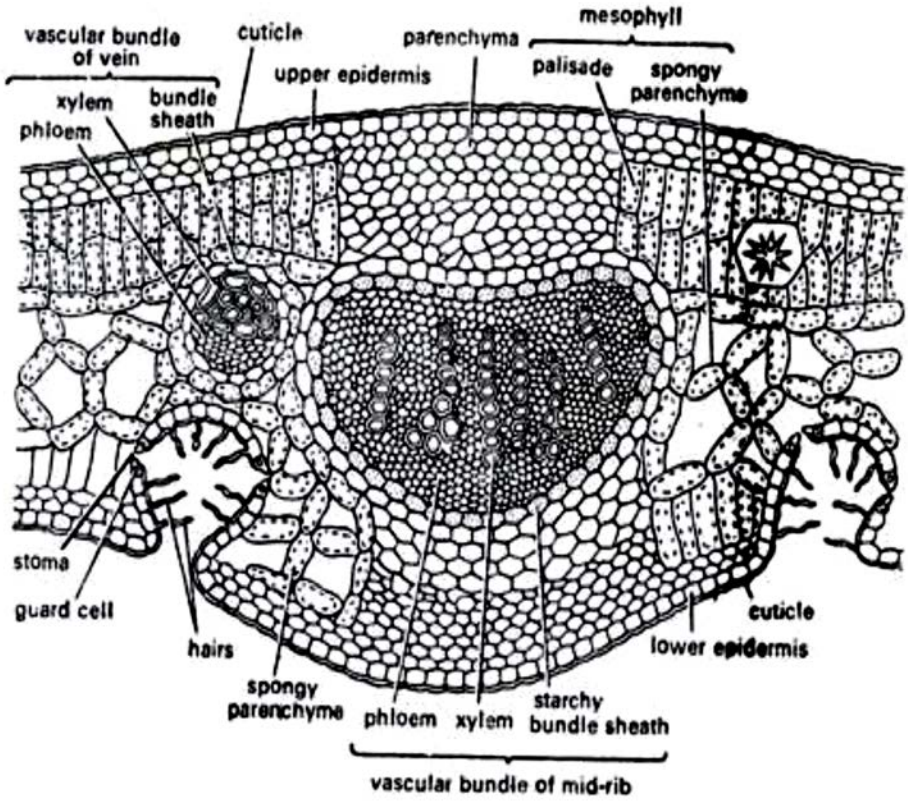


Fig 5.2c : T.S. of *Nerium* leaf

Casuarina stem T.S

The T.S. of *Casuarina* stems (Fig 5.2d) shows ridges and grooves. The section shows the following characters

1. **Epidermis**
   a) **Epidermis is single layered and cuticularized**
   b) **Stomata are sunken and occur in the grooves.**
   c) **Numerous hairs are present in the grooves and around the stomata.**
2. **Cortex**
   a) **Hypodermis present below the epidermis. It is made of sclerenchyma arranged in T – shaped patches.**
   b) **Larger part of the cortex is made up of several layers of parenchyma.**
   c) **Ring of vascular bundles called cortical vascular bundles are present in the parenchymatous region. These are situated below the ridges.**
3. **Endodermis**
   a) **It is single layered**

4. Vascular tissue

a) Vascular bundles are arranged in a ring.

b) Vascular bundles are well developed. The sclerenchymatous patches are present above each vascular bundle. In between two vascular bundles parenchymatous region is present.

5. Pith

a) A well developed parenchymatous pith is present in the centre.

Xerophytic characters of *Casuarina* stem

a) Presence of thick cuticle

b) Stomata sunken and covered with hairs.

c) Sclerenchymatous hypodermis.

d) Presence of palisade in the cortex.

e) Well developed vascular tissue.

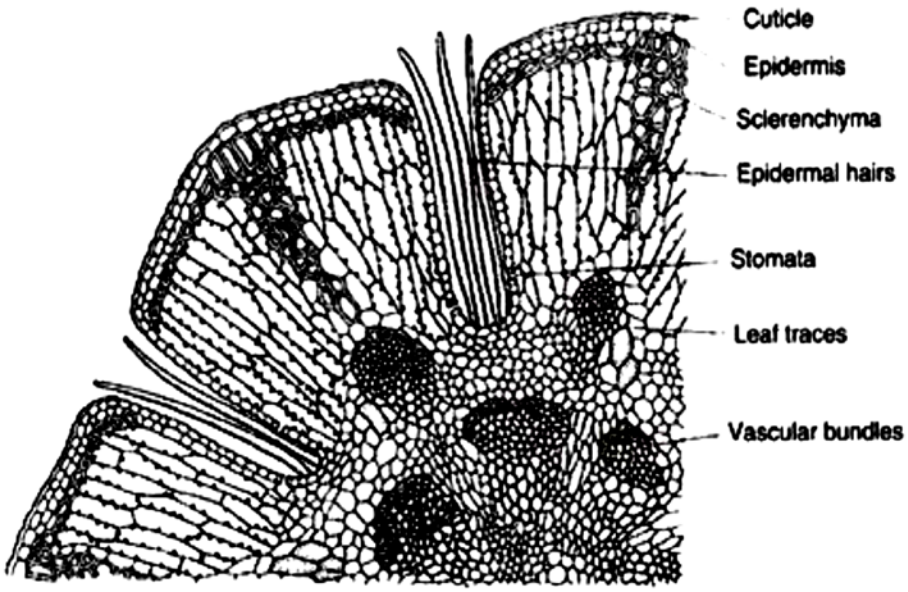


Fig 5.2 d : T.S. of *Casuarina* stem

SAQ 2

a) **Narrow and smaller leaves are common among ……**

b) **Succulents (Xerophytes) are likely to be found in ……..**

c) **In xerophytes……..type of stomata present in the grooves.**

d) **Multilayered epidermis present in……..**

5.5 SUMMARY

- **Hydrophytic adaptations**

- **Cuticle absent**
- **Absence of mechanical tissue**
- **Ground tissue parenchymatous**
- **Presence of arenchyma.**

- **Xerophytic adaptations**
  - **Presence of thick cuticle**
  - **Stomata sunken and covered with hairs.**
  - **Sclerenchymatous hypodermis.**
  - **Presence of palisade in the cortex.**
  - **Well developed vascular tissue.**

5.6 TERMINAL QUESTIONS

Long Answer Questions

Q1. What are hydrophytes? Explain their ecological adaptation.

……
……
……
……

Q2. Give a brief account of ecological adaptation in xerophytes.

……
……
……
……

Q3. What are xerophytes? Mention their morphological and anatomical features with the help of suitable diagrams.

……
……
……
……

Q4. State the morphological and Anatomical characters of hydrophytes.

Short Answer Questions

Write short notes on :

a) Heterophylly

b)* Hydrophytic adaptation in submerged rooted *Hydrilla

c) Xerophytic characters of *Nerium* leaf

d) T.S. *Casuarina* stem

5.7 ANSWERS

SAQ1. a) **Hydrophytes**

b) **Submerged hydrophytes**

c) ***Ceratophyllum***

d) ***Hydrilla***

SAQ2

a) **Xerophytes**

b) **Deserts**

c) **Sunken**

d) ***Nerium***

UNIT-6 EDAPHIC FACTORS

6.1 INTRODUCTION

An abiotic factor relating to the physical or chemical composition of the soil found in a particular area. For example, very alkaline soil may be an edaphic factor limiting the variety of plants growing in a region.

Soil is one of the most significant ecological factors, which is derived from the transformation of surface rocks. It is nothing but soil on which plants depend for their nutrients, water and mineral supply and anchorage. It constitutes an important medium wherein numerous animals live. In fact, soil of a nation is its most valuable material heritage. The importance of soil may be realized from the following statement. "The eternal truth that soil and water are the two significant capitals of mankind and the natural forests are the mother of rivers and the factories for manufacturing soil." The soil provides homes and ideal environmental conditions for living beings.

Objectives :Students will be able to,

- **Define and explain soil.**
- **Understand the composition profile of soil.**
- **Understand the effect of soil erosion.**
- **Learn how they can conserve the properties of soil.**

6.2 EDAPHIC FACTORS

The factors which relate to structure and composition of soil are called edaphic factors. Soil composition, organic matter, soil water, soil air and soil organisms are examples of edaphic factors.

Humidity, rainfall and wind velocity are climatic factors.

Examples of biotic components include animals, plants, fungi, and bacteria.

What Is Soil?

The soil is the covering of the solid crust of the earth's land mass. Soil is made up of broken down rock materials of varying degree of fineness and changed in varying degree from the parent rocks by the action of different agencies, such that the growth of vegetation made possible. Soil is derived from the Latin word solum, which means floor or ground. What a scientist calls soil, a geologist calls fragmented rock, an engineer calls earth, while an economist may call land.

There are basic concepts of the soil.

a) **According to the first concept, soil is a natural body, a biochemically weathered and synthesized product of nature. In other words, pedology considers soil as a natural entity, a biologically weathered and synthesized product of nature. Pedologists study soils which include the study of origin of the soil, classification and its description.**

b) **According to the second concept soil is considered to be natural habitat for plants and other living organisms and justifies soil studies primarily on that basis. Edaphology is the study of soil from the standpoint of higher plants. It considers the various properties of soils as they relate to plant growth and production. Thus edaphologist covers the study of soil in relation to growth, nutrition and yield of crops.**

6.3 DEFINITION OF SOIL

Generally soil refers to the loose surface of the earth as identified from the original rocks and minerals from which it is derived through weathering processes. Soil may be defined in a number of ways.

a) **Soil is a dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms.**

b) **Soil is more or less loose and crumby part of the outer earth crust in which, by means of their roots, plants may or do find foot hold and nourishment and as well as other conditions essential to their growth.**

c) **Soil is the uppermost weathered layer of the soil's earth crust; it consists of rocks that have been reduced to small fragments and have been more or less changed chemically together with the remains of the plants and animals that live on it and in it.**

d) **Soil is a natural body developed by natural forces acting on natural materials. It is usually differentiated into horizons from minerals and organic constituents of variable depth which differ from the parent material below in morphology, physical properties and constituents, chemical properties and composition and biological characteristics.**

In a generalized form soil may be defined as a accumulation of natural bodies which have been synthesized in profile form from a diversified mixture of disintegrated and weathered minerals and decaying organic matter which covers the surface of the earth, and which supplies, when containing the optimum amounts of air and water, mechanical support for plants.

6.4 COMPOSITION OF SOIL

The soil consists of four major components, i.e., mineral matter, organic matter, soil air and soil water. All these components cannot be separated with much satisfaction because they are very intimately mixed with each other. The mineral matter forms the bulk of soil solids and a very small amount of the soil solids is occupied by organic matter.

Volumetric composition of mineral (inorganic) soil is.

1. **Mineral matter (45%),** obtained by the disintegration and decomposition of rocks;
2. **Organic matter(5%),** obtained by the decay of plant residues, animal remains and microbial tissues;
3. **Water, obtained (25%),** from the atmosphere and the reactions in soil (chemical, physical and microbial);
4. **Air or gases (25%),** from atmosphere, reactions of roots, microbes and chemicals in the soil

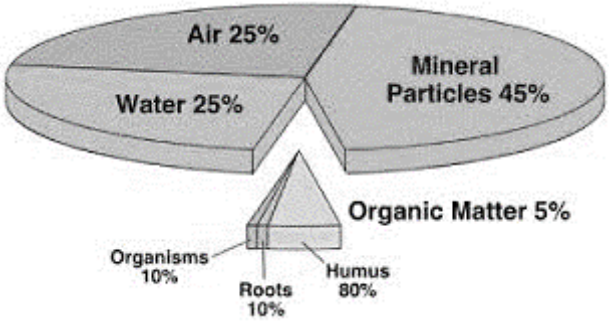


Fig. 6.1 : Composition of Soil

In fact, soil is the mixture of various inorganic and organic chemical compounds. The chief inorganic constituents of soil are the compounds of Ca, Al, Mg, Fe, Si, K and Na. Small amounts of the compounds of Mn, Cu, Zn, Co, B, I, and Fe etc are also present in the soil. Soil solution also contains complex mixtures of minerals of carbonates, sulphates, chlorides, nitrates and also the organic salts of Ca, Mg, K, Na etc. The chief organic compounds of soil is humus, which contains a large number of organic compounds such as amino acids, proteins, aromatic compounds, sugar, alcohols, fats, oils, waxes, resins, tannins, lignin, pigment, purines and many other. As a result, humus is a black coloured, homogeneous complex material.

Physically , the soil consists of stones, large pebbles, dead plant twigs, roots leaves and other parts of the plants, fine sand, silt, clay and humus-derived

from the decomposition of organic matter. In the organic matter of the portion of the soil, about 50% of the organic matter is composed of dead remains of the soil life in all stages of decomposition and the remaining 50% of the organic matter in the soil is alive. The living part of the organic matter consists of plant roots, bacteria, earthworms, algae, fungi, nematodes, actinomycetes and many other organisms including rodents and insects.

There is a three phase system in which the mineral and organic matters form the solid phase, the water containing salts and some gases in solution the liquid phase, and various gases, the gaseous phase. Each phase contains a number of constituents which make the whole system highly complex. The system is never in equilibrium, because of continuous changes taking place in the soil.

As is evident from the volume composition of the soil, the soil contains about 50% solid space (5% mineral matter + 5% organic matter) and 50 % pore space (25% soil water + 25% soil air). The portion of air and water will vary under natural conditions depending on the weather, climate and environmental factors. The four major components of the soil (Mineral matter, organic matter, water and air) exist mainly in an intimately mixed condition which encourages various reactions within and between the groups hence gives optimum conditions for the crop growth.

6.5 SOIL PROFILE

Definition

"Soil profile is defined as the vertical section of the soil from the ground surface downwards to where the soil meets the underlying rock."

The soil is arranged in layers or horizons during its formation. These layers or horizons are known as the soil profile. It is the vertical section of the soil that is exposed by a soil pit. The layers of soil can easily be identified by the soil color and size of soil particles. The different layers of soil are:Topsoil, Subsoil and Parent rock

Each layer of soil has distinct characteristics.

Soil profile helps in determining the role of the soil as well. It helps one to differentiate the given sample of soil from other soil samples based on factors like its color, texture, structure, and thickness, as well as its chemical composition.

Layers of Soil

The soil profile is composed of a series of horizons or layers of soil stacked one on top of the other. These layers or horizons are represented by letters O, A, E, C, B and R.

The O-Horizon

The O horizon is the upper layer of the topsoil which is mainly composed of organic materials such as dried leaves, grasses, dead leaves, small rocks, twigs, surface organisms, fallen trees, and other decomposed organic matter. This horizon of soil is often black brown or dark brown in color and this is mainly because of the presence of organic content.

The A-Horizon or Topsoil

This layer is rich in organic material and is known as the humus layer. This layer consists of both organic matter and other decomposed materials. The topsoil is soft and porous to hold enough air and water.

In this layer, the seed germination takes place and new roots are produced which grows into a new plant. This layer consists of microorganisms such as earthworms, fungi, bacteria, etc.

The E-Horizon

This layer is composed of nutrients leached from the O and A horizons. This layer is more common in forested areas and has lower clay content.

The B-Horizon or Subsoil

It is the subsurface horizon, present just below the topsoil and above the bedrock. It is comparatively harder and compact than topsoil. It contains less humus, soluble minerals, and organic matter. It is a site of deposition of certain minerals and metal salts such as iron oxide.

This layer holds enough water than the topsoil and is lighter brown due to the presence of clay soil. The soil of horizon-A and horizon-B is often mixed while ploughing the fields.

The C-Horizon or Saprolite

This layer is devoid of any organic matter and is made up of broken bedrock. This layer is also known as saprolite. The geological material present in this zone is cemented.

The R-Horizon

It is a compacted and cemented layer. Different types of rocks such as granite, basalt and limestone are found here.

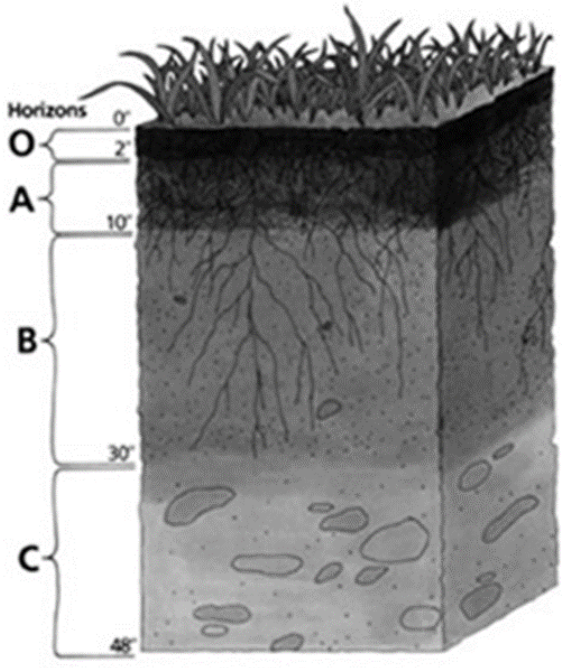


Fig. 6.2 : Soil Profile

6.6 SOIL EROSION

Definition

Soil erosion is a gradual process of movement and transport of the upper layer of soil (topsoil) by different agents – particularly water, wind, and mass movement causing its deterioration in the long term.

In other words, soil erosion is the removal of the most fertile top layer of soil through water, wind and tillage.

According to a Pereira and Muñoz-Rojas (2017) synthesis, soil erosion is one of the major causes, evidence of, and key variables used to assess and understand land degradation. Soil erosion is a consequence of unsustainable land use and other disturbances, such as fire, mining or intensive agricultural uses. The loss of soil may have serious impacts on the quantity and quality of soil ecosystem services, with serious economic, social, and political implications.

Several biotic factors aid in loosening the top soil for the action of physical agencies. Therefore, depending upon the factors involved, there are two types of erosion – geological and accelerated.

Geological or Normal Erosion – The top soil is removed by physical agencies of water or wind under normal conditions of physical, biological and hydrological equilibria. The rate of soil erosion is slow. Equilibrium is maintained between the removal of the topsoil and the formation of new soil from below through weathering. The geological or normal erosion often produces a wavy undulating surface with alternate ridges and depressions.

Accelerated Erosion – The removal of top soil occurs at a much faster rate as compared to the formation of new soil from below. It results in the permanent loss of fertile part of the soil. Accelerated erosion occurs due to both physical and biotic factors. Amongst the most important physical factors are excessive rainfall and drought. Earth-quakes and landslides also promote erosion. The biotic factors are mostly created by human interference. Pimental et al (1995) have estimated that one third of arable land of the world has been lost through soil erosion during the last forty years. The various factors and processes which accelerate erosion are as follows.

1. **Heavy Rainfall –In India heavy rainfall occurs during the monsoons. It reaches 15cm/day in many places. Mumbai can have up to 55cm of rainfall in a day while Mausynram receives up to 115 cm of rainfall/day. Heavy rainfall cannot be absorbed by normal soils. The excess rain water accumulates on the soil. It puddles the soil and fills up the soil pores, so that soil permeability is further reduced. The beating of rain drops against the wet and clogged soils loosens the soil particles from the upper part. They get suspended in water and are lost as the water flows along the depressions. On the slopes the excess rainfall is even more dangerous. As it passes along the slopes, it gathers momentum and develops a high cutting and carrying capacity. It is estimated that in India about 260,000 million tons of soil are annually displaced and dispersed in irrigation channels, reservoirs, river beds and sea.**

2. **Slope – Slope decreases soil absorption and increases run-off. As run-away water along the slope, it gathers momentum and develops a high cutting and carrying capacity so as to cause large scale erosion.**

3. **Nature of soil – Lighter, looser, sandy and gravelly soils are easily eroded by both water and wind. Heavier soils are less likely to lose top layers unless and until it is without plant cover and are continuously exposed to eroding agency.**

4. **Aridity – It is a major factor in the loss of vegetation and loosening of the top soil. According to Legris and Meher-Homji (1975) Rajasthan has suffered 5 arid phases since stone age. Each arid destroyed the previous mesophytic vegetation and laid the area bare for growth of sparse sclerophyllous vegetation and action of wind.**

5. **Overgrazing – India has a large population of grazing animals. Grazing is intense on the outskirts of villages and the edges of forests. The migratory herdsmen take the animals to mountain tops during summer and bring them to foot hills during winter. Overgrazing destroys the platable species. Trampling kills many herbs and seedlings. It also causes compaction of soil, thus decreasing its porocity and permeability.**

6. **Human Interference – It is the major biotic factor since human activity influences the rest of biosphere.**

   i) **Excessive hunting of carnivorous animals has increased the population of herbivorous animals in the forests but have also spoiled crops in the nearby villages.**

   ii) **Scraping and removing of litter from the forests floor are two human activities which lay the ground bare and expose it to agencies of erosion.**

   iii) **Lopping and felling of trees in excess of natural regeneration destroy forests structure.**

   iv) **Forests have been cleared in the past for producing agricultural land and building of new industrial and residential complexes. Forest clearing through felling and burning has been carried out since the beginning of agriculture by man. Mahabharat mentions the clearing of Khandav forest situated between Jamuna and Ganges.**

   v) **Shifting or agricultural (slash and burn method) consisted of clearing forest and sowing crops in the cleared areas for a few years. The practice is still in vogue in parts of Assam.**

   vi) **The cradles of the past civilization have turned into modern-day deserts because of over-exploitation of natural resources and irrigation channels built for obtaining water. The modern Iraq (then Mesopotamia) contains remains of several ancient canals. Two of them are the largest of all time. Indus ValleyCivilization and Sahara Civilization had well irrigated lands. However, irrigation systems could not be maintained with the change of**

political power. The system which was built up for increasing the productivity of the land, turned the same into the most unproductive area.

vii) **Faulty methods of cultivation, especially on the hills and the arid areas, accelerate the process of soil erosion.**

Fig. 6.3 : Soil Erosion

Water Erosion

It is the soil erosion caused by the agency of water. Water erosion occurs during the melting of snow and heavy rainfall which cannot be absorbed by soil. Soil cover and the slope of the area determine the degree of water erosion. In the absence of soil cover rain drops bombard the soil directly and churn up the same. After falling on the soil each rain drop bursts into several parts with each part carrying soil particles in suspension. The compaction cause by falling rain drops and the water borne soil particles clog all the soil pores. Further water absorption is stopped and water collects on the surface of soil. The collected water moves along the slope. It is called run-off. The run-off takes away the suspended the soil particles from the area and causes soil erosion. During rainy season the water of all the rivers becomes muddy on account of this. The degree of water erosion depends upon the intensity and amount of rainfall, the degree of slope and dispersion value of soil constituents. Water erosion occurs in the following forms.

1. **Sheet Erosion It occurs on the smooth and gentle slopes. The top soil is removed in thin layers or sheets. No conspicuous water channels are formed so that sheet erosion is not easily discernible. It is, however, most widespread and occurs in serious proportions on unprotected soils having 1-2% slope. Sheet erosion causes thinning of surface layers of soil. Sheet erosion causes thinning of surface layers of soil. It gives rise to areas of light color or galled spots.**

2. **Rill Erosion The runoff water has a great cutting and carrying power. Whatever it meets loose or tilled soil and an uneven area, it causes cutting of soil. The cuts initially appear in the form of finger like or**

groove-like narrow depressions called rills. The rills function as narrow water channels in which flowing water picks up more speed and higher cutting power.

3. **Gully Erosion** **Rills join to form deeper and wider channels called gullies. Formation of gully is assisted by the presence of natural depressions, field's furrows, animal trails, wheel marks of agricultural implements. These depressions provide natural pathways to rills which collect at these points and slowly cut away the bottom and sides to form wide and deeper channels. Gullies are either V- or U- shaped. Depending upon their width, they are designated as small and large. The smaller gullies are less than 1 metre in width so that they can be easily crossed on foot. The larger gullies are broader than 1 metre and, therefore, cannot be crossed easily on foot.**

   Besides loss of land to the farmers, gullies cut the fields into fragments which cannot be ploughed or harvested together. Continuous passage of water through the gullies cuts the soft bottom and sides to form larger and deeper water channels called ravines. The ravines may be 15-30m deep. They bring down large quantities of water during rainy season and cause floods in the plains.

4. **Water Fall Erosion** **Water falling from a height cuts down its base as well as the area of impact. In the latter region it may produce a big hole if the substratum is loose or spread the water in large area if the substratum is hard. This produces an extensive and severe damage to the soil. Base cutting by the falling water ultimately produces a smooth and deep gully or ravine.**

5. **Landslide or Slip Erosion** **Water passing down a slope may perlocate into the crevices of rocks created by alternate heating and cooling or freezing and thawing. Water may produce holes if the soil is soft. The sifting water loosens the rock masses, which slip downward along the slope. The rock masses are also loosened by the rapidly flowing water impinging upon the bases of the boulders.**

6. **Riparian Erosion** **The soil particles brought by the running or river water from the hills are deposited in the plants when the speed of the water slows down. The process of deposition of fine soil particles brought by running water is called siltation. It occurs at the river beds, flood plains and deltas. Siltation of the beds makes the river shallow. During rains the shallow rivers get flooded and cause extensive damage.**

7. **Ice erosion** **Glaciers and other masses of ice formed on the hill tops slide down during the summer. During their downhill journey, the ice mass rolls large rock pieces and skims away the top or fertile soil from the slopes. The melting of ice and snow adds to the rain water running down the slope.**

8. **Wave Erosion** **Lake and ocean shores are exposed to continuous striking of water waves. The water of these otherwise stationary reservoirs invariably remains in the turbulent condition by air currents and certain celestial phenomena. Due to continuous striking of water**

waves the shores are eroded. The rate of erosion is dependent upon the type of rocky matter constituting the bank or shore-line.

Wind Erosion

It is the removal of top fertile soil through the agency of wind. Wind erosion occurs in arid areas and along the sandy shores of sea or river and lake banks. The soil exposed to wind erosion must be dry and uncovered. Soil particles move by three methods.

1. **Suspension – The fine soil particles, less than the size of 1mm, get suspended in wind. They are carried as dust. The dust storms contain these particles in large number. They are deposited several kilometers away when the wind velocity decreases.**

2. **Saltation – It occurs in case of particles having a size of 1.0 – 1.5 mm. The particles are forced to roll along the ground for some distance and then suddenly kicked up into the air by the force of wind. However, because of their weight they cannot remain in suspension for long. After about a height of 30cm the particles fall back to the ground into an almost straight line. On striking the ground these particles may rebound and undergo another saltation or sink to the surface.**

3. **Surface Creep – This occurs in case of heavier particles usually of the size of 5-10mm. They cannot be easily removed from the ground by the pressure of the wind. Instead they pushed along the ground by the striking of the smaller particles. Surface creep is, therefore, an indirect movement.**

Wind removes away the fine particles from the exposed soils. Only coarser particles of the size of sand remains behind. The process of wind erosion, therefore, makes the soil sandy. The sandy soil is neither chemically fertile nor capable of retaining water. It, therefore, becomes highly unstable and liable to shift with the movement of wind. This gives rise to sand dunes which are even more unstable because velocity of wind increases with the height from the ground level. It is about 2 and 1/2 times as great at height of 1 m as compared to 2 cm above the surface.

Removal of top soil from an area exposes the root systems of the plants growing in that soil. They undergo desiccation and get killed. Many plants get buried inside sand dunes. On settling, wind borne sand particles damage irrigation channels, ponds, lakes, roads, buildings and fertile soil. Wind borne particles have an abrasive action in destroying vegetation and loosening the surface crust of the soil. The deposition of sand particles on a fertile soil makes the latter barren as well. In this way deserts spread in the direction of wind. It is believed that the desert of Rajasthan is growing at rate of 1km/year.

Effects of Soil Erosion:

1. **Loss Of Soil Fertility – Soil erosion causes the removal of top fertile layers of soil. The underlying layers which are exposed after erosion are less fertile with little biological activity. Vegetation cover of the soil is reduced.**

2. **Siltation – Soil particles carried by river water are deposited in the plains. Siltation over the river beds makes them shallow and liable to change course. Siltation over the flood plain on the river banks destroys crop land. Siltation at the bottom of water reservoirs and dams reduces storage capacity and generation of hydroelectric power.**

3. **Loss of Forest Vegetation – Erosion on the hill slopes destroys the forest vegetation of the mountains and foot hills. It brings about shortage of forest products including timber and fire wood.**

4. **Destruction of Wildlife –With the loss of forest vegetation caused by soil erosion, the wildlife of the area also gets destroyed.**

5. **Cattle feed supply of grasses and other palatable plants are reduced. This cause overgrazing in the adjacent fertile area and hence spread of soil erosion. Deficiency of cattle feed deteriorates cattle wealth, reduces supply of milk and meat.**

6. **Rainfall, soil erosion and hence loss of vegetation cover reduces periodicity as well total rainfall of the area.**

7. **Catchment areas are the source of perennial water supply to the rivers. They usually occur in the mountains and derive water from two sources, rains and melting of snow. In the presence of forest vegetation both accumulation of rain water and melting of snow are prolonged so that catchment areas receive water for longer periods. In the absence of nearby forest cover, they get water for shorter periods.**

8. **Climatic change – Vegetation has a blanketing effect on loss of humidity and temperature changes during day or night, summer and winter. The summers are less hot and winters are warmer when soil is covered with vegetation. The erosion of soil brings about the loss of vegetation cover and hence its moderating effect on climate.**

9. **Flash Floods – Rain is normally intercepted by vegetation cover and allowed to slowly percolate in the soil. The latter after passing through the deeper layers give rise to perennial springs and other sources of water. In the absence of vegetation there is no such absorption of water by the soil. The rain water rapidly passes along the slopes and gives rise to several rivulets and chaos. The rivulets produce flash floods in the plains. Other rivers also become flooded during the rainy season. Such floods play havoc with human and animal life. They destroy thousands of buildings, roads, railway lines, electrical and telecommunication systems besides submerging and killing crops over large areas.**

10. **Famine – Soil erosion leads to reduced productivity of the land, reduced water availability for irrigational purposes and reduced hydroelectric power during dry periods of the year. When the seasonal rail fails, there is little water and other inputs available for supporting crops. Hence famine overtakes the area.**

11. **Spread of Desert – The sand particles picked up by wind from a desert area deposited over the adjacent crop lands, ponds, lakes and irrigation channels. Vegetation gets killed through abrasion and suffocation while**

the soil becomes sterile. The filling up of water reservoirs and channels further increases aridity and gives rise to desert conditions.

6.7 SOIL CONSERVATION

Soil conservation is the maintenance of soil fertility through such measures as checking of soil erosion (from water and wind), protection against fire, waste and misuse, planning judicious use, improving soil aeration, soil moisture and soil fertility through biodegradable cycles and fertilizers. Soil conservation is supervised in India by a central Soil Conservation Board which has 9 research centers spread over the country – Dehradun, Kota, Ootacamund, Bellary, Vasad, Agra, Chandigarh, Jodhpur and Chakotra.

Control of Water Erosion

There are two types of methods employed to control water erosion – biological and mechanical.

1. **Biological Methods –**

   They are meant for keeping the soil under cover for maximum period of time. Soil cover, especially that of living plants, decreases water erosion. Erosion becomes negligible under continuous plant cover.

   Biological methods are of two types – Agronomic and agrostological.

A. **Agronomic Methods**

   a) **Addition of fertilizers – Density of plant growth is dependent upon the fertility, hydration and aeration of the soil. When any of them is deficient, plant growth becomes poor and the soil becomes exposed to eroding agencies. Soil fertility is maintained by the addition of manure and fertilizers. Manure improves both aeration and hydration besides serving as a reservoir of mineral nutrients. Presence of manure decreases runoff.**

   b) **Crop Rotation – It is the practice of growing different crop plants in successive years on the same piece of land. It is highly useful because**

      i) **It decreases the incidence of soil borne diseases.**

      ii) **Avoids autopathy.**

      iii) **Removal of minerals from different levels by different crops avoids excessive depletion of minerals at one level.**

      iv) **Maintenance of soil porocity in case of plants having shallow but highly branched root systems.**

      v) **Maintenance of nitrogen fertility of soil when legume crop is rotated with others. Some of the legumes like alfalfa and clover are deep rooted. They keep the sub soil open and prevent the formation of impermeable clay pans in the soil. The legumes, however cause depletion of phosphorous**

content of the soil. Such soils, therefore require addition of phosphate fertilizers.

c) **Mixed Cropping – It is a variant of crop rotation. Two or more crops are grown simultaneously on the same piece of land, e.g., Millets, Black Gram and Pigeon Pea. The method avoids the risk of crop failure, provides a better use of soil fertility and checks soil erosion.**

d) **Mulching – Soil is allowed to remain untilled. It is covered with grasses, straw, leaves, crop residue and other forms of plant litter. Mulching retains soil moisture, decreases run-off, increases soil infiltration, provides thermal insulation, reduces the incidence of weeds, stimulates growth of soil fauna and flora and increases humification. The covered soil does not come in direct contact with the agencies of erosion.**

e) **Fallowing – It is a method which was employed in old times to improve soil fertility and prevent soil erosion. After harvesting of a crop, the land is left untilled for one or more seasons. During the period of fallowing, grasses and herbs come to grow on the soil. Animals are allowed to graze on the land. Their excreta, and organic matter of the previous crop plus the new plant growth will stimulate humus formation and mineral recovery through cycles. The practice is not possible in modern-day India where the pressure on land is already severe.**

f) **Tillage – Tilling the land is useful for removing weeds and improving the soil permeability. It is, however, harmful in dry areas where ploughing makes the soil dry, loose and powdery so that it is exposed to wind action. In such areas only shallow followed immediately by watering can be employed. In humid areas deep ploughing (15-30 cm) is good for increasing soil aeration and water infiltration besides being effective in removing weeds.**

g) **Contour Farming – Contour farming or contour planting is performed on the slopes. The land is ploughed at right angles to the direction of the slope. It produces circular furrows and ridges around the slope. The ridges slow down the speed of running water while furrows hold water to increase absorption. The growth of plants in circular rows provides rigidity to the ridges and prevents soil erosion. It saves water for the crops and thus increases their yield.**

h) **Strip Cropping – It is of several types. Strip cropping is generally practiced on slopes where the angle of slope is about 15 degree. In permanent buffer strip cropping the slopes are covered with plantations of perennial legumes and grasses. In some areas strip cropping involves the sowing of perennials like alfalfa and clover alternating with rowed or broadcast annuals like corn and potato. In another technique annuals with different seasons of sowing and harvesting are alternated. A common practice is to alternate**

sowing of clean tilled or rowed crop (e.g., Potato, Cotton) with broadcast or dense growing crop (e.g., Trifolium, Wheat).

B. Agrostological Methods –

a) Retiring the Land – The land is taken out of cultivation on a permanent basis in areas subjected to heavy erosion, especially on the sloping mountains. The land is ploughed in hot weather rains and sown with grass seeds. Perennial legumes (e.g., Alfalfa, Clover) may also be mixed up with grass seeds. They improve the nitrogen fertility of the soil. Grazing is not allowed in the first year. Controlled grazing is permitted after soil erosion has stopped and the soil becomes stabilized. Several grasses have been found suitable for checking soil erosion in the Nilgiri hills, e.g., *Eragrostisamabitis.*

b) Ley Farming – Grasses are sown either in rotation or along with agricultural crops like Jowarand Gingelly. Grasses prevent soil erosion. They also improve soil permeability.

c) Controlled Grazing – The size of population of grazing animals should not be more than the supporting capacity of the land. Therefore, forest grazing should be allowed only on the basis of grazing permits for a particular number of animals (Stock level management). The grazing land is divided into two or more compartments. They are opened to grazing in successive years. In the season of growth of new herbs (e.g., spring) the grazing is reduced to minimum or completely stopped. It is allowed only after herbage has got itself established.

d) Afforestation and Reforestation – Afforestation is the formation of forests where no forests existed previously because of geological, climatological or political reasons. Reforestation is the replantation of forests which have been previously destroyed by felling, fire or over-grazing.

Destruction of forests or deforestation in hilly areas is accompanied by reduced frequency of rainfall, increased and quicker melting of snow, formation of swift and temporary rivulets in rainy season, production of chaos due to cutting of land by rivulets, occurrence of floods and damage to agriculture.

Afforestation and reforestation have been tried in the past as well. Emperor Ashoka got a number of trees planted along the highways. Coronation of kings was celebrated by planting saplings of useful trees. Since 1950, our country has launched a tree plantation movement called Van Mahotsava. Under this movement new trees are planted throughout the country twice a year in February and July. Plantation of trees in the plains reduces the pressure on the hill forests for obtaining fuel, timber and paper pulp. It also reduces the incidence of dust and electric storms. High water table of certain areas can be lowered by

planting quick growing trees. Tree growth is also helpful in reducing alkalinity and salinity of soils.

Afforestation of hills is highly useful since it prevents soil erosion because :

i) Soil becomes porous and permeable due to in situ decay of roots.

ii) Accumulation of organic matter on the soil surface increases its water holding capacity.

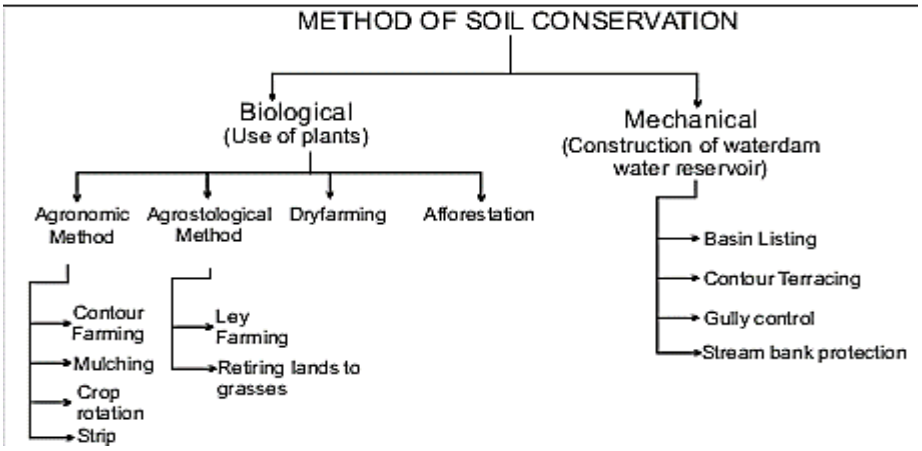
iii) Plant cover protects the soil from the direct beating by rain drops.

iv) Roots hold the soil firmly.

v) Melting of snow is slowed down and delayed by upto three weeks if the hills have a dense growth of trees and bushes.

vi) Catchment areas are slow to get filled. It reduces the chances of floods and provides perennial supply of water to the rivers.

Already success has been achieved in preventing soil erosion in some parts of India through afforestation and reforestation. For eg.Baramulla and Sankaracharya hills of Kashmir have been successfully protected through mixed planting of conifers and broad leaved species. The area to be afforested is often divided into compartments. Water and soil conditions are made favourableif they are not already there. Sometimes soil has to be transported to these areas if denudation has gone very far. Ditches are prepared for retaining rain water. Only those plants are selected which shall form dominated growth according to the climate of the area. The trees are initially planted close together at a distance of 1 m to provide quick protection to the soil and as an insurance against mortality. As the trees become taller, the slow growing plants are removed.



2. Mechanical Methods

They are engineering or mechanical methods which help in increasing water retentivity of soil, decrease the velocity of run-off and prevent soil erosion.

i. Basin Listing – A number of small furrows or basins are made along the slope or contour by means of implement called basin

blister. The basins hold water and snow and stabilize downwardly moving soil on the slopes. The basins can be used for growth of crops.

ii. **Pan Breaking (Subsoiling) – The drainage of the soil is damaged by the formation of impermeable pans of clay and other inorganic materials in the subsoil. The pans are broken at intervals by means of implement called pan breaker or sub-soiler. It improves drainage, soil permeability, prevents residual run-off and, therefore, erosion.**

iii. **Levelling – Small gullies, grooves and undulations falling in the path of the slope increase the incidence of soil erosion. The depressions are filled up and the ground is leveled. Bunds are raised along the margins of leveled areas to increase water absorption and prevent erosion.**

iv. **Terraces – A slope is divided into a number of small flat fields called terraces. Because of their step-like appearance, they are also called bench terraces. The terraces slow down the velocity of run-off by decreasing the degree of slope and acting as velocity breakers. The terraces are slightly raised towards the free end to further decrease the speed of water. Their edges are raised or bunded to about 30 cm height to decrease soil erosion and prevent quick downward flow of water. Rather broad and shallow channels are built to conduct the flowing water slowly to a stabilized outlet. Building of terraces is, however, a costly process.**

v. **Channel Terracing – Shallow but wide horizontal channels are built along the contour. The excavated soil is used to build small ridges on the lower edges of the channels. The water channels are stabilized by growth of grasses.**

vi. **Ridge Terracing – Where terraces cannot be built, small ridges are constructed at a distance of 1-2 m throughout the slope along its contour. Along with channel terracing, ridge terracing is useful for retaining moisture and prevention of soil erosion.**

vii. **Contour Bunding – On the edges of the fields small bunds are built up to check sheet erosion. The bunds also help in retaining water for longer period over the fields. Such bunds are built up in the direction of slope. They function as ridges and check the velocity of flowing water besides preventing soil erosion.**

viii. **Contour Trenching –A series of small shallow pits or trenches are dug up across the slope at small distances. The excavated soil is deposited at the lower edge of the trench. The trenches hold water and keep the adjacent soil of the ridges moist. Seeds of useful trees are sown on the ridges for building a suitable forest on the slope.**

ix. **Gully and Ravine Control (Check Dams) – The gullies are filled up with brush and stone dams. Stones or wooden logs are placed at the bottom of the gully or ravine. They are fixed in their places**

by knots of wire. Layers of straw may be laid in between the layers of wooden poles or stones. The logs are usually forked on one end to provide proper fixation. The sides of the gullies are similarly protected. The check dams reduce the rapidity of water flow and are slowly filled up with the deposition of silt.

Earth cutting is prevented by diversion trenches. Soil erosion from the sides of gullies and ravines is checked by growth of grasses and other vegetation.

x. **Ponding – In terrains where rain does not occur for sufficient period to sustain agriculture or forestry, ponds are build up in the path of rain water rivulets. The ponds provide irrigation water during dry periods. The silt accompanying the rain water also builds up soil over the fields covering rocky substrata.**

xi. **Dams – They are large upstream water reservoirs built out of the excess water that flows a large stream during the rainy season. The dams provide perennial supply of irrigation water besides generating electricity because they are built in areas where there is a natural fall. Dams are an insurance against flood loss. They however, do not prevent erosion in the uphill's. Rather if afforestation is not practiced upstream the dams may become useless after sometime due to siltation.**

xii. **Bank Protection – Stone and brushwood spurs are built up to keep water flow in a particular area. Bends are straightened as far as possible or are strengthened with concrete. The banks are stabilized by the growth of several types of grasses, legumes, vines, shrubs and trees.**

Control of Wind Erosion

Wind erosion occurs on sandy sea shores, sandy river banks and arid areas. In Indian Sub-continent maximum wind erosion is found in Thar desertwhich covers Rann of Kutch in Gujarat, Rajasthan, parts of Haryana, Punjab and U.P. bordering Rajasthan and Sind province of Pakistan. Coastal sands occur in Sunderbans, Nellore, Vellore, Karwar, Alibagh and Saurashtra region. River sandy tracts or bhur areas occur near the banks of several rivers. All of them are prone to wind erosion. Wind erosion can be controlled by the following methods.

1. **Fields Bunds – Chepil (1949) has found that 92% of soil movement occurs below the height of 30cm. More than 50% of it takes place below the height of only 5 cm. Therefore, most of the soil particle movement like surface creep and saltation is prevented by constructing ridges or bunds at the boundaries of the fields. They should be at right angles to the prevailing wind.**

2. **Furrows – The soil is ploughed at right angles to the direction of the prevailing wind. The crops are planted in rows in the furrows. The crops reduce the velocity of the wind. The particles shifted from the ridges by wind action fall down in the furrows. The furrows also increase absorption of rain water.**

3. **Ploughing and Irrigation – The pulverished or freshly ploughed fields are not allowed to remain as such since they are an ideal source for wind movement of soil particles. The fields are irrigated immediately after ploughing.**

4. **Stubbles – After the harvesting of crops, the stubbles and other plant residue is left in the fields. A 10.5 m strip of stubble is able to trap upto 79% of particle movement caused by a wind velocity of 40km/hr.**

5. **Strip Cropping – Strip cropping is resorted to prevent wind erosion. Two different crops having different seeding and harvesting periods are sown in adjacent strips.**

6. **Sand Binding Plants – Sand binding plants are grown in sandy areas. The coastal sands are protected from wind action by the growth of sand binding and salt tolerant grasses (e.g., *Spinifexlitoreus, Saccharum spontaneum* and *Arsitidapennata*) along with other plants (e.g., *Ipomoea pescapre, Portulaca oleracea, Indigofera cordifoliaetc*). Similar plants for inlands include grasses (*Capparis decidua*, *Calotropis procera, Zizyphus nummularia*).**

7. **Pastures development of Grassland or pastures for the grazing of cattle and stabilizing of soil.**

8. **Dry Farming – Where irrigation is not assured, drought enduring crops are selected for sowing according to the season and climate of the area. Bunding and other methods for preventing the loss of water are adapted. The technique is called dry Farming.**

9. **Irrigation – Fresh water is made available from deep tube wells or irrigation channels. The saline ground water should not be used for irrigation. Rajasthan canal is being built to help bloom the Thardesert, our future land bank.**

10. **Ponding –Wherever suitable rocky or impermeable beds are present, ponds or lakes are built up to store rain water. The same is utilized during the dry season for meeting agricultural and human requirements.**

11. **Mulching – The harvested field is covered with plant residue in order to retain moisture, provide thermal insulation and soil erosion.**

12. **Trees – Wherever slight moisture is available, drought enduring and economically useful trees are grown. They reduce wind action and protect the soil from greater evaporation and overheating during the day time. *Acacia modesta, Populus, Eucalyptus and Mulberry* have been found to be highly successful in Haryana. Other trees which can be grown in arid areas include *Robinia pseudo-acacia, Tamarix, Casuarina, Prosopis, Albizzia* etc.**

13. **Wind Breaks and Shelter Belts –The spread of the desert and the removal of soil particles by wind action can be prevented by growing trees in rows. They are called wind breaks. Trees are planted alongwith shrubs in 1-10 rows at right angles to the direction of wind. The trees**

planted in 1-2 rows are closely spaced while the distance between adjacent trees and rows is increased in multiple row belts. In the latter case the trees of adjacent rows are alternated.

The important trees and shrubs used in dry areas as winds breaks are *Acacia, Prosopis, Dalbergia, Mangifera, Tamarindus, Zizyphus, Thevetia, Lawsonia, Calotropis, Agave, Calligonum, Erianthus, Leptadenia, Balanites,* etc. shrubs are planted on the windward side while tress are grown on the leeward wide. Another method of checking wind erosion is the development of shelter belts. A shelter belt consists of extensive growth of trees over wide belts along water channels, on the banks of water reservoirs, etc.

Wind breaks and shelter belts perform a number of functions:

i. **Reducing wind velocity and hence damage by lodging, breakage and abrasion.**

ii. **Prevention of soil erosion.**

iii. **Reduction in the movement of soil particles, and hence spread of desert conditions.**

iv. **Reduction in the excessive heating up or cooling down of soil.**

v. **Retention of soil mixture. Wind breaks have, however, a shading effect on nearby crop plants. They also reduce the availability of minerals and water to them. Therefore, near wind breaks shade tolerant plants should be grown. Deep ploughing is also useful for decreasing weed and root growth in superficial layers of the soil.**

6.8 SUMMARY

- **The factors which relate to structure and composition of soil are called edaphic factors. Soil composition, organic matter, soil water, soil air and soil organisms are examples of edaphic factors.**
- **The edaphic factor includes the physical, chemical, and biological properties of soil that result from biologic and geologic phenomena or anthropogenic activities.**
- **Instruct students to record the four components of soil and the basic characteristics of soil texture in their guided notes. The four components of soil include: mineral matter 45%, organic matter 5%, air 25%, and water 25%.**
- **A soil profile is a vertical section divided into layers called horizons. The A horizon is where there is most soil life and is sometimes called topsoil.**
  Soil erosion is a naturally occurring process that affects all landforms. In agriculture, soil erosion refers to the wearing away of a field's topsoil by the natural physical forces of water and wind or through forces associated with farming activities such as tillage.

- **Soil Conservation is a combination of practices used to protect the soil from degradation. ... This means returning organic matter to the soil on a continual basis.**
- **Soil conservation improved soil quality and productivity. Reduced erosion. Increased water infiltration and storage. Improved air and water quality.**

6.9 TERMINAL QUESTIONS

Q.1: What is the profile of soil?

Q.2: Why is soil profile important?

Q.3: What is soil erosion?

Q.4: What causes soil erosion?

Q.5: What is the effect of soil erosion?

Q.6: What are the types of soil erosion?

Q.7: What is meant by soil conservation?

Q.8: What are methods of soil conservation?

Q.9: Why is soil conservation important?

Q.10: What is soil composition and properties?

Multiple Choice Question :

Q.1 Edaphic factors are related to-

a) Humidity

b) Soil texture

c) Rain fall

d) Wind velocity

Q.2 What is the original source of energy for nearly all living organisms on earth?

a) Soil

b) Sun

c) Water

d) Plants

Q.3 Development of soil from parent rock is termed as:

a) **Edaphic factor**

b) **Pedogenesis**

c) **Edaphotropism**

d) **Edaphic clim**

Q.4 The plants growing on saline soils are called:

a) **Heliophytes**

b) **Xerophytes**

c) **Halophytes**

d) **Hydrophytesax**

Q.5 Water holding capacity is highest in

a) **Clayey soilb) Loamy soil**

c) **Silty soil**

c) **Sandy soil**

Q.6 Plants growing in loose non-saline soil are:

a) **Xerophytes**

b) **Halophytes**

c) **Mesophytes**

d) **Lithophytes**

Q.7 Water available to plant is

a) **Run off wate**

b) **Gravitational water**

c) **Hygroscopic water**

d) **Capillary water**

Q.8 Water logging occurs

a) **In sandy soil**

b) **On gravels**

c) In loamy soil

d) In clay soil

Q.9 The soils that are fully laden with water i.e., water logged, are known are:

a) Physically dry soils

b) Physiologically dry soils

c) Alkaline soils

d) Acidic soils

Q.10 Soil is a complex mixture of

a) Soil biota

b) Eroded rock

c) Gases and water

d) All of the above

Q.11 Deforestation causes

a) Soil erosion

b) Pollution

c) No floods

d) None of these

Q.12 Soil conservation means

a) Prevention of spread of desert

b) To check soil erosion by wind and rains

c) To check soil erosion by afforestation

d) All of these

Q.13 Soil erosion is prevented by

a) Afforestation

b) Deforestation

c) Denudation

d) Overgrazing

Q.14 If the top soil has been eroded, we retire a land and grow over it

a) Lichens

b) Blue-green algae

c) Legumes

d) Grasses

6.10 ANSWERS

1) b 2) b 3) b 4) c 5) a 6) c 7) d

8) d 9) b 10) d 11) a 12) d 13) a 14) d

UNIT-7 PHYTOGEOGRAPHY

7.1 INTRODUCTION

Phytogeography (from Greekword, Phyton = "Plant" and geographia = "geography" meaning also distribution) is the branch of botany that deals with the geographical distribution of plants on earth. As it is concerned with the geographical distribution of plant therefore, also known as botanical geography. It explains the distribution of plants in past, the evaluation of present day's plants from the past flora and the pattern of distribution of present day plants. It includes two aspects of study about the distribution of plants. One is the descriptive approach and the other is interpretive approach. The descriptive approach is known as descriptive phytogeography whereas, the interpretive approach is known as interpretive phytogeography. The descriptive phytogeography deals with the pattern of distribution of present day plants. The interpretive phytogeography analyses about the actual causes, methods and conditions of the distribution of plants in the world.

There are aquatic as well as terrestrial plant communities. The Aquatic plant communities occur in water. The terrestrial plant communities occur in soil. The soil is mixture of rock debris and organic materials, which develop on the earth surface. The major factors that determines soil characteristics are parent material, climate, relief, vegetation, time and some other life forms. The major constituents of the soil are mineral particles, humus, water and air. This soil is very important and valuable resource for geographical distribution of terrestrial plants on earth. Besides soil climate of that region is another important factor which, also affects the phytogeography and vegetation.

Objectives :

After studying this unit you will be able to :

- **Know the major plant communities of world.**
- **Know the soil of India.**

- **Know the climatic regions of India.**
- **Know the vegetation of India.**

7.2 MAJOR PLANT COMMUNITIES OF WORLD

On the basis of habitat and environmental conditions, the major plant communities of the world are classified into following two types:

I- Aquatic communities

II- Terrestrial Communities

I- Aquatic Communities:

Majority of earth surface is occupied by aquatic environment. The aquatic environment may be fresh water, marine water or estuarine. These environment have different types of plant communities, which are as follows:

(i) Fresh water communities

(ii) Marine communities

(iii) Estuarine communities

(i) Fresh water communities: This community occurs in fresh water habitats which covers hardly one precent of the earth's surface. The habitats may be lentic or lotic. Lentic habitat includes standing water such as lake, pond, swamp and bog. Lotic habitat includes running water such as river, spring, stream etc. The main fresh water communities are seed plants and phytoplanktons (floating green plant).

The seed plants may be submerged, floating and emergent type. The phytoplaktons include diatoms, desmids, greenalgae, blue green algae, protozoa and green flagellates.

(ii) Marine Communities: Marine water covers 3/4 of the earth surface. It includes water of seas and oceans. The marine biome is made up of salt water regions and includes estuaries, coral reefs, shores and the open ocean. Life in marine communities is just as diverse as life in terrestrial communities. The organisms that live in marine communities must be adapted to live and survive under a wide variety of conditions.

(iii) Estuarine Communities: This community occurs in estuarine. It is transition zone between fresh water and marine habitats. This zone has strong influence of tidal actions and has macrophytes such as sea weeds, sea grasses, marsh grasses as plant communities. Benthic microphytes and some phytoplanktons also occur as estuarine communities.

II- Terrestrial Communities:

Terrestrial communities are recognised as biomes as they are large unit or major life zone. The life form of the climatic climax vegetation is uniform in biome. Followings are the major biomes of the world:

1. **Tundra : Tundra biome covers large areas of the arctic zone. There are two tundra biomes. One biome is in the pale arctic region while other in the nearctic region. Many species are common in both the regions. The vegetation consist of dwarf treeless communities live grasses, sedges, mosses and lichens. The ground remains frozen except for the upper few inches during the open season.**

2. **Moist temperate coniferous forest biomes: This biomes occur along the west coast of North America from central California to Alaska. The vegetation is dominated by conifers which are different from northern coniferous forest. This difference is ecological and in their floristic composition. *Tsuga heterophylla, Thuja plicata, Abies grandis* and *Pseudotsuga* are the major dominant trees.**

3. **Northern Coniferous forest biomes : This biomes have thick belts of evergreen forest across both North America and Eurasia. The main evergreen trees are spruces, firs and pines.**

4. **Temperate deciduous forest biomes: This biome covers eastern north America, all of Europe, Part of Japan, Australia and tips of South America. The dominant trees of this biomes are beech, maple, Oak, chestnut etc. Herbs and shrubs are well developed in layers. Plant producing pulpy fruits and nuts are common. Conifers mainly pines are also present in subclimax states.**

5. **Broad leaved evergreen subtropical forest biomes : This biomes occur in central and Southern Japan, Florida, along the Gulf and South Atlantic coasts in the warm-temperate marine climate. In these areas the moisture is high with less difference in summer and winter temperature. The dominant plants of evergreen subtropical forest are *Quercus virginiana*, *Magnolias*, *Bays*, *Hallies*, *Ficus, Lysilkoma* and *Bursera*.**

6. **Temperate grass-lands biomes: This biome covers large areas of the earth. The rainfall in this biome is very low (10"-30") therefore, forest life forms are not supportive but higher than that of disserts. These grasslands generally occur in the interior of continents. In north America, this biome is divided into east and west zones. The vegetation consists of tall grasses, mid grasses and short grasses. The dominant species are *Andropogon gerardi, Panicum virgatum, Spartina pectinata* (tall grasses), *Stipa spartea, Sporobolus heterolepis, Oryzopsis* (mid grasses) and *Buchloe dactyloides, Bouteloua graciles, Poa, Bromus* sp (short grasses).**

7. **Desert biomes : The desert biomes occur in the region where rainfall is less than 10". Sometimes it may also occur in the regions of greater rainfall that is very unevenly distributed. They occur in**

Sahara, Australia, Western north America, Tibet, Bolivia and Gobi. The plants like annuals, succulents and desert shrubs are found in this desert. Besides these mosses, algae and lichens may be present on bare ground. Some blue-green algae may also occur on sand.

8. **Tropical savanna biomes: The tropical savanna biomes occur in warm regions where rain fall is 40"-60". The dry season is prolonged with common fires. It is found in Africa, South America and Australia. The vegetation has less number of trees. *Panicum, Pennisetum, Andropogon* and *Imperata* are dominant grasses. Species of Adansonia, arborescent euphorbias and palms are trees of savanna biomes.**

9. **Chaparral biomes : This biome is present in mild temperate region with adundant winter rainfall and dry summers. Such communities are common in California, Maxico and southern coast of Australia. The climax vegetation consists of trees or shrubs with hard, thick evergreen leaves. *Adenostroma* and *Arctostaphylos* are common shrubs in California where as, *Eucalyptus* are dominant in *Australia.***

10. **Pinon-Juniper biomes : These woodlands occupy large area in Colorado, Utah, Arizona, New Mexico, Nevada and west central California. It has species of *Pinus* and *Juniperus.***

11. **Tropical rainforest biomes: It occupies zones near the equator. The annual rainfall exceeds 80" or 90" over the year with one or more relatively dry seasons. Such forests occur in three main areas.**

    (i) **The Amazon and Orinoco basin in South America and the Central American Isthmus.**

    (ii) **Nigar, Congo and Zambezi basins of central and Western Africa and Madagascar.**

    (iii) **The indo-Malay-Borneo-New Guinea region.**

12. **Tropical scrub and deciduous forest biomes : They cover large areas of thorn forest type vegetation in Africa, Australia and Brazil.**

SAQ 1.

(a) **.....water covers 3/4 of the earth surface.**

(b) **.....is a transition zone between fresh water and marine habitats.**

(c) **Tundra biome covers large areas of.....**

(d) **The desert biomes occur in the region where rainfall is less than.....**

(e) **Tropical rain forest biomes occupy zones near the.....**

7.3 SOIL OF INDIA

In the different parts of India soil differ from each other. On the basis of their nature and composition, soils of India are classified into six major types:

(i) Alluvial soil

(ii) Black soil

(iii) Desert soil

(iv) Red soil and Yellow soil

(v) Skeletal soil

(vi) Laterite soil

(i) Alluvial soil : This type of soil is alkaline or neutral occurs in Indo-Gangetic plain. In the plains it cover the states of Punjab, Haryana (in north west), U.P., Bihar (in the north), Bengal, parts of Meghalaya and Orrisa. Besides plains this soil also occurs in the east coast deltas and terrace, deltic and lagoon alluvium of Peninsular India. In Punjab and western Ganga plains, the soil is rich in loams and clay components. In the central Ganga plains, the loam component increases and sand decreases. In the plains of Ganga-Brahmputra region. The soil has very fine particles varying from loams to very fine silt clay.

(ii) Black soil : This type of soil is common in Deccan region of India. It covers Maharashtra, Mysore, Madhya Pradesh and Krishna-Tungabhadra basin of Tamilnadu. In the western part, the soil is black whereas in the eastern part it is light black type. Black soils are predominantly clay, with patches of clay loams, loams and sand loams.

(iii) Desert soil/Arid soil : This type of soil covers large part of Rajasthan and the semi-desert areas of the Rann of Kutch.

(iv) Red soil and Yellow soil : This soil covers large area in south and in the north-east of the Peninsula. Such soil occurs in Andhra Pradesh, Tamilnadu, parts of Bihar, Orrisa, Uttar Pradesh and West Bengal. The colour of soil is red due to high proportion of iron. Texture of soil is mainly sandy to loam.

(v) Skeletal soil : This soil occurs in north-western hills or the Aravallis, where it is stony sandy hill foot fans and slope colluvium. In the humid south, east of the Himalayas and in Meghalaya, the texture of soil is more clayey.

(vi) Laterite soil : This soil is present in the western Ghats, northern half of the eastern Ghats, eastern margins of Chota Nagur plateu, Meghalaya, few patches around Kathiawar, two areas in the centre of the peninsula north of Bangalore and west of Hydrabad. Laterite soil is porous clay rich in hydroxides of aluminium and iron. This soil is suitable for cultivation of paddy at low elevations. It also favours the growth of

coffee, tea, rubber and Cinchona at higher elevations. This soil is widely used to make bricks. (Fig. 7.1)

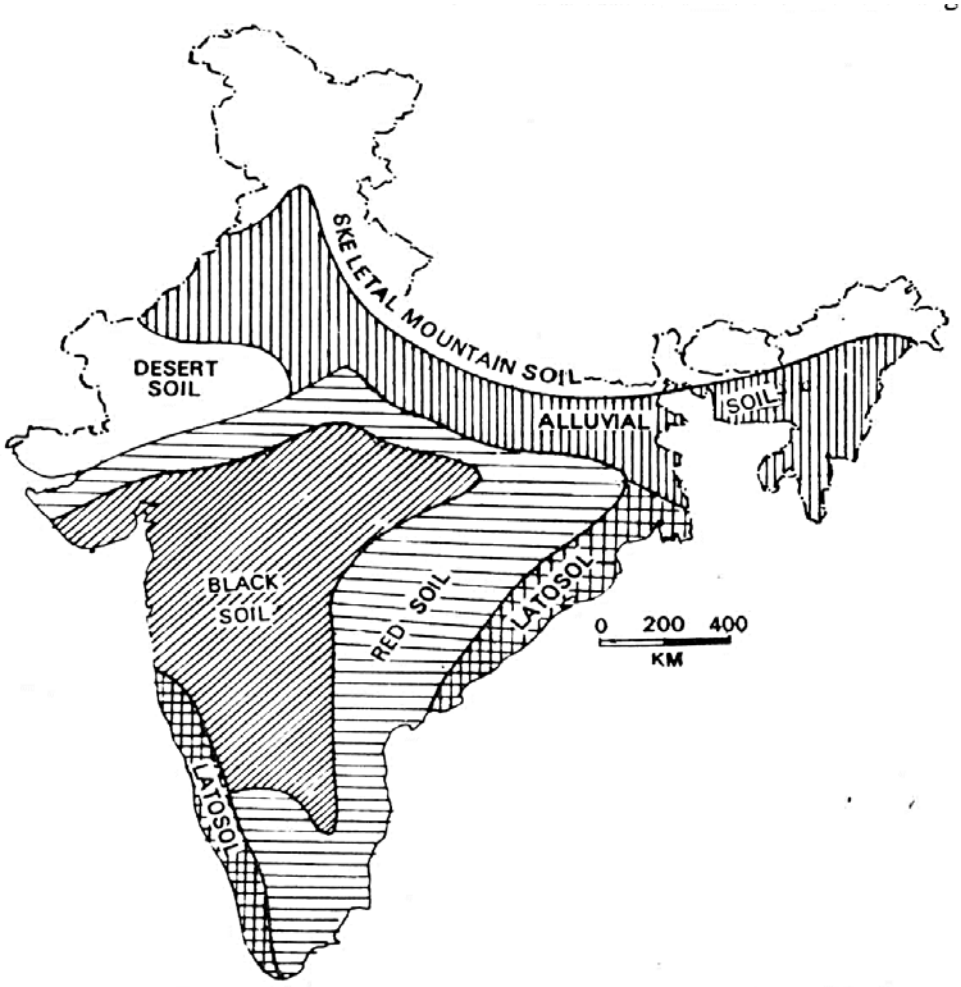


Fig. 7.1 Map showing different types of soil of India.

7.4 CLIMATE OF INDIA

India is home to an extraordinary variety of climatic regions, ranging from tropical to the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert.

India has a monsoon type of climate. India receives pre-monsoon showers in the month of May, proper monsoon during the hot weather season, winter monsoon due to western disturbance in winter and a little rain when the monsoons retreat.

The term "monsoon" is derived from Arabic word "mausim" which means seasonal reversal in the wind direction. The Indian Meterological Department (IMD) designates four official seasons: 1. Winter (from December to early April); 2. Summer or Pre monsoon seasons (April to July in north-

western India); 3. Monsoon or Rainy season (June-September); 4. Post monsoon season (October-December).

India's climate is affected by two seasonal winds-The north-east monsoon and the south-west monsoon. The north east monsoon commonly known as winter monsoon blowns land to sea whereas south-west monsoon known as summer monsoon blows from sea to land after crossing the Indian ocean, the Arabian Sea and the Bay of Bengal. (Fig. 7.2)

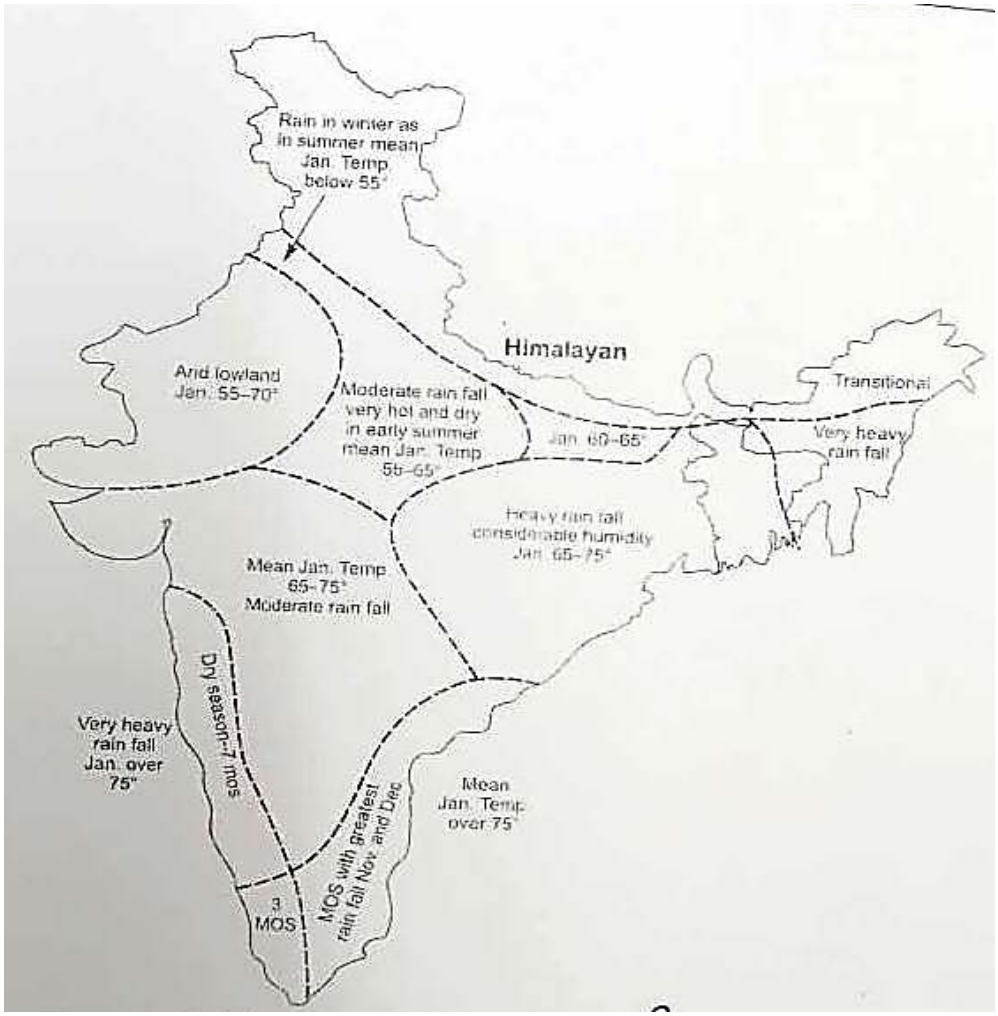


Fig. 7.2 Map showing climate of India

Climatic regions of India :

India is a tropical country. The rainfall has been taken as main criteria for climatic type. On the basis of annual precipitation. India has been divided into following four climatic regions.

(1) Wet zone

(2) Intermediate zone

(3) Dry zone

(4) Arid zone

(1) **Wet zone :** This zone has very heavy rainfalls, more than 200cm. It includes the western slopes of the western Ghats and hills of Meghalaya, Bengal and tarai regions of Bihar and U.P. The northern half of the western slopes has long dry season whereas the southern half has short dry seasons. The vegetation of wet zone is mainly ever green forest type. Paddy is the main crop of this zone.

(2) **Intermediate zone :** This zone also has heavy rain fall of 100 to 200 cm. Intermediate zone occurs in part of west Bengal, Bihar, Orissa, eastern M.P., foot hills of Himalayas, northern U.P., H.P., Jammu, north-east Andhra Pradesh, eastern slopes of western Ghats and east Tamilnadu. Deciduous forests are main vegetations of this zone. The leaves of trees shed during hot weather.

3. **Dry zone :** The rainfall in this zone is moderate, between 50 to 100cm. This zone includes Punjab, U.P., Delhi, western M.P., Gujrat, Maharashtra, Karnataka, Southern Andhra Pradesh and Tamilnadu. The vegetation of this zone is dry, deciduous and thorn scrub type. In some localities there are dry deciduous forest also. The main agricultural crops of this zone are wheat and millets.

4. **Arid zone :** This zone has very low rainfall, less than 50cm. It covers whole of the western part of the country i.e. south western part of Punjab, Rajasthan and north-west Gujarat. The vegetation of arid zone is thorn forest with large areas of desert and semi-desert conditions.

SAQ 2.

(a) Soils of India are classified into .....major types.

(b) ..... soil occurs in Indo-Gangetic plain.

(c) Black soil is common in .....region of India.

(d) India has been divided into .....climatic regions.

7.5 VEGETATION OF INDIA

Due to varied climatic conditions, India has a wide range of natural vegetation. This sub continent has been affected worst by human influences since long time. Therefore, the present vegetation of the country that we see around us are much affected by plants, animals, soils, climate and man. The factors like rainfall, temperature, biotic influences and life forms are used in the classification of vegetation. In India the most common type of vegetation are-

(I) Forest vegetation

(II) Grass land vegetation

I. **Forest Vegetation :** The forest vegetation have been classified into four major types :

1. Tropical deciduous forest
2. Montane forest

3. **Temperate forest**

4. **Alpine forest**

1. **Tropical Deciduous Forest :** **They are most wide spread forest of India spreading over the region receiving rainfall between 200cm to 70cm. Therefore, also known as monsoon forests. Trees of this forest type shed their leaves for about six to eight weeks in dry summer. On the basis of availability of water, these forests are further divided into moist and dry deciduous.**

   (a) Moist deciduous forests : **They are found in tropical region where both rainy and dry seasons occur during the year. These forests are different from tropical rain forests in that the trees are not as tall and have rather thick bark. In the first month of the dry season, the leaves fall. New leaves sprout just before the rainy seasons begins.**

   It is found in areas receiving rainfall between 200 and 100cm. Exist mostly in the eastern part of the country, northeastern states, along the foot hills of the Himalayas, Jharkhand, west Orissa and Chhattisgarh and on the eastern slopes of the western Ghats. Teak is the most dominant species of this forest. Bamboos, Sal, Shisham, Sandalwood, Khair, Kusum, Arjun and Mulberry are other commercially important species.

   (b) Dry Deciduous Forest : **The dry deciduous forest are found in areas having rainfall between 100cm and 70cm. These forests are found in the rainier parts of peninsula, plateau and plains of Bihar and Uttar Pradesh. There are open stretches in thick teak, Sal, peepal and Neem grow. A large part of this region has been cleared for cultivation and some parts are used for grazing.**

Difference between Dry and Moist Deciduous Forests

Dry deciduous forest	Moist deciduous forest
➢ Found in areas with rainfall between 75 and 100cm.	➢ Found in areas with rainfall between 100 and 200cm.
➢ Found in rainier parts of peninsular plateau and the plains of Bihar and Uttar Pradesh.	➢ Found in Northern states along foot hills of Himalayas, Jharkhand, West Orrisa, Chhattisgarh and eastern slopes of western Ghats.
➢ Important species-Teak, Bamboo, Sal, Shisham, Khair, Kusum, Arjun, Malberry and Sandalwood.	➢ There are open stretches in which teak, sal, peepal, neem and other trees grow.

2. Montane Forest :

In montanious areas, the decrease in temperature with increasing altitude leads to the corresponding change in natural vegetation. As such, there is succession of natural vegetation belts in the same order as we see from the tropical to the tundra region. The wet temperate type of forests are found between a height of 1000 and 2000 meters. Evergreen broad leaf trees such as oaks and chestnuts predominate. Between 1500 and 3000 meters, temperate forest containing coniferous trees like pine, deodar, silverfir, spruce and cedar are found. They cover mostly the southern slopes of the Himalayas, place having high altitude in the southern and northeast India.

At the higher elevations, temperate grasslands are common. The temperate forests and grasslands give way to the Alpine vegetation. Silverfir, junipers, Pines and birches are common trees of these forests. At higher altitudes mosses and lichens form part of tundra vegetation.

3. Temperate Forest :

Temperate forest is a forest found between the tropical and boreal region located in the temperate zone. It is within the second largest biome on the planet covering 25% of the worlds forest area, only behind the boreal forest, which covers about 33%.

4. Alpine Forest :

Alpine biomes are found in mountain regions worldwide including the Andes, Alps and Rocky mountains. The Alpine biomes usually lies between an altitude of about 10,000 feet (3,000 meters) and the place where the snow line of a mountain begins combined the Alpine and Arctic biomes cover 16% of the earth's surface area.

The alpine biome is a tough place for plants to live. It's windy, cold and the sunlight at these high altitudes is very strong. There are only about 200 species of alpine plants. At the high altitudes where these plants live, there is very little carbon dioxide necessary for plants to carry on photosynthesis. Because of the blustery weather, most plants are small ground cover plants, which grow and reproduce slowly. They protect themselves from the cold and wind by hugging close to the ground when plants die the cold weather makes it hard for them to decompose quickly. This makes for poor soil conditions. Most alpine plants are adapted to grow in sandy and rocky soil. Plants have also adapted to the dry conditions of the alpine biome.

II. Grassland vegetation :

Grasslands in India are lands dominated by grasses with a certain number of other plants like trees, shrubs and herbs. Indian grasslands

are found at various altitudes and in various geographical regions under various climatic conditions.

The main grasslands are-

1. ***Northern mountain and hill grasslands :*** ***Consists of subtropical hill Savannah-Arundinella*** **sp,** ***Themeda*** **sp** ***Temperate grassland-Stipa, Poa Alpine grassland-Glyceria*** **sp,** ***Festuca*** **sp.**

2. **Grassland on sandy soil, alluvial deserts and crystalline plateaus-e.g. Dichanthium and Savannah grassland-e.g.** ***Phragmites, Saccharum.***

3. ***Deccan grasslands*****: Consists of** ***Sehima, Bothriochloa, Themeda, Cymbopogon*** **etc. (Fig. 7.3)**

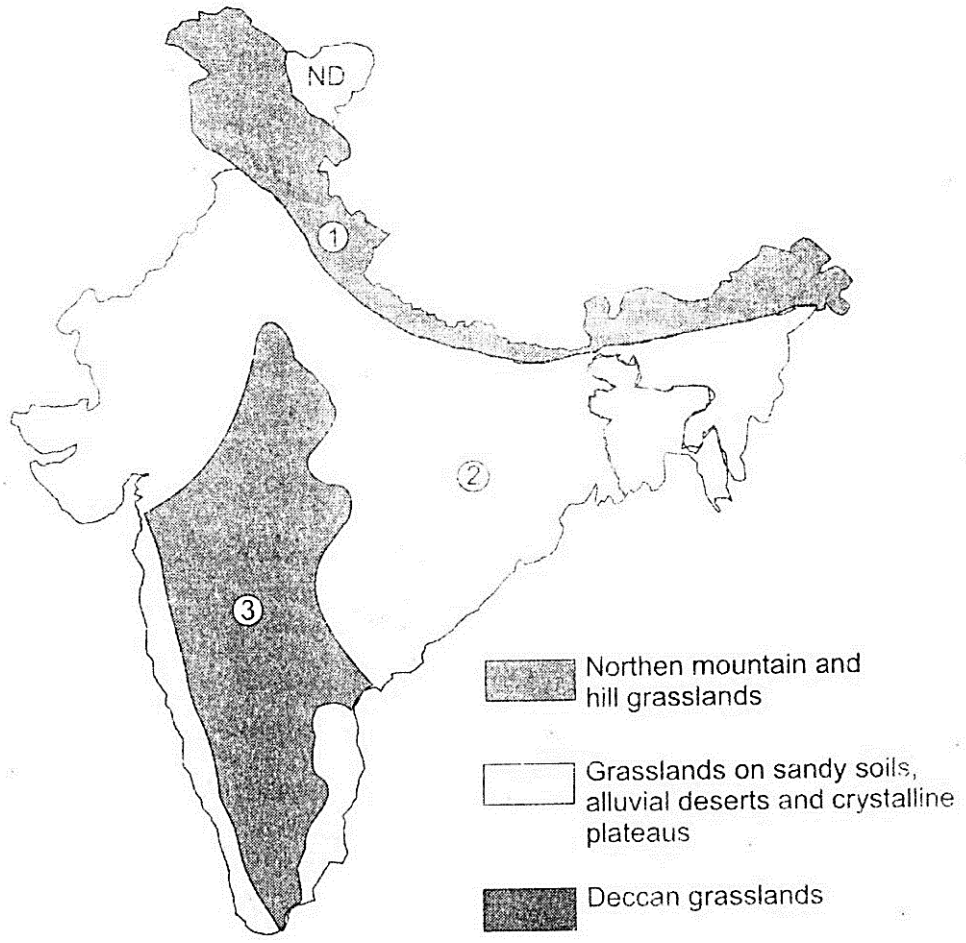


Fig. 7.3 Map showing grasslands of India

SAQ 3.

(a) India has wide range of .....vegetation.

(b) The most common type of vegetation are ..... and..... vegetation.

(c) Forest vegetation have.....major types.

(d) ..... forest are the most widespread forest of India.

7.6 SUMMARY

- **Major plant communities of the World are aquatic communities and terrestrial communities.**
- **Aquatic communities are freshwater, marine and eustarine whereas, terrestrial communities are divided into 12 major biomes.**
- **In the different parts of India soil differs from each other. It is classified into six major types.**
- **India has variety of climatic regions such as wet zone, Intermediate zone, Dry zone and Arid zone.**
- **The natural vegetation of India has wide range due to various climatic conditions.**
- **The most common type of vegetation occur in India are Forest vegetation and grassland vegetation.**
- **The forest vegetations are Tropical deciduous forest, Montane forest, Temperate forest and Alpine forest.**
- **The grasslands in India are dominated by grasses with certain number of trees, shrubs and herbs.**

7.7 TERMINAL QUESTIONS

Long Questions

1. **Give an account of vegetation of India.**
2. **Give an account of major plant communities of world.**
3. **Give an account of climate and soil of India.**

Short Questions

Write Short notes :

(a) Aquatic Communities **(b) Soil of India**

(c) Climate of India **(d) Climatic region of India**

7.8 ANSWERS

SAQ 1

(a) Marine (b) Estuarine (c) Arctic zone (d) 10" (e) Equator

SAQ 2

(a) Six (b) Alluvial (c) Deccan (d) Four

SAQ3.

(a) Natural (b) Forest, Grassland (c) Four (d) Tropical deciuous

UNIT-8 ENVIRONMENTAL EDUCATION

Structure

8.1. INTRODUCTION

Human beings have the ability to transform their environment for their own benefits. Thus, by doing so they can bring about economic development and enhance the standards of their living. However if this power is recklessly

misused by man, it can cause irreparable damage to the environment and greatly harm the human life.

Man has been felling millions of tree for centuries to create pastures for his cattle and farms for agriculture without realising that by doing so he has been allowing rain and wind to erode soil. He without caring for the unintended consequences of his action, has been opening the gate for floods to sweep, vast tracts of land causes dereliction. In industrial revolution, he is polluting air by allowing factories emit smoke which has increased carbon and sulfur content of the atmosphere. He has been dirtying rivers too by throwing effluents in them. He has got to be restrained from doing all this and from pushing the world further towards destruction. There should be no delaying in tackling the task of solving these environment problems as these problems have a cumulative impact. If there is delayed in remedial action will cost considerable more and the damage will become irreversible. Life will survive only as long as Earth survives. These challenges can overcome by a well planned and efficiently managed environment education program. There are various definition of environmental education which are as follows : -

According to International union for the conversation of Nature (IUCN: 1971) Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelatedness among men, his culture and his biophysical surroundings. Environmental education also entails practice in decision making and self-formulation of a code of behaviour about issues concerning environment quality.

Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges and fosters attitudes, motivations and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi declaration 1978)

Objective

Environmental education is also a process in which individual gain awareness of their environment and acquire participation knowledge skills, values, experiences and awareness which will enable them to act individually and collectively to solve present and future environment problems.

- **Participation - to provide individuals, groups and societies with opportunities to be actively involved in exercising their skills of environmental citizenship and be actively involved at all levels in working towards sustainable development.**
- **Knowledge - to help individuals, groups and societies gain a variety of experiences in, and a basic understanding of, the knowledge and action competencies required for sustainable development.**
- **Values - to help individuals, groups and societies acquire feelings of concern for issues of sustainability as well as a set of values upon which they can make judgments about appropriate ways of acting individually and with others to promote sustainable development.**

- **Skills - to help individuals, groups and societies acquire the action competence or skills of environmental citizenship in order to be able to identify and anticipate environmental problems and work with others to resolve, minimise and prevent them.**
- **Awareness - to create an overall understanding of the impacts and effects of behaviours and lifestyles - on both the local and global environments, and on the short-term and long-term.**

8.2. IMPORTANCE OF ENVIRONMENTAL EDUCATION

- **Environmental Education is very important for the child and adult for self-fulfillment and social development. It helps in maintenance of life and health. In self-preservation and in the preservation of human race.**
- **It helps to understand different food chains and the ecological balance in nature.**
- **It helps to understand and appreciate how the environment is used for making a living and promoting material culture.**
- **Environmental Education helps in appreciating and enjoying nature and society.**
- **It stimulates concern for changing environment in a systematic manner for the long run as well as the immediate welfare of mankind.**
- **It directs attention towards the problems of population explosion, exhaustion of natural resources and pollution of the environment and sheds light on methods of solving them.**

The education for environmental awareness is essential for the younger generation as well as for the older generation. It also needs to cover both urban and rural populations. Hence, environmental education needs to be conveyed to the different categories of people through formal education systems, non-formal education systems and the use of mass media. Our country is highly diverse climatically, geographically, floristically, Faunistically, lingually, socially and economically. Therefore, environmental education has to be essential location-specific. At the first level, specific attention must be paid to school going children and women's (about 50% of the population). They are to be made awareness of health, family planning, nutrition, rural development, slum improvement, sanitation, hygiene, water and food contamination etc. Non government organizations have to play a significant role.

SAQ.1. The education for environmental awareness is essential for the -------- generation as well as for the ---------- generation.

Formal Environmental Education

The four components are required to build up the social awareness about environmental education are awareness, exposure to real life situations, concepts of conservation and sustainable development. These can be further

adjusted in terms of the requirement at primary, secondary and higher secondary levels.

Awareness involves making the individual conscious about the physical, social and esthetic aspects of the environment. One has to appreciate the fact that man is only one of the numerous species on earth and is linked with the life support systems with six elements like air, water, land, flora, fauna and sunlight.

Real life situations bring men closer to the environment. These conditions are location specific, with different environmental aspects being emphasised in different states. Agriculture based areas may be emphasised on pollution due to agriculture practices.

The conservation and sustainable development are concerned, the main focus would be on utilization of resources and not on exploitation. Utilization stands for long term sustainability of the resources. Sustainable development aims at utilization of resources not only by the present generation but their preservation for the future generations also, so that life can be sustained for a long period of time.

1. **At the primary stage, emphasis will be more on awareness followed by real life situation and conservation. Attempt will be only on sensitizing child to environment.**
2. **In lower secondary stage onwards the focus on awareness will begin to decrease in favour of increased knowledge about real life situations, conservation and sustainable development.**
3. **In higher stage, the conversion will get a priority over other factors.**
4. **College stage : At this level, the picture would be almost reverse of the primary level. The content must be college/university based on science and technology. Teaching, practical and action oriented fieldwork is to done.**
5. **University stage : Environmental education at this stage is being looked after by the University Grants Commission. At present environment finds a place only through the biology courses and there is no holistic approach. There is a high powered committee to suggest areas of environmental education at post graduate level.**

Non-formal Environmental Education

It is designed for any age group working in social, economic and cultural development of the community. They form groups or clubs and organize exhibitions, public lectures, meetings, environmental campaigns. This can be done only through channels of adult education. Through programmes for adult education are already in progress and are duly emphasized by the New Education policy, the time has come to emphasis environmental education for sections like women, tribal's, agricultural, slum dwellers and residents of drought prone areas, voluntary agencies or non-government organizations have played important role in adult education. Information packs like posters, slides and audio-visual materials can be used. Special exhibitions in rural areas

at the time of fairs and festivals should be arranged for creating environmental awareness. In our society where information spreads through personal encounter and by word of mouth. Audio-visual media have certain limitations. But media provide use and views for community leaders and opinion makers who in turn influence the beliefs and attitudes of others. For literature population print media like newspapers and magazines are effective. Important programmes should be shown on television to create awareness about environmental matters. But language is another problem, because most of these programmes are either in Hindi or English which are not easily understood by many people. So use of local languages will be effective for educating masses.

There are over 200 non-government organization of which most are involved in environmental education and awareness. Kalpavriksh, Kerala Sastra Sahitya Parishad, World wide fund for Nature (WWF-India), Bombay Natural History Society, Chipko Movement, Appiko Movement are some of the important NGOs which are important agents for creating awareness of environment. They act as a source of information work as pressure groups, and advise government and undertake education and research.

The basic aim of environmental education is to make aware the people regarding the abiotic and biotic environment and their resources. By environment aware people may use conserve and protect the valuable renewable and non renewable environment resources and by it sustainable development may be brought in practices.

SAQ.2. The basic aim of environmental education is to make aware the people regarding the ---------- and ---------- environment and their resources.

8.3. COMPONENTS OF ENVIRONMENTS

Abiotic (Non living components) – It includes climatic and edaphic aspects. The climatic aspects are light, temperature, pressure, humidity and precipitation. The Edaphic aspects are like rocks, soils and subsoils. The water is an essential aspect of abiotic without it life cannot exist. Light is essential in the process of photosynthesis for the food/energy to plants and organisms. The minerals present in soil are used by certain organism for their growth.

Biotic (Living components) – All the organism derive energy from food. The growth & life process depends on food. Plants being autotrophs and self food producers provide energy to herbivorous and then to carnivorous the consumers. Some micro-organism like bacteria and fungi live on dead and decaying plants and animals are known as decomposers.

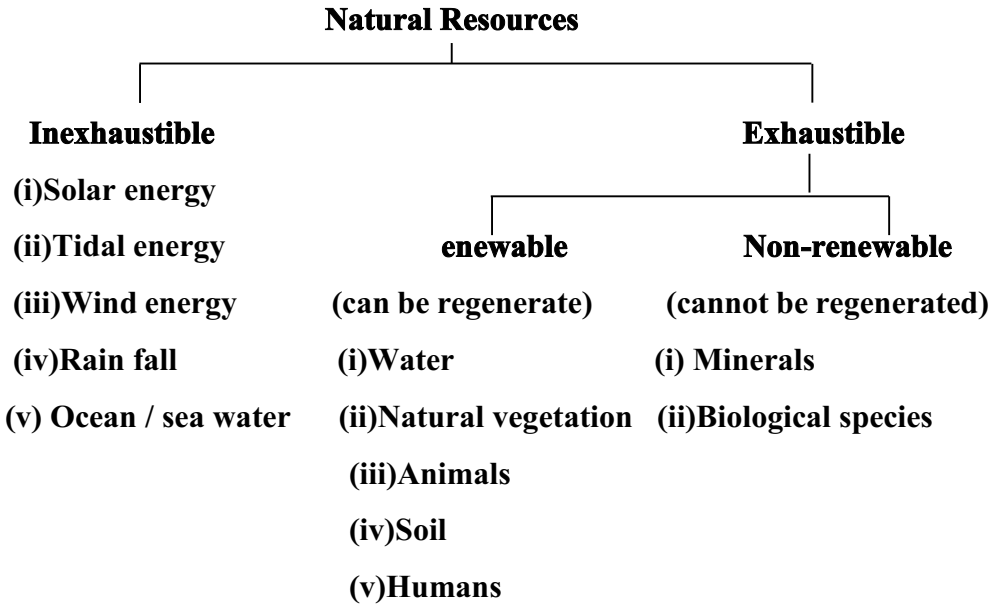
8.4. NATURAL RESOURCES

The surrounding of men is full of natural and man-made environment. All the life forms are related with large number things including physical, chemical, biological and social factors. All the things which are available in the environment of man and can be utilized by man for his survival are example of natural resources are air, water, soil, forest, coal, wildlife etc.

The term resource consists of're' mean again and 'source' mean any natural element which can provide the needs of man.

SAQ.3. Example of ---------- are air, water, soil, forest, coal, wildlife etc.

Classification of natural Resources



8.4.1. INEXHAUSTIBLE RESOURCES

These are freely available in nature. They cannot be exhausted by human activities. But some of these resources may be affected by human beings. The quality of air or water can be changed at certain places. Solar energy, wind power, tidal power, rainfall etc. are the example of inexhaustible resources.

8.4.2. EXHAUSTIBLE RESOURCES

The storage of these resources are limited and it may be exhausted by human activities. It can be classified into two type renewable and non-renewable resources.

(a) Renewable Resources : These are inexhaustive and can be regenerated or reappear by recycling, reproduction and replacement within a given period in the nature. Forest, water, living beings like plants, animals and micro-organism etc. are renewable resources. Solar energy is also renewable resource which is inexhaustible in nature. When the rate of consumption of these resources is beyond the limit, they may be exhausted totally.

(b) Non-Renewable Resources : These resources cannot be regenerated. Once they are used, they are finished forever e.g. Fossil fuel like petroleum, coal gas etc. After unlimited use, the fossil fuels will definitely be exhausted. Some biotic use, are also non-renewable. Such biological species which have evolved in the course of million years are non-renewable but cannot be created again.

So it is very important to protect and conserve our natural resources. They should be used in such a way so that they should be available for our future generations. It does not also mean that we should stop using of the natural resources.

8.5. SOME IMPORTANT NATURAL RESOURCES

Water

Water is the most essential component of life. It is renewable resources. It helps in movement, circulation and cycling of nutrients in the biosphere. Nearly three fourth of the total world surface is covered by water. The oceans and sea contain about 97.20% of the total earth surface water but it is in saline condition. In polar ice caps 2% of water are present. So only small amount of fresh water is available for human consumption.

The Hydrological cycle plays an important role in maintaining different forms of water in nature. There is a circulation of water from sea to land and back again into sea or ocean. After evaporation with the help of solar energy, water passes into atmosphere. Water vapour gets condensed and returns on the surface of the earth in the form of rain, hail or snow.

Uses of water :

(i) Municipal purpose : Cleaning, hospitals, schools, fire fighting.

(ii) Agriculture purpose : Water irrigation, dairy processes, for livestock. About 70% water is used for agriculture purpose.

(iii) Domestic purpose : Drinking for all living beings, washing, sanitation, cooking and cleaning. Nearly 7% water is use for domestic purpose.

(iv) Power Generation purpose: For hydel power i.e. hydroelectricity in a form of running or stored water and tidal waves.

(v) Transportation purpose: Inland water ways and sea or ocean water ways, navigation.

(vi) Industrial purpose : Steam generation, cooling, processing, industrial activities.

Problem related to over utilization of water

(i) Lowering of water table : Over use of ground water for drinking, irrigation and domestic purpose has lowered the water table in various regions.

(ii) Water logging : Excessive irrigation leads to water logging and salinity problems. Over irrigation in arid and semiarid areas can cause salt accumulation in soil. It may reduce the productivity of soil.

(iii) Shortage of water : Due to increasing population, there is shortage of water in some parts of the world. Rajasthan, Gujarat, Madhya Pradesh Orissa etc. are in the grip of a severe shortage of water. It is estimated that by 2024 two third of population of the world would suffer from water shortage.

(iv) **Infiltration of salt :** Due to over pumping of ground water near the coastal area, lead to infiltration of salt from the sea into fresh water.

(v) **Waste-water effects :** More the water used for industrial and municipal purpose, more is the degradation of water by adding suspending solids, salts, bacteria and toxic materials. Such water causes pollution of surface water because ultimately it enters into river, pond, lake, sea or ocean water.

Conservation of water

(i) Modern and efficient systems of irrigation like sprinkle and drip irrigation should be adopted so that water wastage through traditional method can be reduced.

(ii) Urban refuse and industrial disposal must be controlled by sewage treatment plants.

(iii) Town and urban planning must charge the top priority to maintain water purity in surrounding areas.

(iv) There should be awareness of water pollution by everyone.

(v) Recycling of waste water in industries must be done.

(vi) Harvesting of rain water can be done by storing rain water and recharging ground water.

(vii) Government must bring in force effective laws for water pollution control measures.

(viii) Dams and water reservoirs must be constructed at suitable places to control floods.

(ix) Deforestation must be controlled.

(x) The people having orthodox religious must be educated property to understand the nature of water pollution and its adverse effects on human health.

Minerals

Minerals play an important role in modern society. It is non-renewable natural resource. The distribution of mineral resources on the earth is uneven. After mining and processing they are used by man for various purposes. The processes of mineral formation are beyond human control. The rate of utilization of those resources is rapid. So they are of limited resources.

Minerals are categories into three types

(i) Metallic : Ore, copper, silver, gold, aluminum, manganese.

(ii) Non-metallic : Mica, gypsum, limestone etc.

(iii) Energy resources : Coal, petroleum, Uranium, platinum, thorium etc.

Uses of Minerals:

(i) **Iron Ore :** steel production, heavy machinery.

(ii) **Aluminium :** Utensils, electronic and electrical goods.

(iii) **Copper :** Cooking vessels, electric wiring, alloy material in gold, jewellery, brass, etc.

(iv) **Gold :** Jewellery, medical use

(v) **Lead :** Car batteries, paints.

(vi) **Manganese :** Steel alloys, heat resistant for high strength.

(vii) **limestones :** Cement industry

(viii) **Sulphur :** Medicine

(ix) **Silicate :** Glass industry.

(x) **Gypsum :** Agriculture, plaster wall board.

Problem related to mining activities

(i) **Defacing of landscape:** The vegetation and top soil cover of the mining area is removed due to mining. Thus devegetation and deforestation leads to ecological losses. The total area is also affected.

(ii) **Air Pollution :** While separating and purifying the metal from impure ores, smelting is done. A lot of air pollutants are emitted during smelting and the suspended particulate matters (SPM) soot, arsenic particle, lead etc. shoot up in the atmosphere. The public also suffer from several health problems.

(iii) **Health hazards :** Due to suspended particulate matter and toxic substances most of workers suffer from skin and respiratory diseases.

(iv) **Surface water pollution :** The acidic water of mines affected various forms of aquatic life when such water enter into water bodies like river, lakes or seas.

(v) **Social impacts :** The land use patterns shift from open range, forest and agriculture to urban patterns. Constructional activities and urbanization affect local streams through sediment pollution which cause to reduce water quality. Air quality is also reduced due to increasing vehicles and dust particles.

Conservation of minerals

(i) **Recycling :** The wastse materials like iron, copper, lead, zinc or aluminum scraps must be collected and then after remelting and reprocessing, it should be turned into new products.

(ii) **Reuse :** The reuse of some items is more beneficial than their recycling e.g. reuse of glass bottles.

(iii) **se of eco-friendly technology :** The use of eco-friendly mining technology is very useful for reducing the adverse effects of mining. The

low grades ores can be better utilized by adopting "microbial teaching technique". Such ores are inoculated with suitable bacteria which remove the impurities (like sulphur) and leave the pure mineral. Such biological method is useful not only from economic but also environmental point of view.

(iv) **Use of wastage :** The waste materials of one industry may be used as raw material in the related another industry.

(v) **Substitution :** Instead of using some materials like steel, tin or copper in many industries plastic, ceramic, fibres glass can be substituted.

Soil

Soil is a complex physical biological system providing support water, nutrient and O_2 for the plants. It is made up of mineral matter (40%), organic matter (humus) (10%), soil water (25%), soil air (25%) and biological system. The soil contains top soil, which may be of different colours depending upon the types of humus and mineral materials. The top soil is followed by subsoil, which contains the roots of most plants, humus and minerals. The soil is formed from the parent rock material by the process of physical, chemical and biological weathering. Physical weathering caused by various climatic factors such as light, temperature, water, wind etc. The chemical process like hydrolysis, hydration, oxidation and reduction. The biological weathering involves the decomposition process by which organic materials are broken down and leads to humification and mineralization.

Problem related to soil

Soil erosion is one of the big problem. The top fertile layer of soil is eroded away by any agent, which losses the fertility of soil. It is called soil erosion There are various reason for soil erosion which are as follows :-

(i) The fast flowing water steep slopes erodes top soil.

(ii) The top soil cover gets heated during summer. Soil particles become separated due to dry particles and are blown away by wind or flow in away by running water.

(iii) Forest cover is removed by deforestation. The bare top soil is eroded by agents like wind, water etc.

(iv) Shifting agriculture causes for removal of forest cover and leads to soil erosion.

(v) Over grazing removes grass or shrub cover which causes soil erosion.

Conservation of soil

The conservation of soil is needed to prevent soil erosion. It can be done by following

(i) **Contour farming :** The horizontal planting across the slope prevents soil erosions from runoff water by holding soil particles.

(ii) **No-till farming :** The tilling (ploughing) is done for farming but provides suitable conditions for soil erosion. So by till farming causes minimum disturbance to the top soil particle and controls soil erosion

(iii) **Strip cropping :** Strips of soil saving cover crops like grasses, reduces soil erosion.

(iv) **Organic farming :** Organic components are increased in the soil by using biofertilizers which add soil fertility.

(v) **Terracing :** Terrace farming along the slopes must be done for controlling run-off.

(vi) **Afforestation :** Planting trees in desert, checks the velocity of wind and prevents soil erosion.

Forest

The forest is a biotic community which is composed of trees, shrubs and woody vegetation and is one of the most natural resources. According to National forest policy (1988) about 33% area for the plains and 67% for the hills of the country must be covered by forests. But in most of the countries, the forest cover is going on decreasing year after year.

India had abundant forests in ancient times. But due to the lack of foresight and unplanned felling of trees, the forest cover has been reduced very much According to state of forest report 1999 the forest cover of the country has been estimated to be 637,293 sq km, which is 19.39% of the geographic area of the country. The dense forest, open forest, and mangrove forest constitute 11.48%, 7.76% and 0.15% respectively of the geographic area. The National forest policy 1998 envisages to bring one third of the geographic area of the country under forest cover to maintain ecological balance and environment stability.

Use of forest

(a) **Commercial uses :** Forest provide us various commercial goods raw materials to industries like food items, fodder, rubber, fibres, non-edible oils, timber, firewood, pulpwood, gums, resins, medicines, drugs etc.

(b) **Ecological uses :** These are as follows

(i) **Reducing global warming :** Co_2 is the main gas in green house. It is absorbed by trees in forests as a raw material for photosynthesis. Thus forest acts as a sink for Co_2 which reduce global warming problem.

(ii) **Ecological balance :** Tree absorb Co_2 during day period and release oxygen. At night tree absorb O_2 and release Co_2. Thus the environment balance is maintained.

(iii) **Hydrological cycle :** Forest help in increasing the precipitation (rainfall). They reduce the frequency, intensity and dimension of flood.

(iv) **Wild life habitats :** Forests provide shelter to innumerable humans, animals and micro-organism.

(v) **Soil conservation :** Forest maintain fertility of soil by returning nutrients to it. Trees and shrubs offer protection to soil by binding the soil particles through the network of their roots and prevent soil erosion. They also work as wind breaks.

(vi) **Pollution moderators :** Forest can absorb the toxic gases and help in keeping the air clean and pure. They also work as wind breaks and prevents noise pollution.

(vii) **Tourism :** Due to natural scenery, pleasant climates, variety of animal and bird life, forest attract a number of tourists.

Conservation of forest

(i) The conservation of forestry is a national problem so it must be tackled with perfect co-ordination between forest department and other departments.

(ii) The people'ss participation in the conservation of forest is of vital importance. So we must get them involved in this national task.

(iii) Afforestation or special programme like Van Mahotsava should be launched on bigger scale.

(iv) The cutting of trees in the forest must be stopped at all costs.

(v) Cutting of timber and other forest product should be restricted.

(vi) Grassland should be regenerated.

(vii) Forest conservation act 1980 should be strictly implemented to check deforestation.

(viii) Several centres of excellence have been setup and award should be instituted.

SAQ. 4. Forest, water, living beings like plants, animals and micro-organism etc. are ---------- resources.

8.6. ENVIRONMENTAL POLLUTION

Environmental pollution may defined as " any undesirable change/ alteration in the physical, chemical or biological characteristic of our air, water and soil harmfully affect human life or create a potential health hazard of any living organism". Pollution is thus direct or indirect change in an component of the biosphere i.e. harmful to living components and in particular undesirable for man affect adversely the industrial progress, cultural and natural assets or general environment. Thus pollution is a necessary evil of all development. Pollution is a worldwide problem. The developed countries are more responsible than less develop countries.

Pollutants : Pollutants are the material, matter or any form of energy that causes degradation and pollution in the existing natural balance and adversely

affect on the natural quality of any component of the environment. There are various type of pollutions

- **Air pollution**
- **Water pollution**
- **Soil pollution**
- **Noise pollution**
- **Solid waste pollution**

Air pollution : Air is an essential component of life, without it no life can be sustained on the earth. Air is present in the atmosphere and it is composed of oxygen (20.95%), Co_2 (0.03%), N_2(78.303%), Argon (0.93%) and very little amount of other gases like methane, hydrogen, neon, helium, crypton, ozone and water vapour. Thus atmosphere is an envelop of gases divided into different layers and forms an insulating blanket around the earth, without atmosphere there will be no life. If there is changes in the composition of the gases in atmosphere by introduction of potentially harmful substances like gases and particulate matter causes air pollution.

Causes of air pollution

The atmospheric air gets polluted by number of causes and by number of sources. They may be

(a) Natural causes

- **Volcanic eruption**
- **Dust storms/ deflation**
- **Forest fire**
- **Inversion of temperature**
- **Process of decomposition**

(b) Man made causes

- **Industrialization**
- **Thermal power plants**
- **Nuclear plants**
- **Nuclear test**
- **Urbanization**
- **Automobile vehicles**
- **Over population**
- **Change in culture**
- **Agriculture activities- use of pesticide, insecticides**

- **Heavy plant cutting – deforestation**

Industrialization and urbanization in modern world have lead to a great problem of air pollution, which is a main cause of global warming. It is estimated that every year about 200 million ton of Co_2, 50 million ton of various hydrocarbon and 15 million ton of So_2 are released into atmosphere. Nuclear explosion, accidental discharge of poisonous gas due to instrumental or human negligence like Bhopal gas tragedy, burning of oil well in gulf countries during gulf war contribute in air pollution. Pesticide used for control of insect pests also cause air pollution. Thermal power plants release fly ash, soot and So_2 in the air. Fertilizer plant, textile industries, smelters, steel plant, oil refineries, chemical plant and decomposition of organic waste and garbage pollute air. The secondary pollutants such as acid rain, peroxy acetyl nitrate (PAN), photochemical and smog are the dangerous pollutant of air pollution.

SAQ. 5. ---------- is also renewable resource which is inexhaustible in nature.

Effect of Air Pollution

It can be broadly divided into 6 categories

- **Effects on Climate**
- **Effects on human health**
- **Effects on vegetation and animals(livestock)**
- **Effects on soil**
- **Effects on aquatic life and micro-organism**
- **Corrosive effect on building and monuments**

Effects on Climate

(i) Increase of CO_2 in atmosphere causes increase in atmospheric temperature.

(ii) Increase in concentration of Co_2 in atmosphere may create green house effect which will bring climatic changes as it will influences on solar and terrestrial radiation e.g. incoming and outgoing radiation.

(iii) Increase in temperature i.e. Global warming would cause melting of ice caps, continental glaciers and this would bring the rise in sea level and costal low land will be submerged.

(iii) Emission of CFC from refrigerators, air conditioners, aerosol and foam plastic cosmetics increases the concentration of chloroflurocarbon in atmosphere which do not degrade for longer time. CFC gets broken down by ultra-violet and ozone get destroy and protective cover of all biotic get damaged in biosphere. So increase in CFC concentration is most dangerous form of air pollution.

(iv) Solid particulates take part in the cloud formation and so urban pollution and increased water vapour emission can produce up to 10% increased cloud cover, up to 10% more wet days and increased mist, fog and smog compared to non-industrial areas.

Effects on human health

(i) **So_2 when combine with smoke in urban and industrial area forms poisonous smog which causes respiratory disease.**

(ii) **Carbon monoxide in human body combines with haemoglobin of blood faster than oxygen which causes suffocation and respiratory problem.**

(iii) **Depletion of ozone due to CFC leads skin cancer.**

(iv) **When So_2 crosses the permissible limit, it causes throat, lung and eyes disease and irritation of nose.**

(v) **If for long time exposure of benzene emitted from refineries and motor vehicles may causes low white blood cell counts and leukemia.**

(vi) **If long term exposure to cadmium damage kidneys and lungs.**

(vii) **Exposure of lead causes high blood pressure and impairs growth.**

Effects on vegetation and animals (livestock)

(i) **Air pollution damage to crops and trees. It is estimated crop losses from ozone pollution are 5 – 10 %. There are several abiotic and biotic factors that can affect the response of plants to an air pollutant exposure dose.**

(ii) **Fluorine compound deposited on fodder causes fluorosis, diarhoes, loss in weight and lameness. Air born microbes causes diseases to domestic animals.**

Effects on soil

(i) **The reduction in soil moisture, productivity, photosynthesis, phytoplankton, plant yields get adversely affected when CFC, nitrogen oxides, sulphur dioxides and ultraviolet increase beyond the certain limit.**

Effects on aquatic life and micro-organism

(i) **Acid rain, a product of air pollution brings acute danger to molluscs and fish which can tolerate water with pH 5.0. pH below 5.0 adversely affects the aquatic life.**

Corrosive effect on building and monuments

(i) **World famous historical monuments and building, precious stones and marble get damaged by acid rain. The oxide of So_2 and No_2 are blown by wind and cover large area from the source. In traveling in air it reacts with water and form acid H_2So_4 & HNO_3. When this acid rain fall on monuments and building it damaged. For e.g. Marble of Talmahal of Agra is affected by emission of sulphur dioxide from Mathura refineries.**

Control of Air pollution

The air pollution can be controlled and minimized by preventive and control measures.

(A) ***Preventive measures*: These are follows**

(i) Selection of site for plant (industry) by atmospheric consideration.

(ii) Before industry set up we must consider the environmental impact assessment first.

(iii) Setting of industry should be remote from residential areas.

(iv) Selection of suitable fuel and its efficient and utilization.

(v) Install tall chimneys

(vi) Use of low sulphur content coal in industries and industrial processes so that emission level will become low.

(vii) Use of modern technology in industries so that emission level become low.

(viii) Remove sulphur from coal either by washing or by bacteria.

(ix) Use alternative less harmful product like solar cooker, solar heater, solar powered vehicles.

(x) Be aware and motivate people in society. Government bodies and officials to make best use of environmental resources.

(B) ***Control measures* : The reducing of the pollutants can be done by following means**

(i) Collect the pollutants by some instrumental devices.

(ii) Destroy the pollutants by thermal or catalytic combustion.

(iii) Change the form of pollutants to be less toxic.

(iv) Use of filters for collecting extreme fine particulate.

(v) Gaseous pollutants in combustion technique burns completely at high temperature.

(vi) Unburnt hydrocarbons into emission can be reduced at multy point fuel engine.

(vii) Use good quality fuel for reducing toxic contaminants in exhaust, at a drastic rate.

(viii) Lead free petrol minimizes pollution.

(ix) There should be given preference of CNG.

(x) Use biofilters and bioscrubbers.

(xi) Plant more trees and keep more open spaces

Water Pollution : Water pollution may be defined as "the addition of any substance to water, changing physical and chemical characteristic of water in any way which interferes with its use for legitimate purpose".

Water is one of the most important natural resource which is essential for variety of purposes to human beings as well as plants and animals. It has many uses include drinking and other domestic uses, industrial cooling, power generation, agriculture or irrigation, transportation and waste disposal. In any chemical industries water is used as a reaction medium, a solvent, a scrubbing medium and a heat transfer agent. Water is a source of life for living organism hence it is an important elements in biosphere. It helps in circulation, movement and cycling of nutrients.

Most of our water bodies such as ponds, lakes, stream, rivers, sea and oceans have become polluted due to urbanization, industrial growth and other man made problems. Water pollution is one of the lost serious environmental problems. It occurs when water is contaminated by such substances as human and animals wastes, toxic industrial chemicals, agriculture residue, oil and heat. Most of our water bodies river, lakes, seas, oceans estuaries and underground water sources like tube wells, bore wells are generally polluted. When the water get polluted it however become turbid, unpleasant, bad smelling, unfit for bath and washing or other purposes. They are harmful and resources of a number of diseases such as cholera, dysentery, typhoid etc. Polluted water may look clean or dirty but contains germs, chemicals, and other harmful toxic materials that can cause inconveniences, illness or death.

Sources of water pollution

There are several water pollutants which contaminate the water. These are as follows

(i) Domestic waste water and sewage

(ii) Industrial wastes (effluents)

(iii) Agriculture wastes

(iv) Physical pollutants (thermal and radioactive)

(i) Domestic waste water and sewage : It includes water borne wastes derived from household activities such as bathing, laundering, food processing and washing of utensils. Domestic waste contains garbage, soaps, detergents, waste food, paper cloth, use cosmetic, toiletries and human excreta. This waste water is known as sewage is the largest primary source of water pollution. Most of our natural water bodies like river, pond, lake, and stream are heavily polluted by sewage. The uncontrolled dumping of wastes of rural areas, towns and cities into our ponds, lakes, stream, river and oceans. So there is accumulation of sewage and other wastes in these bodies on very large scale, they are not able to recycle them. Because of their heavy load of sewage the natural water bodies have lost their self regulatory capability and such water becomes unfit for drinking and other domestic purpose. The decomposition of sewage and other oxygen demanding wastes is largely an aerobic process. When these aerobic process increases its oxygen requirements. This is called Biological oxygen demand (BOD). BOD is the amount of oxygen required for biological oxidation by microbes in any unit volume of water.

(ii) Industrial wastes (effluents) : Most of the rivers and fresh water streams which pass near the major cities, townships or other human dwellings are polluted by industrial wastes called effluents. A wide variety of both inorganic and organic pollutants are present in the effluents of common industries such as paper and pulp industry, textile, sugar mills, distilleries, breweries, tanneries, steel industries and mining operations, thermal power plants. The kinds of effluents generated by industries are also numerous. The paint and varnish industries produce aromatic long chained hydrocarbons, textile industries put out various dyestuffs and metal salts which are used as mordents. The other industrial effluents contains a most of pollutants such as oils, greases, plastic, plasticizers, metallic wastes, phenols, acids, salts, dyes, cyanides, DDT, etc. These metallic wastes such as copper, zinc, arsenic, cadmium, lead, mercury, chromium are discharged from industries.

(iii) Agriculture wastes :

Agriculture chemicals are mainly pesticides and fertilizers are important water pollutants. Their discharge reaches into the water bodies and get polluted. The animal waste also contributes water pollution. These pollutants make harmful effects on aquatic life including human. The pesticides includes insecticides, fungicides, acaricides, nematicides, herbicides, rodenticides, molluscicides. These are Malathion, sumithion, BHC, DDT, Aldrin Furadan etc.

(iv) Physical pollutants (thermal and radioactive) : The thermal discharge and radioactive substance are physical pollutants of water.

(a) Thermal discharges : The power plants and industry use large quantities of water for cooling purposes. The used coolant water is usually discharge directly into water bodies. This could result in increase in temperature of water bodies with deleterious effects on aquatic inhabitants. This is called thermal pollution. An increase in water temperature decreases the O_2 saturation percentage and lowers dissolved oxygen levels. This is because the hot water tends to forms a separate layer above the cool water due to density differences between the two layers. The upper hot layer which itself hold less O_2 than the cooler layer below, prevents the replacement of oxygen in the cooler layer as it is denied contact with the atmosphere. The dissolved oxygen level falls rapidly due to normal biological functions in the lower layer and may lead to anaerobic conditions. The thermal pollution adversely affects aquatic life. An increase in temperature also increases the toxicity of some chemical pollutants.

(b) *Radioactive substance* : Wastes of uranium and thorium mining and refining from nuclear power plants and from industrial use of radioactive materials damage to aquatic environment from radiation. Radium is the most significant waste product and is considered to be a hazard in drinking water. There are certain marine organisms have the capacity for accumulating radio

nuclides from water. The radioactive substance enter humans with food and water and get accumulated in blood and certain vital organs like bone, liver, thyroid gland and causes harmful effects like leukemia, bone cancer and mutagenic changes.

Effect of water Pollution

(i) If water gets contaminated with heavy metals cause serious health problems. Mercury compound in waste water converted into toxic methyl mercury by bacterial action which causes weakness of tongue, lips and numbness of limbs, bluming of vision and deafness.

(ii) If fish were catch from mercury contaminated water consume by the human, it causes minimata disease detected in Japanese people in 1953.

(iii) Cadmium contaminated water causes liver and lung cancer.

(iv) If water is polluted by lead it causes loss of muscle power, headache and anemia.

(v) Sewage polluted water mostly contains bacteria's, worms, and pathogens. The sewage contaminated water is a source of water borne diseases like typhoid, amoebabiases, jaundice etc.

(vi) Excess of copper in water causes hemolytic anemia and necrotic hepatitis. Chemical presents in pesticides, plastic and metals damages endocrine system, neurological reproduction system and alternation in normal hormone and causes testicular cancer.

(v) Effluents from zink smelters and mine water drainage when used for irrigation in paddy field, where rice get cadmium contaminated has caused Itai-itai disease in the people of Japan an damage lungs, kidney, liver and bones.

(vi) Nitrate present in excess in drinking water causes blue baby syndrome due conversion of hemoglobin into non-functional oxidized form.

(vii) If drinking water have excess of flourides it causes mottied teeth, fluorosis.

Control of water pollution

(i) Water pollution at point source can be reduced by legislation and to prevent water pollution from non point source is difficult due to absence of proper policies and strategies.

(ii) ewage treatment is must before it is released into water by physical method- sedimentation and filtration for removing large and suspended particles.

(iii) Industrial hot water should be cooled when released from power plants or from industrial plants.

(iv) Washing clothes and taking baths in tanks or wells from where supply of drinking water is made it should be strictly prohibited.

(v) Acids and Alkalies can be neutralized before releasing into water.

(vi) **Avoid chemical fertilizer and use biofertilizers.**

(vii) **Integral pest management, need of sustainable yield.**

(viii) **Separate drainage-channels for sewage and rain water should be provided.**

Soil pollution

Soil is the most basic fundamental resources of our environment. It is the sources of many materials essential to man and other organisms. The exponential growth of population with limited soil and water resources have create great concern throughout the world today. Environment is being exploited and threatened by his reckless activities. The problem of land degradation as a result of human activities is alarming and seriously affecting the quality of human society. Improved technology, fertilizers, pesticides are important and essential for increase in yield but eventually they threaten to create environmental imbalance. To meet the ever increasing demand from ever increasing population requires intensive cultivation. Various claimants of land like agriculture, industries, transports, mining, urbanization, forest and grazing and associated activities have damaged and harmfully affected land (soil).

Soil pollution is defined as "the addition of substances to the soil, which adversely affect physical, chemical and biological properties of soil which reduced its productivity".

Pollution of soil is an extremely complicated process. It may occur directly by the sources which pollute it. Dumping and disposal of waste, application of agrochemicals or indirectly affected by air pollution and its associated product like acid rain.

Sources of soil pollution

- **Fertilizers and Pesticides waste**
- **Domestic /Discarded waste**
- **Industrial waste**
- **Radioactive waste**

The waste from these sources produces soil polluting pollutants which make the soil unfit to produce more. The soil erosion is a type of soil pollution where fertility loss makes the soil contaminated.

Control of soil pollution

(i) **Biodegradable waste should be separated and be use to generate biogas.**

(ii) **Animal and agriculture waste can be used for biogas production.**

(iii) **Construct transfer station for discharge site.**

(iv) **Use filters in industries to collect fly ash and other suspended matter.**

(v) **Low lying areas (ditches) preferable used as dumping grounds for industrial waste.**

(vi) **Recover waste from waste so that it will produce some useful product.**

(vii) **Use of biofertilizer rather than chemical fertilizers.**

(viii) **Mining waste can be reduced by the application of modern technology.**

(ix) **Avoid use of DDT like pesticide, residue of which remains years together in soil or in food chain.**

(x) **Adopt organic farming.**

Noise pollution

Noise is unpleasant, unwanted high intensity sound which causes discomfort and interferes the efficiency of human being. In the modern period man is also suffering from noise or man made sounds from all sides. The super fast trains, their whistles, aeroplanes, trucks, buses and cars, pneumatic drill machines, sirens, radio and television all produce noise, the most dangerous pollutants of mans environment. Noise or sound has ability to harm the body and mind of human beings. It not only cause irritation or annoyance but responsible for constriction of blood vessels, increased flow of adrenaline and force the heart to work faster. Noise can be define as "wrong sound in the wrong place at the wrong time". The unit of sound can be measure in decibel(dB).

Sources of noise pollution

- **Industries**
- **Automobiles/vehicles**
- **Domestic appliances**
- **Celebrations/functions/crackers**
- **Construction activities/blasting/stone crushing.**
- **Musical clubs/ Hostels/Bars/weekly markets**
- **Thunder storms**

Control of noise pollution

(i) **Modify the source to reduce noise output.**

(ii) **Proper lubrication and maintenance of machine reduce the noise level.**

(iii) **Machine chamber should be sound proof.**

(iv) **Worker working in heavy industries must have ear muffs or cotton plugs e.g. use of protective device provided by industrialist.**

(v) **Plant more trees because trees absorb sound and acts as buffer zone.**

(vi) **There should be silent zones e.g. educational institutes, hospitals, around residential areas where unwanted blowing of horns and declare heavy vehicle prohibition zone.**

(vii) Noisy machine can be installed in separate glass cabins.

(viii) Law and legislation can ensure that sound production at various functions is at minimum level and faulty must be punished.

(ix) Use of loudspeaker at public places should be banned.

Solid waste pollution

The solid wastes are those substances which are useless after the short period of use. These substances cause environmental pollution. The pollution caused due to the refuse material is called solid waste pollution. The materials such as new-papers, different type of canes, bottles, broken glass-wares, plastic containers, polythene bags, ashes, agriculture waste, human excreta, animal dung's etc. are solid waste materials are also called as Refuse, Garbage or Rubbish. To avoid solid waste pollution proper dumping and disposal is essential. Dumping and disposal requires proper and ample space. Increasing trend of urbanization there is a rapid growth in solid waste.

Sources of solid waste pollution

- **Urban waste :** It is a complex mixture of minerals refused by urban society. These include kitchen waste, concrete, leather, plastic, glass, hospital waste, garbage etc.
- **Industrial waste :** It include coal ash, fly ash, furnace slag, metal scraps, chemical waste like alkalies, acids and dyes and used batteries, radioactive substance from nuclear plants.
- **Agriculture waste :** It includes straws, hay, stems, dung.
- **Human and animal waste :** It include bones, skeletons of death bodies, excreta of human etc. are human waste. Animal wastes are also dead bodies, bones, dung, urine, remainants of fodder etc.

Control of solid waste pollution

(i) The huge heaps of industrial solid waste should be inside the industrial premises which cannot be contacted by any person or animals.

(ii) Metal is solid waste consist of number of smallest particles of various metals, these can be utilized again in manufacturing industries.

(iii) Industrial discharge of solid waste should not be done in fertile land for dumping.

(iv) Industrial effluents and industrial waste should not be discharges in water bodies.

(v) Oceans and river should not be the dumping ground for solid waste.

8.7. ENVIRONMENTAL PROTECTION ACT

Man has created several environmental problems such as deforestation, depletion of ozone layer, increasing rate of species extinction, disposal of toxic and nuclear waste in the vulnerable areas of the planet, air,

water, soil and sound pollution. These are responsible for deterioration of our environment and make a global problem. The global environment changes will affect the survival of the present and future generations. Therefore all over the world there have been several legislative measures used to prevent and control different components of our environment.

First time in real sense of awareness about environment protection at global level was "United Nation conference on human environment" held at Stockholm (Sweden) in June 1972. In this 113 nations participated in this conference. The result of this conference proclaimed that "The protection and improvement of human environment is a major issue which affects the well being of people and economic development throughout the world and it is duty of all governments and people to exert common effort for the preservation and improvement of human environment, for the benefit of all people and their prosperity".

Many countries have therefore introduced control mechanisms to deter and punish the enterprises violating the environment. India was the first country to impose a constitutional obligation on state and citizens to protect and improve the environment as one of its primary duties.

Article 48 A of Indian Constitution provides "The state shall endeavour to protect and improve the environment to safeguard forests and wildlife of the country".

Article 51 A Provides "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

So our country is very strictly follow all the rules and regulation that is passed by parliament and state legislature to control for environment protection like land improvement, irrigation, town planning, slum clearance, housing schemes, pest control, smoke, water, air pollution, forest and wildlife.

Some of the important laws passed by the Indian parliament are

(i) The Insecticides Act, 1968

(ii) The Water (Prevention and control of Pollution) Act, 1974

(iii) The Air (Prevention and control of Pollution) Acts, 1981

(iv) The Forest (Conservation) Act, 1980

(v) The Wildlife (Protection) Act, 1972

(vi) The Environmental (Protection) Act, 1986

(i) The Insecticides Act, 1968 :- Indiscriminate use of pesticide in agriculture and public health and cause deleterious effects on animal life and environment hazards. Being aware of the prime responsibility of protecting the health of citizens and the environment, this act has been introduced. The Act regulates import, manufacture, sale, transport, distribution and use of the insecticides with a view to preventing risk to human beings and animals.

(ii) **The Water (Prevention and control of Pollution) Act, 1974 :** The water Act prohibits dumping of poisonous, noxious or polluting matter into streams and wells, as well as any activity which impedes the proper flow of the water of stream causing aggravation of pollution due to other causes.

(iii) **The Air (Prevention and control of Pollution) Acts, 1981 :** This Act is mainly to regulate and control emissions from automobiles and industries plants.

(iv) **The Forest (Conservation) Act, 1980 :** It has several objectives as protection and conservation of forests, preventing de-reservation of forests that were reserved under forest Act 1927, restrict private leasing of forest land, preventing clear felling of natural grown tree and restricted the use of forest land for non-forest purpose.

(v) **The Wildlife (Protection) Act, 1972 :** The most serious threat to wild life is posed by habitat destruction. Over expanding agriculture industry and urbanization etc. are the important causes of habitat destruction. Realising the importance of the wild life resource this Act was passed. India has taken certain steps by setting up an Indian Board of wild life (1952), creation of wild life parks and sanctuaries, enactment of an All India Wild life Protection Act (1972), becoming a party to the convention of International Trade in Endangered species of fauna and flora (CITES, 1976), Man and Biosphere Programme (1971) etc.

The wild life (Protection) Act governs wild life conservation and protection of endangered species. It has

- Strengthening management and protection of infrastructure of national parks and sanctuaries.
- Protection of wild life and control of poaching an illegal trade in wild life products.
- Captive breeding programmes for endangered species of wild life.
- Wild life education and interpretation.
- Development of selected zoos.

(vi) **India's Environment (Protection) Act 1986**

The Environment (Protection) Act, 1986 was made into force on 23rd May 1986 and a National Environmental Awareness Campaign was launched by the Union Ministry of Environment, wild life and Forest on 19th November 1986. This Act consists of 4 chapters.

Chapter –I- Preliminary definition about environment.

Chapter –II- General Powers of the Central Government.

Chapter –III – Prevention, Control and abatement of Environment.

Chapter -IV- Miscellaneous Further describe the powers of government for effective implementation of act.

8.8. SUMMARY

- **Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges.**
- **Environmental Education is very important for the child and adult for self-fulfillment and social development. It helps in maintenance of life and health.**
- **The education for environment at awareness is essential for the younger generation as well as for the older generation.**
- **The basic aim of environmental education is to make aware the people regarding the abiotic and biotic environment and their resources.**
- **The example of natural resources are air, water, soil, forest, coal, wildlife etc,**
- **Solar energy, wind power, rainfall etc. are the example of inexhaustible resources.**
- **Exhaustible resources are classified into two type, renewable and non-renewable resources.**
- **Pollution are the material, matter or any form of energy that causes degradation, and pollution in the existing natural balance and adversely affect on the natural quality of any component of the environment.**
- **There are various type of pollution- Air pollution, Water pollution, Soil pollution, Noise pollution, soil waste pollution.**
- **India's Environment (protection) Act,1986 was made into force on 23 may 1986 and a National Environmental Awareness Campaign was launched by the Union Ministry of Encironment , Wild life and forest on 19 november 1986.**

8.9. TERMINAL QUESTIONS

Q.1. What are man made disasters? Give four examples.

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Q.2. What do you mean by environment awareness?

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Q.3. Explain the difference between renewable and non-renewable resources.

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Q.4. What are the approaches of environmental education?

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Q.5. State any two effects of noise pollution.

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Q.6. Write short notes- (a) Air Pollution (b) Water Pollution

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8.10 ANSWERS

SAQ.1. younger, older SAQ.2. abiotic , biotic SAQ.3. natural resources

SAQ.4. renewable SAQ.5. solar energy

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Notes