BSCZO- 202

B. Sc. II YEAR

ENVIRONMENTAL BIOLOGY & ANIMAL BEHAVIOUR

DEPARTMENT OF ZOOLOGY
SCHOOL OF SCIENCES
UTTARAKHAND OPEN UNIVERSITY

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COURSE 1: ENVIRONMENTAL BIOLOGY & ANIMAL BEHAVIOUR
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UNIT 1: ECOLOGICAL CONCEPT

CONTENTS

1.1 OBJECTIVES

To the study of Basic concept of ecology, definition, types of ecology, significance, concepts of habitat and ecological niche.

1.2 INTRODUCTION

Ecology is mainly concerned with the biological connections and processes of organisms, land, water etc. It can be referred as the scientific study of the interactions that determine the distribution and abundance of organism. The term ecology (oekologie) is derived from two Greek words- oikos= means 'house ` or place of live` and-logos means 'a discussion or study` Ecology is the study of organism at home in their native environment. The term was first of all introduced by Reiter in 1868, but because the German biologist Ernst Haeckel (1869) first of all fully defined ecology as the study of reciprocal relations between organism and environment.

Ecology is divided into the two main divisions:

1. **Autecology:** It is also called species ecology. It is concerned with the study of individual organism or the population of individual animals or plant species in relation to environment.
2. **Synecology**: The branch of ecology that studies about the relationship of various groups organism to their common environment.

1.3 BASIC CONCEPT OF ECOLOGY

The four basic concepts of ecology are Holism, ecosystem, succession, and conservation.

Holism

Ecology as a basic division of biology attempts to define and explain patterns within and among organisms, at each level of organization. The hierarchical levels at which we discus interacting units of ecology are, individual < population < community < ecosystem < biome < Biosphere. Each level of organization has characteristics peculiar to it that are not identifiable at the levels below. Each unit is a whole built up by the interactions of lower level wholes into a higher level whole in this kind of Hierarchy Williams Ophuls (1974) considered holism as the real base of ecology. It focuses on the system paradigm of interrelationships.

The term holism (from Greek word holon, meaning entity) was coined by the south African statesman, Jan Christian Smuts in his book Holism and evolution in 1926 to explain the process of evolution by the coming together of lesser wholes in order to create the universe.

Holism or the Holistic philosophy as one of the basic concepts of ecology explains the characteristics of units at successive higher level of organization of organisms.

Ecosystem

The concept of Ecosystem was first formulated by A.G.Tensley in 1935.An ecosystem is the whole biotic community in a given area plus its abiotic environment. It therefore includes the physical and chemical nature of the sediments, water and gases as well as all the organisms. Ecosystem ecology emphasizes the movements of energy and nutrients (chemical elements) among the biotic and abiotic components of ecosystem.

The biotic components of any ecosystem are linked as food chains. Food chains are interlinked to form complex food webs. Food webs are the basic units of ecosystem ecology. Thus ecology begins with populations and culminates in ecosystems. Food webs are basic units of ecosystem ecology the ecology begins with population and culminate in ecosystems Food webs are basic unit since it is around then that energy and nutrients transfers take place.

Succession

All living organisms and their environment are mutually reactive, affecting each other in various ways. Animal population, flora, and vegetation are interdependent through the environment and are mutually reactive.

Under natural condition, different kinds of population undergo succession. Ecosystems undergo an orderly process of change with time, passing from a less complex to a more complex state. This process involves not only change in species composition but also changes in the physical environment of a community. The terminal or stabilized state is known as climax.

Succession is thus an ecological phenomenon of replacement of an earlier ecosystem by a higher biomass-rich and trophically- diversified ecosystem. It is usually a longer term process taking centuries for a time-series procession of more resistant system of producer, consumer and decomposer organisms resulting into a stable system accompanying biotically transformed terrain or habit under a given climate.

1.3.1 CONCEPT OF ECOLOGY

The world in which we live consists of living organisms and non-living structures. Often, relationships between organisms or between organisms and non-living structure are clearly visible. The science of ecology in its pure form studies the relationships of organisms with their environment. "Organisms" means all living entitles; this definition excludes relationships between non-living entities as a possible objects of study for ecology.

The term "environment" is meant in the sense of "the surrounding world," i.e., all entities, living or not, which surround a living entity.

Ecology is divided into the two main divisions:

1. **Autecology:** Autecology deals with the study of the individual organism or an individual species. It is also called species ecology. It is concerned with the study of individual organism or the population of individual animals or plant species in relation to environment.

2. **Synecology** : Synecology is the study of inter-relationship of the organisms, such as populations, biotic communities and ecosystem and ecosystems and there environment, which are associated together as unit (i.e., community).It can be differentiated into 5 types which are:

1.Organism (physiological and behavioral ecology): organism forms a basic unit of study in ecology. At the level of organism, we know to understand the form, physiology and behaviour, distribution and adaptations in relation to the environmental conditions.

2.Population Ecology: Population ecology is a sub-field of ecology that deals with the dynamics of species populations and how these populations interact with the environment. It is the study of how the population sizes of species change over time and space. The term population ecology is often used interchangeably with population biology or population dynamics.

A **population** is a group of interacting organisms of the same species, and contains stages: pre-reproductive juveniles and reproductive adults. Most populations have a mix of young and old individuals, and characterizing the numbers of individuals of each age or stage indicates the **demographic structure** of the population. In addition to demographic structure, populations vary in the number of individuals in the group, called **population size**, and how densely packed together those individuals are, called **population density**. A population's **geographic range** has limits, or bounds, established by the encroachment of other species, by the physical limits that the organisms can tolerated, such as temperature or aridity.

3.Community Ecology: Community ecology is the study of the interactions between population and coexisting species. Community is made up of populations of different species, or animals, plants, fungi, and bacteria, living in the same area.

4.Ecosystem Ecology: Ecosystem ecology is the combined study of the physical and biological components of ecosystem. It focuses on how matter and energy flow through both organisms and the abiotic components of the environment**.**

Ecosystem ecology is the integrated study of living (biotic) and non-living (abiotic) components of ecosystems and their interactions within an ecosystem framework. This science examines how ecosystems work and relates this to their components such as chemicals, bedrock, soil, plants, and animal

5.Global ecology: A landscape is a unit of land with a natural boundary having a mosaic of patches. These patches generally represent different ecosystem. Global ecology is the study of the interactions among the Earth's ecosystems, land, atmosphere and oceans. Global ecology is very important because it is used to understand large scale interactions and how they influence the behavior of the entire planet, including the earth's responses to future changes.

1.3.2 DEFINITION OF ECOLOGY

Ecology has been defined variously by different classical and modern ecologists with different viewpoints. The traditional definition of ecology is '*the study of an organism and its environment*` however, different ecologists have defined it variously.

Ernst Haeckel (1869): defined ecology as '*the total relation of the animal to both its organic and its inorganic environment*.

Taylor 1936,: defined ecology as '*the science of all the relations of all organisms to all their environments.*

Charles Elton 1947: in his pioneer book Animal Ecology defined ecology as '*scientific natural history*.

Allee *et all.*1949: Ecology may be defined broadly as '*the science of the inter-relation between living organism and their environments, including both the physical and biotic environments, and emphasizing interspecies as well as intra-species relations.*

G.L Clarke (1954): defined ecology as '*the study of inter-relations of plants and animals with their environment which may include the influences of other plants and animals present as well as those of the physical features'.*

Woodbury (1953): regarded ecology as 'the science which investigates organisms in relation to their environment: a philosophy in which the world of life is interpreted in terms of natural processes.'

Clarke (1954): Ecology is the study of inter-relations of plants and animals with their environment.

Kendeigh (1961): It is the study of animals and plants in their relations to each other and to their environment.

Odum (1963): Ecology is the study of the structure and function of nature.

Misra (1970): In a broad sence, ecology is the study of ecosystems.

C.J.Krebs: Ecology is the scientific study of the interactions that determine the distribution and abundance of organism.

1.3.3 TYPES OF ECOLOGY

1: Habitat ecology- It deals with the study of different habitats of the biosphere. According to the kind of habitat, ecology is subdivided into marine ecology, freshwater ecology, and terrestrial ecology. The terrestrial ecology too is further subdivided into forest ecology, cropland ecology, grassland ecology, etc.

2: Ecosystem ecology-It deals with the analysis of ecosystem from structural and functional point of view including the interrelationship of physical (abiotic) and biological (biotic) components of environment.

3: Community ecology –It deals with the study of the local distribution of animals in various habitats, the recognition and com-position of community units, and succession.

4: Conservation ecology- It deals with methods of proper management of natural resources such as land, water, forests, sea, mines, etc., for the benefit of human beings.

5:Production ecology- It is the modern subdivision of ecology which deals with the gross and net production of different ecosystems such as freshwater, sea water, crop-fields and tries to do proper management of these ecosystems so that maximum yield can be obtained from them.

6: Radiation ecology- It deals with the study of gross effects of radiations and radioactive substances over the environment and living organisms.

7: Taxonomic ecology- it is concerned with the ecology of different taxonomic groups and eventually includes sub division of ecology – plant ecology, insect ecology, invertebrate ecology, vertebrate ecology, microbial ecology and so on.

8: Human ecology-It deals with the study of relationship of man with his environment.

9: Space ecology- It is a modern subdivision of ecology which remains concerned with the development of partially or completely regenerating ecosystems for supporting life of man during long space flights or during extend exploration environments.

10: System ecology- The system ecology is the most modern branch of ecology which is concerned with the analysis and understanding of the function and structure of ecosystem by the use of applied mathematics such as advanced statistical techniques, mathematical models and computer science.

11: Palaeoecology-It is the study of environmental conditions, and life of the past ages, to which palynology, palaeontology, and radioactive dating methods have made significant contribution.

12: Applied ecology- It deals with the application of ecological concepts to human needs and thus, it includes following applications of ecology: wild-life management, range management, forestry, conservation, insect control, epidemiology, animal husbandry, aquaculture, agriculture, horticulture, land use and pollution ecology.

13. Fire ecology: Studies the role of wild land fire in the environment (i.e, how it affects ecosystem processes, etc) and causes for these fires. Some species are fire-adapted while some are fire-dependent and require fire for part of their life cycle. The latter are pyrophytic plants. For instance, lodgepole pine requires the heat of fire to melt the resin on its cone, opening it up and disbursing its seeds. At my undergraduate institution (Humboldt State University) they had a fire lab to study fire ecology.

1.3.4 SIGNIFICANCE OF ECOLOGY

Ecology is about the interactions between organisms, their habitat (home) in nature. And we are all part of the ecosystem, dependent on it for our survival, since in many ways we are just one more species. But we are also in the unique situation that we can change the ecosystem in many different ways. And understanding what all the effects of changing an ecosystem will be, is important in order to avoid our actions having unintended consequences

(like the famine in the Sahel region of Africa being largely because of human changes to the ecosystem). But that is just the part of ecology that has direct consequences for us as humans.

If we want to conserve and protect nature in general and prevent the extinction of species, we need to know how they all fit together, what their habitat requirements are, how they influence each other, what the minimum population sizes are to ensure their survival, etc. So both for managing natural areas, as well as the sustainability of agriculture and our own continuous survival as a species, ecology is important. In the end, without a good knowledge of ecology, all the other fields of study will be useless… an extinct human species will no longer do any science at all.

1.4 BASIC CONCEPTS OF HABITAT

Habitat approach to nature is very important, as it aims to study organisms and non-living thing factors operating there. Thus we become well acquainted with organisms as they grow in different kinds of habitats in nature. Such an approach is mainly descriptive when we describe the environmental conditions and organisms present in different type of habitat. There are four major types of habitats in the biosphere- freshwater, marine, estuarine, and terrestrial ecology. The terrestrial ecology too further subdivided into forest ecology, cropland ecology, grassland ecology, etc.

1. Fresh water Habitats:

Fresh water habitats occupy a relatively small portion of earth's surface as compared to marine and terrestrial habitats. But the fresh water habitats are much importance to mankind. Such habitats are of two general types:

1. Standing water or (Lentic ecosystem) - Lentic habitats are represented by the ponds , lake swamps, bog etc.
2. Running water or (lotic ecosystem)- Lotic habitats are those existing in relatively fast running streams, springs, rivers.

The classification of the freshwater environments is based on two conditions: currents and the ratio of the depth to surface area. However, temperature, light, currents, amount of respiratory gases, and concentration of biogenic salts are important limiting factors influencing the organisms of all freshwater.

- **Temperature** in freshwater habitats does not show much range of variations, which is due to several unique thermal properties of water. Although temperature in such

habitats shows less variations, it is a major limiting factor in distribution of organisms, as aquatic organisms generally have narrow tolerances i.e. are stenothermal. Temperature of water is measured with the instrument, thermistor. Turbidity of water depends upon the kind and amount of suspended materials, chiefly as silt clay particles and living organisms etc. Turbidity affects the penetration of light (transparency), and thus is important limiting factor in the distribution of organisms.

- **Transparency** (that is directly related to turbidity) of water is generally measured with a very simple instrument called a secchi disk. Current action water, especially in streams, has direct very important effect on the organisms. The current generally affect the distribution of vital gases, salts, and small organisms. Concentrations of respiratory gases O_2 and CO_2 is often limiting factor in such habitats. Their concentration is measured in the terms of D.O. - dissolved oxygen, and B.O.D.- biological oxygen demand etc. **Lentic Community**:

Lentic waters are generally divided into three zones or sub-habitats: littoral, limnetic, and pro fungal. A small pond may consist entirely of littoral zone. However, a deep lake with an abruptly sloping basin may possess an extremely reduced littoral zone.

Lake Zonation: The three major zones of a lake described as follows:

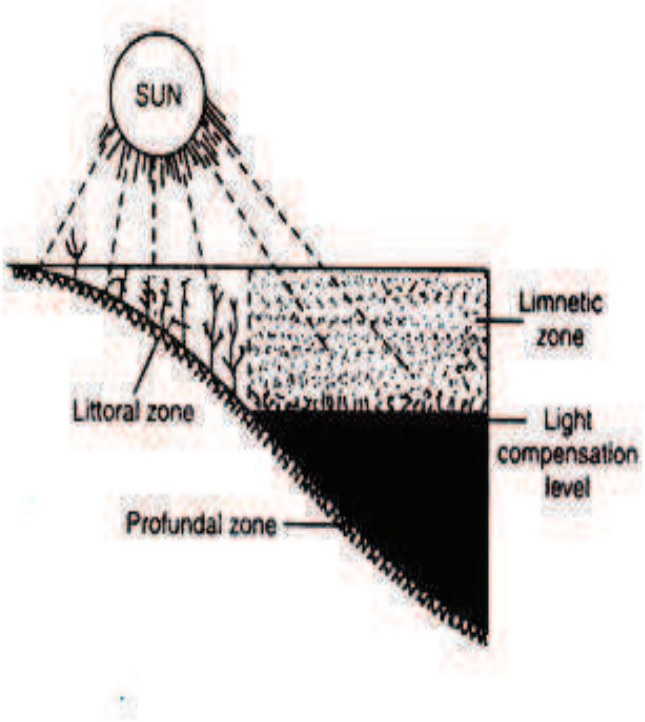


Fig: 1.1 Three Major zones of fresh water lake

(a) Littoral zone:

The littoral zone adjoins the shore (and is thus the home of rooted plants) and extends down to a point called the light compensation level, or the depth at which the rate of photosynthesis equals the rate of respiration. Within the littoral zone producers are of two main types: rooted or benthic plants, and phytoplankton (plant plankton) or floating green plants, which are mostly algae.

The littoral zone is the home of greater variety of consumers than are the other zones. The zooplankton (animal plankton) of the littoral zone is rather characteristic and differs from that of the limnetic zone in preponderance of heavier, less buoyant crustacean which often cling to plants or rest on the bottom when not actively moving their appendages. Important groups of littoral zooplankton are large, weak-swimming species of Daphnia and Simocephalus, some species of copepods, many families of ostracods and some rotifers.

The nekton of littoral zone is often rich in species and numbers. Adult and larval diving beetles and various adult Hemipetra are conspicuous. Various Diptera larvae and pupae remain suspended in the water, often near the surface. Pond fish, frogs, turtles, and water

snakes are almost exclusively the members of the littoral zone community. Tadpoles of the frogs are important primary consumers, feeding on algae and other plant material.

Periphyton of the littoral zone exhibits a zonation paralleling that of the rooted plants, but many species occur almost throughout the littoral zone. Among the periphyton forms, for example, pond snails, damselfly nymphs and climbing dragonfly nymphs, rotifers, flatworms, bryozoa, hydra, and midge larvae rest on, or are attached to stems and leaves of the plants.

Another group containing both primary and secondary consumers may be found resting or moving on the bottom or beneath silt or plant debris— for example, sprawling odonata nymphs (which have flattened rather than cylindrical bodies), crayfish, isopods, and certain mayfly nymphs. Descending more deeply into the bottom mud are burrowing odonata and ephemeroptera, clams, true worms, snails, chironomids (midges), and other diptera larvae.

(b) Limnetic Zone:

The limnetic zone includes all the waters beyond the littoral zone and down to the light compensation level. The limnetic zone derives its oxygen content from the photosynthetic activity of phytoplankton and from the atmosphere immediately over the lake's surface. The atmospheric source of oxygen becomes significant primarily when there is some surface disturbance of water caused by wind action or human activity. The community of the limnetic zone is composed only of plankton, nekton, and sometimes neuston (organisms resting or swimming on the surface).

Phytoplankton producers consist of diatoms, green algae, blue- green algae, and algae- like green flagellates, chiefly the dinoflagellates. The limnetic zooplankton consists of few species but the number of individuals may be large. Copepods, cladocerans, and rotifers are generally of first importance; but their species are largely different from those found in the littoral zone. The limnetic nekton consists almost entirely offish. In ponds, the fish of the limnetic zone are the same as those of the littoral zone, but in large bodies of water a few species may be restricted to the limnetic zone.

(C) Profundal Zone:

The bottom and deep water area of a lake, which is beyond the depth of effective light penetration, is called the pro-fundal zone. In north-temperate latitudes, where winters are long and severe, this zone has the warmest water (4°C) in the lake in winter and coldest water in summer.

The major community consists of bacteria and fungi and three groups of animal consumers:

(a) Blood worms, or haemoglobin containing chironomid larvae and annelids

(b) Small clams

(c) Phantom larvae, or Chaoborus (corethra)

The first two groups are benthic forms, the last are plankton that regularly move up into the limnetic zone at night and down to the bottom during the day. All the animals of the pro-fundal zone are adapted to withstand periods of low oxygen concentration, whereas many bacteria are anaerobic. Large numbers of bacteria in the bottom ooze constantly bring about decomposition of the organic matter (plant debris, animal remains, and excreta) that accumulates on the bottom.

Eventually the organic sediments are mineralized and nitrogen and phosphorus are put back into circulation in the form of soluble salts. In this way, the pro-fundal zone provides rejuvenated nutrients, which are carried by currents and swimming animals to other zones.

2.Marine Habitats:

The marine habitat is the largest of all habitats. The seas, oceans and bays have occupied about 70% of the earth's surface. The physical features of the marine habitat are relatively stable. All oceans are interconnected .Temperature salinity, and depths are the chief barriers to free movements of marine organisms.

In marine habitat, the most important physical factors as light, temperature, pressure, salinity, tides and currents.

Light:-

Light acts as a very important factor in the life of marine organisms due to its connection with photosynthesis, heating, radiation and vision. It is the amount of light available that determines plant life and in turn affects animal life. Penetration of light is affected by the angle of light rays. Only perpendicular rays reach deeper while slanting rays are reflected. Loss of light by reflection is about 10% and it is only the rest that penetrates.

Light determines diurnal migration of marine organisms. It also regulates color pattern of marine animals. Deep sea fauna exhibit either colorlessness or uniform coloration. It is also related with the development of visual sense organs.

Temperature:-

Ocean is the largest store house of the sun's heat and it occupies much space. Stored heat of the ocean is able to regulate the temperature of the world. Thus it also regulates the terrestrial life. Large amounts of heat reserved by the sea are lost by evaporation and these vapors are condensed over the land masses. Likewise the various tributaries of rivers and streams that merge with the sea cause a variation in the temperature of the oceans.

Temperature gradually drops in seas as depth increases. At certain intermediate depths the fall in temperature exceeds that of the surface waters and deeper water. This is called thermocline and is supposed to occur between 50 and 150 meters depth. Life in the seas has been considerably influenced in the course of evolution by the thermal variation.

Pressure:-

Pressure in the ocean varies from one atmosphere at the surface to 1,000 atmospheres at the greatest depth. Pressure changes are many times greater in the sea than in terrestrial environments and have a pronounce defect on the distribution of life in seas.

Certain organisms are restricted to surface waters where the pressure is not so great, whereas certain organisms are adapted to live at great depths. Some marine organisms like sperm-whale and certain seals can dive to great depths and return to surface without difficulty.

Animals that have a great vertical range in the sea are called eurybathic like many pelycypods. *Natica* extends between 35-225 meters. On the hand animals which are limited to a narrow range of depth are called stenobathic animals. The fish Chimarea and the sanil Turris are Setnobathic.

Salinity:-

Salinity of sea water varies from place to place depending on the amount of inflow of fresh water rivers or melting glaciers or the amount that is concentrated by evaporation.

Salinity of the open ocean at about 300 meters depth is about 3.5%. The salinity in the Mediterranean is 3.95%, while in the Red sea it is 4.6%. Salinity of the sea is due to two elements, sodium and chlorine which account for 80% of the salts in sea. In the sea water

cations and the anions are not balanced against each other. As a result sea water is weakly alkaline (pH 8 to 8.3) and strongly buffered. This factor is of much biological significant.

Animals absorb and utilize many substances like Ca, K, Na ,Mg, S, CI etc. they also use in many inorganic materials like Na, Mg, Ca and silica acid to build their bodies. A few animals even use and store rare elements. Strontium sulphate is utilized by some radiolarians. Bromine and iodine are stored by horny corals and vanadium by Ascidians.

3. Estuarine Habitats

Estuarine or Brackish zone is formed in those regions where a river meets a sea. The composition of water in this zone undergoes constant change. The concentration of dissolved substances in such habitats is unstable. At high tides such habitats experience maximum salinity. Salinity decreases during low tide and periods of heavy rain.

The rate of flow of the water or current varies greatly in different estuaries, also in various regions of any one. The constant turnover in the water of estuaries brings about considerable changes in temperature of comparatively short duration. Thus the conditions prevailing in different estuaries vary greatly depending upon topography and other factors.

4. Terrestrial Habitats

Of the three major types of habitats, terrestrial habitat is the most variable. In altitude it ranges from below sea-level (Death-valley) to mountain peaks more than 28,000 feet in height. A considerable variation of temperature is encountered in terrestrial habitat.

The lowest recorded temperature is —60°C and the highest recorded temperature is 60°C in certain deserts. The chemical and physical nature of the soil, sand and surface rocks varies greatly. The amount of moisture or relative humidity and rate of precipitation are extremely variable in different- regions of the globe.

The major subdivisions of the terrestrial habitat are given below:

(i) Tundra:

The arctic region of North America, Europe and Asia is known as Tundra region. This treeless region is characterized by long-cold winter with no or little sunlight. The summer is cool, short and is with long daylight hours. Frosting is very common and may appear at any time in this region.

Soil is never thawed beyond a depth of few inches from the surface. Bogs, marshes and ponds are the common features of this region. Mosses, Lichens and low herbs are the common vegetation. Migrant birds, like water fowls make their summer nesting grounds in the region. Resident birds of North America are Snowy owls and Ptarmigan. Amongst the mammals, Lemmings, Arctic hares, Arctic foxes, Caribou, Musk-oxen and Weasels live in this region. The alpine community on the top of many high mountains of both temperate and tropical region resembles the tundra biomes in many respects. The plant and animal species of tundra and alpine regions are almost identical.

(ii) Taiga:

The broad band just south of the tundra region of Eurasia and North America is known as taiga region. The taiga region in the southern hemisphere is poorly developed because of the absence of land mass. The region bears evergreen coniferous forests.

Climatic condition of this region is represented by bleak winter and cool summer. Precipitation is of moderate type. The summer lasts from three to six months. Red foxes, Lynx, Caribou, few reptiles and birds are found here. Spruce, Firs, Pines and Cedars are the common vegetation.

(iii) Temperate deciduous forest:

This region is characterized by warm summer and cold winter. There is about 40 inches of rainfall throughout the year and the rainfall is uniform throughout the year. The dominant trees of this region bear broad leaves. The leaves are shed in summer and new leaves develop in the following spring.

Beech, Maples, Oaks, Walnuts are the common plants of this region. Deer, Gray foxes, Racoons, flying squirrels, many snakes and amphibia are the major vertebrates present in this region.

(iv) Grass lands:

Large areas in both temperate and tropical regions do not support trees but remain covered with heavy growth of grass. This is because of lack of sufficient moisture. All the grass lands are ecologically similar in appearance.

These grass lands are also known as Steppes, Prairies, and Savannas etc. The rainfall in these regions is usually 12 to 40 inches per year. The rainfall is limited to few weeks in the year. Dominant plants of this region are Blue stem and Grama grasses. Characteristic grass land vertebrates are Bison, Pronghorn antelope, Coyotes, Prairie dogs, Rabbits, Larks, several snakes and lizards.

(v) Deserts:

Deserts occur both in temperate and tropical regions. Precipitation of moisture is the controlling factor in all deserts. The average rainfall in a desert is less than 10 inches per year and that too is very erratic with half or more than half of the annual rainfall occurring in one or two heavy downpour. Summer temperature is very high. The rate of evaporation too is very high.

The plants of the deserts are highly modified for the purpose of conservation of water. The leaves are reduced or absent or modified into thorns. The roots are long and go deep inside the soil. Many plants possess internally spongy tissue collect and store water obtained during rainy season.

Cacti, Yucca are the dominant plants. Kangaroo, rats, Foxes, Coyotes, many lizards, several snakes and toads are the common vertebrates present in the desert.

Deserts may be snowy too. The sage brush area of North America and the Sierra-Cascade mountain system are deserts of this type. The climate in these deserts is very dry. The deserts are hot in summer and cool in winter. Pronghorn antelope, Coyote, ground squirrels and many reptiles are found in these snowy deserts.

(vi) Rain forests:

Abundant rainfall in the tropics, subtropics and few regions in the temperate zone results in the formation of luxuriant vegetation of broad-leaved evergreen trees. Vines, Orchids and Epiphytes are plentiful in these regions. Characteristic vertebrates of these regions are: Monkeys, Sloths, Ant -eaters, Bats, many colourfull birds, frogs and salamanders, turtles and snakes.

A close similarity between terrestrial zonation and the zonations in mountains of high altitude is found. The zonation in a high mountain consists of a number of vegetational belts located various altitudes along a mountain slope.

Temperature and rainfall play a role on the distribution of these vegetational belts. In a high mountain temperature decreases correspondingly at higher altitudes and thus produces communities of both animals and plants located along the slopes similar to more spacious biomes that occupy large areas within certain latitudes from the equator to the poles

1.4.1 ECOLOGICAL NICHE

An ecological niche is the role and position a species has in its environment; how it meets its needs for food and shelter, how it survives, and how it reproduces. A species' niche includes all of its interactions with the biotic and abiotic factors of its environment. Biotic factors are living things, while abiotic factors are nonliving things. It is advantageous for a species to occupy a unique niche in an ecosystem because it reduces the amount of competition for resources that species will encounter.

1.5 SUMMARY

Ecology is a multidisciplinary science. Because of it focused on higher levels of the organization of life on earth and the interrelationship between organisms and their environment. Habitat is the natural abode or locality of an animal, plant or person. It includes all features of the environment in a given locality.

1.6 GLOSSARY

Adaptation: any feature of an organism that substantially improves its ability to survive and leave more offspring. Also, the process of a species' or a population's genetic variability changing due to natural selection in a manner that improves its viability.

Community: an integrated group of living organisms inhabiting a given part of an ecosystem.

Ecosystem: is a dynamic complex of plant, animal and microorganism communities and their abiotic environment, all interacting as a functional unit

Primary Production – The process of converting inorganic energy, such as Sun light, into biological energy, usually glucose.

Niche – A role or position that a creature can role within an ecosystem.

Nutrient cycling – The process through which different elements pass from organism to organism, and are used in different ways or returned to the environment.

Biosphere – The sum of all ecosystems on the planet, acting as one ecosystem.

Population: a group of individuals with common ancestry that is much more likely to mate with one another than with individuals from another such group.

Organism: an individual plant or animal.

Habitat: the natural environment in which an organism normally lives.

1.7 SELF ASSESSMENT QUESTION

1. Write short account of basic concepts of ecology.
2. Define the term ecology?
3. Write short notes on:
   (1) Autecology (2) Synecology (3) Population ecology
4. What is the importance of the study of ecology?
5. Describe various kinds of lake and pond.
6. Write the difference on fresh water habitats and marine water habitats.
7. Write a note on Rain forest and Desert forest.
8. Write an essay on Terrestrial ecology.

1.8 REFERENCES/ SUGGESTED READINGS

1. P.D. Sharma: Ecology and Environment
2. R.L. Kotpal &N.P. Bali: Concepts of Ecology
3. P.S.Verma &V.K. Agarwal: Principle of ecology
4. Eugene P.Odum: Fundamentals of Ecology
5. Eugene P.Odum &Gary W.Barrett: Fundamental of Ecology

UNIT 2: ENVIRONMENT

CONTENTS

2.1OBJECTIVE

To study of Abiotic and biotic factors. Abiotic factors like (Light intensity, Temperature, Humidity, Topography, Edaphic factors) Producer, Consumer and Decomposer. Primary and Secondary Productivity.

2.2 INTRODUCTION

The term environment means the surrounding, or all the conditions, circumstances, and influence surrounding and affecting the life of an organism or group of organism. It may be defined as the whole complex of climatic, edaphic, physiographic and biotic factor that act upon an organism or an ecological community and ultimately determine its form and survival. In other, all of the external, physical and biological factors that directly influence the survival, growth, development and reproduction of organisms depict environment. It comprises the biotic or living environment which refers to the relationship between different organisms and physical or abiotic or non-living environment being controlled by the physical the physical factors such as temperature, soil, light and electric potentials. Thus environment is multifactorial as it consists of many external factors acting in concert to affect organism. .

2.3 ABIOTIC FACTOR

In biology and ecology, **abiotic components** or **abiotic factors** are non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems. Abiotic factors and the phenomena associated with them underpin all biology. In biology, abiotic factors can include water, light, radiation temperature humidity, atmosphere, and soil. The macroscopic climate often influences each of the above. Pressure and sound waves may also be considered in the context of marine or sub-terrestrial environments. Abiotic factors in ocean environments also include aerial exposure, substrate, water clarity, solar energy and tides.

2.3.1 LIGHT INTENSITY

The sun is the main source of energy to all life on earth. Green plants and photosynthetic bacteria need light to manufacture their food. Animals depend on plants for food.

Light affects living things in terms of intensity, quality and duration. Light intensity and quality affects photosynthesis, flowering and germination of plants while in animals affects migration, hibernation and reproduction.

Sunlight affects the living conditions of all organisms to a great extent. The existence of plants and all other organisms would cease without the sun. Light provides plants with the energy they need to carry out photosynthesis. This production of food inside plant bodies initiates the chain of life and would not take place if there was no light.

In environments with little light, plants have had to adapt to these conditions. The microscopic algae or plankton are only found in the surface waters of the ocean where there is sufficient light for photosynthesis to occur. Seaweed and kelp will grow where some light can penetrate through the water but no plants are found on the deep, dark ocean floor.

Light plays an important role in the species composition and development of vegetation. Light is abundantly received on the surface of the earth. And, on an average approximately only 2-3 per cent of this solar energy is used in Primary Productivity.

Light intensity shows special variations due to the factors like atmospheric water layer, particles dispersed in the air, etc. Further, the vegetation of an area may also affect the light intensity. In deep shade under trees, or under water, light becomes limiting below which photo-synthesis is not sufficient for effective growth.

(a) Effect of Light on Plants:

Light plays a vital role directly or indirectly in regulating the growth (structure, form, size) metabolism, development and distribution of plants.

The plants are influenced by light in the following ways:

1. Effect on Chlorophyll synthesis:

The synthesis of chlorophyll in green plants can take place only in the presence of light. It is seen that if a coprophilous plant is kept in prolonged darkness, the chlorophyll amount practically disappears.

2. Effect on number and Position of Chloroplasts:

Light has marked effect on the number and position of chloroplasts, the chlorophyll bearing organelle. The upper surface of leaves which receive maximum sunlight has the largest number of chloroplasts arranged in line with the direction of light. On the other hand, the leaves of the plants which shade chloroplasts are very few in number and arranged at right angles to the light rays, thus increasing the surface of absorption.

3. Effect on Photosynthesis:

Photosynthesis is a process of conversion of solar energy (light) into chemical energy (in presence of chlorophyll) which is subsequently used for the preparation of carbohydrate from carbon dioxide and water.

Photosynthesis can be represented using a chemical equation:

The overall balanced equation is:

$$6CO_2 + 6H_2O \xrightarrow{\text{sun light}} C_6H_{12}O_6 + 6O_2$$

Where: CO_2 = carbon dioxide

H_2O = water

Light energy is required

$C_6H_{12}O_6$ = glucose

O_2 = oxygen

From the above statement, it is clear that light is highly essential for photosynthesis. The rate of photosynthesis is slower at lower intensity and it increases linearly with increasing light intensity up to a particular point, known as “Saturation point,” and after attaining this point, it remains constant. The intensity of light at which the plants no longer carry on photosynthesis or when the photosynthesis balances respiration is called compensation intensity.

4. Effect on Respiration:

In plants, respiration is a process of the oxidation of carbohydrate (produced in the photosynthesis) into carbon dioxide and water. According to Calvin.

5. Effect on Transpiration:

The rise in atmospheric temperature which may be due to the conversion of solar radiation into heat increases the rate of transpiration. The process of opening of stomata (which depends upon light) leading to loss of water from the aerial surface of plants is known as transpiration.

6. Effect on Production of Hormone:

Light inhibits the synthesis of auxins or growth hormones in plants as a result of which the shape and size of the plants gets modified (1958), the rate of respiration increases at higher light intensity and it decreases at lower light intensity.

7. Effect on development of Flowers, Fruits and Vegetative parts:

The intensity of light largely influences the growth and development of flowers, fruits and vegetative parts of plants. Light of higher intensity favours development of flowers, fruits and seeds but light of lower intensity promotes the development of vegetative parts and causes delicacy.

8. Effect on Formation of Anthocyanin Pigment:

Intense light helps in the formation of anthocyanin pigments in plants.The plants in Alpine regions have beautiful flowers containing this pigment.

9. Effect on Movement:

The effect on sunlight in modulating the movement of plants is called phototropism or heliotropism. The elongation on stem towards light is known as positive photo-tropism and the movement of roots away from light is known as negative photo-tropism. The leaves grow transversely to light.

10. Effect on Photoperiodism:

The response of plants to the relative length of the day (known as photo-period) is known as photoperiodism. According to the response of the plants to the length of the photo-period, the plants have been classified into three groups:

(i) Long Day Plants (L.D.P.):

The plant which bloom when the light duration is more than 12 hours per day e.g. radish, potato, spinach, etc.

(ii) Short Day Plants (S.D.P.):

The plant which bloom when the light duration is lesser than 12 hours per day eg. Cereals, tobacco, cosmos, dahlia etc.

(iii) Day neutral Plants (D.KP.):

The plants which show little response to the length of the day light e.g. cotton, balsam, tomato, etc.

11. Effect on Seed Germination:

The germination of seeds is largely influenced by light. In most of the plants, the red light induces seed germination and in some plants blue light promotes the process. In some cases, far-red light is seen to inhibit seed germination.

12. Effect on Distribution of Plants:

The duration and intensity of light plays an important role in determining the distribution of plants. Hence the vegetation of different geographical regions are different from one another (Krebs 1972).

13. Effect on Photo-morphogenesis:

The development of plants in seedling stage is controlled by light. The seedlings present in dark condition are non-green and highly elongated with poorly developed root system and no-foliage. However, an exposure of the dark grown seedling to light makes it normal.

(b) Effect of Light on Animals:

Besides the multifarious influence of light over plants, it has far reaching effects on the various biological activities of animals such as growth, development, reproduction, locomotion, pigmentation, metabolism etc. Some major effects of light on animals are described below.

1. **Effect on Metabolism:** Light affects metabolic processes of animals through its heating effect on tissues and by ionization of the protoplasm. This all results into an increase in the enzyme activities, general metabolic rate and degree of solubility of salt and mineral. Animals
2. receiving poor light in caves thus shows slow rate of metabolism. Light also affect photo-oxidation and respiration rates.

The rate of metabolism in animals is largely influenced by light intensity through enzyme activity.

2. Effect on Reproduction:

In case of some animals and birds, the breeding activities are induced by light through its inoculating action over the gonads. In addition, there exists a definite relationship between the length of the day (i.e. the amount of light) and egg lying by the birds.

3. Effect on Development:

Light has differential action over development. In case of some animals, light accelerates the development and in some other cases, it retards the same. For example, Salmon larva grows larger in darkness.

4. Effect on Pigmentation:

Light induces the formation of pigments in animals. It is seen that higher the intensity of light, higher will be pigmentation. For example, the human inhabitants of tropical region have higher concentration of melanin in their skin. Hence comparatively darker than their counter part in temperate region. In Mytilus, larvae in their earlier stages grow larger inn darkness than light. Some insects, crustaceans, fishes, amphibians, reptiles and cephalopods are able to change their colour or patterns rapidly according to the environmental conditions where they live.

5. Effect on Locomotion:

In some lower animals, light controls the speed of locomotion and such a process is known as photokinesis.They are of two types-

(a) Phototaxis:

It is a process of the movement of animals in response to the light stimulus. When an animal moves towards the light source, it is said to be positively phototactic and when moves away from the light source, it is said to be negatively phototactic.

(b) Phototropism:

Some animals, like many tubicolous worms and polyps of many coelenteratces, only a part of their body shows movement in response to light and this has been termed as phototropism. It is seen in case of sessile animals.

6. Photoperiodism:

The response of animals to the length of the day or the rhythms of light and darkness is called photophase. And, portion of darkness is called scatophase.Midration of eels, salmons and birds known to be affected by photoperiodism, as some birds are seen migrating towards north during summer when days are longer, and towards south during winter when days are shorter.

7. Effect on Eyes:

The degree of development of eyes depend on the intensity of light available in the environment. For example, in case of the cave dwelling animals and deep sea fishes, the eyes are absent or rudimentary as these animals live in total darkness.

Thus, from the above discussion, it is clear that light is most important environmental abiotic factor which produces diverse ecological effects. Besides, the preparation of food by photo-synthesis, it has direct effects on morphology, growth, development, metabolism, reproductive behavior, and survival of most of the plants and animals.

2.3.2 TEMPERATURE

Temperature is an abiotic factor that is strongly influenced by sunlight. Temperature plays an important role for animals that cannot regulate their own body temperature, such as reptiles. Unlike humans, whose normal body temperature is usually around 98.6°F, reptiles (such as snakes and lizards) cannot maintain a constant body temperature. Reptiles are usually found in warm regions around the planet. To regulate their body temperatures, reptiles will sun themselves on rocks, which absorb heat from sunlight and then radiate heat back into the environment

Temperature of the air and water affect animals, plants and humans in ecosystems. A rise in temperature has the potential to change the way a living thing develops, because it changes the metabolic rate of the organism. All living organisms have a tolerance level for temperature range. For example, a human being would die if he stood out in minus 50 degree temperatures for any length of time. Light exposure often affects the temperature. Areas with direct sunlight are warmer.

Biochemical processes of most organisms function effectively within a narrow range of temperature. Temperature varies due to seasons, altitude, latitude and also diurnally especially in hot deserts.

This therefore affects the distribution of organisms in a habitat. Temperature variations influence the distribution of organisms more in terrestrial habitats than aquatic habitats. Living organisms

must develop necessary physiological and behavioral adaptations to cope with extremes of temperatures.

Temperature is a measurement of the degree of heat. Like light, heat is a form of energy. The radiant energy received from the sum is converted into heat energy. Heat is measured in calories. The temperature at which physiological processes are at their maximum efficiency is called optimum temperature.

The minimum, optimum and maximum temperatures are called cardinal temperatures. The cardinal temperature varies from species to species and in the same individual from part to part. The distributions of plants, animals are also influenced by temperature.

(a) Effects of Temperature on Plants and Animals:

In affecting the structure physiology, growth and distribution of plants and animals, temperature plays an important role.

The effects of temperature on plants and animals are briefly listed below:

(i) Effect on cell and Protoplasm:

In the extremely low temperature, the protoplasm may be frozen to ice. On the other hand, in the extremely high temperature, the protein may coagulate.

(ii) Effect on Metabolism:

In the presence on different enzymes, various metabolic activities in the living organisms are carried out. With a slight increase in temperature, the metabolic activities may increase. However, the metabolic rate may decrease when there is higher increase in temperature. Finally, there will be no such activities when enzymes become defunct.

(iii) Effect on Respiration:

The rate of respiration usually doubles as per the Van't Hoff's law with increase in temperature by 10 °C in case of poikilothermic animals.

(iv) Effect on Development:

The development of plants and poikilothermic animals is influenced by temperature. The development of eggs and larvae is higher in the hot climates compared to cold climates in case of poikilotherm animals.

(v) Effect on Growth:

When the temperature is slightly increased, the poikilothermic invertebrates indicate an increase in temperature the seedlings of several plants exhibit the elongation of the hypocotyls.

(vi) Effect on Transpiration in Plants:

Transpiration is the process of loss of water from the aerial surface of plants. The rate of transpiration increases with increase in atmospheric temperature and vice versa.

(vii) Effect on Reproduction:

Maturation of gonad and gametogenesis need specific temperature which varies from species to species. The animals have different breeding periods and the maturation of gonads occur at different times. All these are due to the effect of temperature.

(viii) Effect on Sex-ratio:

The Sex-ratio in the poikilothermic animal population is determined by temperature. There is considerable increase in the number of male individuals in the copepods macrocyclops (an arthropod) with the increase in the temperature.

(ix) Effect on Morphology:

As per Jordan's Rule, the fishes living in low temperature water regions tend to have more number of vestibules than their counterparts living in the high temperature water regions.

As per the principle of Bergman's rule, the homoeothermic animals of colder climates are longer in size than their counterparts found in the hot regions of the globe. As per the Allen's Rule, the tail, snout and legs are comparatively smaller in the mammals of cold climates than those in the hot climatic regions.

(x) Effect of Coloration:

As per the principle of Gloggei's Rule, the body colour of animals is influenced by temperature. In the hot and humid climates the birds and mammals have darker pigmentation than their counterparts in the dry and cold climate.

2.3.3 HUMIDITY

It refers to the amount of water vapors in the atmosphere. When humidity is high there is much water vapors and vice versa.

Humidity affects the rate at which water evaporates from the surface of organisms such as in transpiration or sweating. This in turn affects their distribution on earth. Paper Hydrometer is used to measure or a wet and dry bulb hydrometer

Humidity is the amount of water vapour in the air. The humidity of the air will determine the amount of water an organism loses into the air. In areas where there is high humidity such as in tropical biomes, organisms will lose very little water. Desert biomes, however, have very little humidity and so plants and animals living in these areas will have special adaptations that help them to retain as much water as possible.

Atmospheric moisture in the form of invisible vapour is known as humidity. Humidity is greatly influenced by intensity of solar radiation, temperature, altitude, wind, water status of soil etc. Low temperature causes higher relative humidity by decreasing the capacity of air for moisture. Processes as transpiration, absorption of water etc. are influenced by atmospheric humidity. Humidity, thus, plays an important part in the life of plants and animals.

2.3.4 TOPOGRAPHY

The factors concerned with physical geography of the earth are known as topographic factors. These factors influence vegetation which causes variation in climate of a geographic region, ultimately give rise to a characteristic microclimate.

The different topographic factors are:

(1) Altitude of the place

(2) Steepness and exposure of the slope, and

(3) Direction of the mountain chains.

1. Altitude of the place:

As the altitude above the sea level increases, there happens a decrease of temperature. Besides, the values of pressure, humidity, wind velocity etc. also changes. All these factors together give a definite pattern of vegetational zone.

2. Steepness and Exposure of the slope:

The slope of mountain affects the nature of vegetation. In northern hemisphere, south facing slopes receives more solar radiation than the north facing slope. This may be due to the fact that the steep southern slope receives the solar radiation almost at right angles during the mid-day whereas the northern slopes receive only oblique rays during morning and evening hours. This difference in solar radiation brings about a change in vegetation in the two sides of the slope.

In addition to this, the steepness of slope accelerates the downward movement of surface water. The downward movement of water over the slope causes soil erosion and as a result, the vegetation disappears from that area.

3. Direction of mountain chains:

The direction of mountain chains considerably influences the rainfall in an area. If the mountain chains lie in the path of wind full of water vapour, then there is heavy rainfall on the wind striking side on the mountain chain.

2.3.5 EDAPHIC FACTOR

Edaphic factors deals with different aspects of soil, such as the structure and composition of soil, its physical and chemical features. A galaxy of complex factor constitutes the soil.

(A) DEFINITION:

Soil is usually defined as “any part of earth’s crust in which plants root”. The soil is constituted as a result of long-term process of complex interaction leading to the production of a mineral matrix in close contact with interstitial organic matter both living and dead.

After a long time, the parent mineral matter takes the modified shape which forms soil. The interactions among climatic, topographic and biological factors pave the process of transformation and modification of mineral matter into soil.

Thus, soil has mainly the following components:

(i) Mineral matter.

(ii) Soil organic matter or humus.

(iii) Soil water/soil solution.

(iv) Soil Atmosphere.

(v) Biological system (fauna of bacteria, fungi, algae, protozoa, ratifies, arthropods, etc.).

According to Dakuchayer (1889):

"The soil is a result of the actions and reciprocal influences of parent rocks, climate, topography, plants, animals and age of the land."

The following formula explains the components of soil:

S = (g.e.b.) x t In which, S = soil

g = geology e = environment b = biological influences t = time.

(B) Formation of Soil:

The soil development may be classified into two major phases:

1. Weathering of parent rock.

2. Maturation and profile development.

1. Weathering:

The weathering is the process by which large rocks are broken down to small pieces and converted to a fine powder. This is a long-term process occurring mostly under the influence of the climatic conditions of the area, and hence called weathering.

The mechanical or physical weathering takes places by the movement of rocks with running water or ice (as in rivers and glaciers) and by action of gravitational forces as landslide in mountainous regions. The freezing of water in small crevices in the rocks may also exert enough pressure to breakdown rocks into pieces.

In hot desert, large diurnal fluctuations in temperature also cause breaking down of rocks, especially exfoliation of sedimentary rocks. The chemical weathering includes hydrolysis, oxidation and carbonation of mineral compounds in the rocks by the action of weak acids like carbonic acid. Traces of sulphuric acid and nitric acid also occur in certain regions and influence weathering.

Biological weathering includes the action of various organisms, particularly lower plants (lichens and mosses) which secrete various organic acids, and produce humic acids after death and decay. These acids help in the weathering process.

(2) Maturation:

The maturation process determines the structure of the soil profile and the type of the soil. It is largely influenced by the prevalent climatic conditions, and indirectly by the type of vegetation found in that area.

There are four major maturation processes:

(a) Melanization:

The humus derived from the dead organic matter gets mixed in the upper layers of the soil which become dark coloured. It occurs mostly in the regions of low humidity.

(b) Podzolization:

In regions with high rainfall or high humidity and low temperature, the minerals in the humus get leached from the upper horizon and get precipitated in middle of B horizon (alluvial) forming a hard pan. This leaves an ash-coloured surface layer of the soil from which the soil derives its name Podzol.

(c) Gleization:

In very cold climates the underground water lying above the rock layer continuously reacts with the partly weathered mineral matter. The hydrolysis and reduction of the minerals result in the formation of a hard gley horizon.

(d) Patternisation:

In very hot and humid climate, the rapid decay of organic matter and release of base from organic combination result in the solubility of silica and formation of oxides of iron, aluminums and manganese, etc. This results in a red coloured soil, usually rich in iron, and deficient in bases and organic matter.

However, on the basis of the nature of transporting agents, the transported soil may be classified as follows:

(i) Coiluvial (by gravity)

(ii) Alluvial (by running waters)

(iii) Qlacial (by glaciers—large masses of snow, ice)

(iv) Eolian (by wind)

Thus, the classification of soil has been made on the basis of a combination of climatic/vegetation and soil morphology.

2.4 PRODUCERS

Producers are organisms that can make their own energy through biochemical processes, which are just processes in living things that involve chemical reactions. Also called autotrophs, the usual way producers make energy is through photosynthesis. Here, light energy is converted into sugars, which can then be broken down to release their chemical energy. When light is not present, like at the bottom of the ocean, some producers convert chemicals into energy through a process called chemosynthesis. However they do it, producers make energy for themselves and often provide food for other organism.

Producers make their own food. They do not have to obtain energy from other organisms. They obtain their energy from the sun and make food with that energy through the process of photosynthesis. Producers may also be called autotrophs. Most producers are plants, but there are some small organisms that produce food through photosynthesis as well. Producers are at the beginning of any simple food chain. On the African savanna, examples of producers would be any of the plants that grow there.

2.5 CONSUMERS AND DECOMPOSERS

The producers make their own food through photosynthesis. But many organisms are not producers and cannot make their own food. So how do these organisms obtain their energy? They must get their energy from other organisms. They must eat other organisms, or obtain their energy from these organisms some other way. The organisms that obtain their energy from other organisms are called consumers. All animals are consumers, and they eat other organisms. Fungi and many protests and bacteria are also consumers. But, whereas animals eat other organisms, fungi, protests, and bacteria "consume" organisms through different methods.

Consumers can be classified as herbivores, carnivores and omnivores. Herbivores eat only plants and plant products. Cows, deer and rabbits are herbivores. Carnivores eat only the flesh

of other animals. Tigers, snakes and hawks are carnivores. Omnivores eat plants as well as the flesh of other animals. Man and crow are examples of omnivores.

Sometimes it is useful to classify the consumers in an ecosystem on the basis of 'who eats whom'. Primary consumers are those who feed directly on the producers (plants). In other words, herbivores are primary consumers. Carnivores who feed on plant-eating animals (herbivores) are secondary consumers.

For example, a grasshopper that feeds on plants is a primary consumer, and the frog that eats the grasshopper is a secondary consumer. The frog could be eaten by a larger carnivore like a snake. A carnivore that feeds on smaller carnivores is called a tertiary consumer. This consumer may be eaten by the largest carnivore, or the top carnivore, of the ecosystem.

The top carnivore is not killed and eaten by other animals of the ecosystem. The top carnivore belongs to a higher order of consumers.

The consumers can be placed into different groups, depending on what they consume.

- **Herbivores** are animals that eat producers to get energy. For example, rabbits and deer are herbivores that eat plants.. Animals that eat phytoplankton in aquatic environments are also herbivores.
- **Carnivores** feed on animals, either herbivores or other carnivores. Snakes that eat mice are carnivores. Hawks that eat snakes are also carnivores.
- **Omnivores** eat both producers and consumers. Most people are omnivores, since they eat fruits, vegetables, and grains from plants, and also meat and dairy products from animals. Dogs, bears, and raccoons are also omnivores.

DECOMPOSERS refer to small consumers like bacteria, fungi and worms that cause the decay of dead organism. They are sometimes called to as micro consumer because many of them are microorganisms that are too small to be seen by the naked eye.

They are also described as heterotrophic because the feed on other organism. Some decomposers like fungi are **saphrotrophic**. This means fungi take in food by absorbing dissolved organic substances that are products of decay.

Decomposers break down the complex substances in bodies of dead plants and animals into simpler materials. They are the final consumers of a biotic community. They return to the nonliving environment the materials which were originally absorbed by plants from the soil.

The substances formed in decomposition are released into the soil and the atmosphere. Thus, decomposers play an important role in the recycling of materials, replenishment of the soil's nutrients, etc. They also clean up our surroundings by decomposing dead organisms and wastes from animals and plants.

2.6 PRODUCTIVITY

The productivity of an ecosystem refers to the rate of production, i.e., the amount of organic matter accumulated in any unit time.

2.6.1 PRIMARY PRODUCTIVITY

It is defined as the rate of which radiant energy is stored by the producers, most of which are photosynthetic, and to a much lesser extent the chemosynthetic microorganisms. Primary productivity is of following types:

(a) Gross primary productivity:

It refers to the total rate of photosynthesis including the organic matter used up in respiration during the measurement period. It depends on the chlorophyll content. The rate of primary productivity are estimated in terms of either chlorophyll content as chl/g dry weight/unit area, or photosynthetic number, i.e., amount of CO_2 fixed/g chl/hour.

(b) Net primary productivity:

Also known as apparent photosynthesis or net assimilation, it refers to the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by plants during the measurement period.

2.6.2 SECONDARY PRODUCTIVITY

It is the rate of energy storage at consumer's levels-herbivores, carnivores and decomposers. Consumers tend to utilize already produced food materials in their respiration and also convert the food matter to different tissues by an overall process. Some ecologists such as Odum (1971) prefer to use the term assimilation rather than 'production' at this level-the consumer's level. It actually remains mobile (i.e., keeps on moving from one organism to another) and does not live in situ like the primary productivity.

2.7 SUMMARY

Consumers must obtain their nutrients and energy by eating other organisms.Decomposers break down animal remains and wastes to get energy.Decomposers are essential for the stability and survival of an ecosystem.Consumers in ecosystems are heterotrophs, or organisms that consume other organisms for food.Consumers include herbivores, such as deer, carnivores, such as lions, and omnivores such as humans.

2.8 GLOSSARY

Habitat: the natural environment in which an organism normally lives.

Latitude: Distance from the equator.

Lentic water: Standing water (Lake, Pond).

Adaptation: any feature of an organism that substantially improves its ability to survive and leave more offspring. Also, the process of a species' or a population's genetic variability changing due to natural selection in a manner that improves its viability.

Biosphere – The sum of all ecosystems on the planet, acting as one ecosystem.

Population: a group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group.

Organism: an individual plant or animal.

Phytoplankton: Floating or freely suspended plants.

Poikilothermic: Cold –blooded animals whose body temperature fluctuates with that of environment.

Topography: The physical features of a surface area including relative elevations and the position of natural and man- made feature.

Factor: An external force, substance or condition that affects an organism**.**

Decomposers: Microbes that obtain their nutrition from breakdown products of dead organic matter.

2.9 SELF ASSESSMENT QUESTION

1. Discuss the role of light as an ecological factor.
2. What important role do decomposers play in our environment?
3. What is environment?
4. Write short notes on the following-
   1. Abiotic Factors
   2. Biotic factor
5. How temperature affecting distribution of animals?
6. How the light affecting the distribution of animals?
7. What is Primary Productivity?
8. Write short notes on the following-
   1. Decomposer
   2. Consumer

2.10 REFERENCES/ SUGGESTED READINGS

1. P.D. Sharma : Ecology and Environment
2. R.L. Kotpal &N.P. Bali: Concepts of Ecology
3. P.S.Verma &V.K. Agarwal : Principle of ecology
4. Eugene P.Odum : Fundamentals of Ecology
5. Eugene P.Odum &Gary W.Barrett : Fundamental of Ecology

UNIT 3: ECOSYSTEMS

CONTENTS

3.10- References/ Suggested Readings

3.1 OBJECTIVES

The study of Major ecosystems (Freshwater, marine, forest and desert). Concept, component and their function, energy flows, food chain, food web, trophic structures, ecological pyramid. Introduction of law of limiting factor.

3.2 INTRODUCTION

The structural and functional system of communities and their environment is called an ecosystem. Thus ecosystem is the basic structural and functional unit of ecology. The term ecosystem was proposed by A.G.Tansley in 1935. It may be defined as a system formed by the community and the environment. The ecological study of ecosystems or "Ecosystem ecology" is considered the most important aspect of ecology. There are many other parallel terms or synonyms for the ecosystem which have been proposed by various ecologist e.g., biocoenonsis (Karl Mobius, 1877), microcosm (S.A.Forbes, 1887), holocoen (Friederichs, 1930), biosystem (Thienemann, 1939).

3.3 MAJOR ECOSYSTEM

3.3.1 FRESHWATER ECOSYSTEM

The Freshwater pond as a whole represents a complete self-maintaining and self-regulating ecosystem. The pond can be defind as a body of shallow standing water characterized by relatively quiet water and abundant vegetation with thousand of micro-organism, large plant and animal. In the pond ecosystem all the four basic unit of an ecosystem are well represented these are:

1. Abiotic substances-:

These are non- living components of the pond eco system and include basic inorganic and organic compound such as water, carbon dioxide, oxygen, calcium, Nitrogen and phosphorus and their compound, amino and humus etc. Only a small amount of these vital nutrients is found in soluble state in the pond water, but much large proportion is held in reserve solid form especially in the bottom sediments, as well as in the organisms themselves. The rate of release of the nutrients from the solids, the solar input and cycle of temperature, day length and other climatic conditions regulate the rate of function of the entire ecosystem of pond on day-to-day basic.

2. Biotic Component:

The biotic component of a pond ecosystem comprised the producers and variety of consumers. In a pond the produces organism are of following main types:-

(i) Phytoplankton's- These are minute floating plants usually algae, distributed throughout the pond as deep as light penetrates. When in abundance, phytoplankonts give a greenish colour to pond water. These are very important in the production of basic food for the ecosystem such as lakes, deep ponds and even oceans. The phytoplankton of a pond usually comprise of Eudorina, Volvox, Closterium, Mycrocystis, Anabaena, Oscillatoria , Euglena, Ceratium and Malosira. The phytoplanktons are more important as producers in a pond ecosystem than the large plants.

(ii) Filamentous algae:-These also occur floating in water and include Spirogyra, Oedogonium, Nitella and chara.

(iii) Marginal and emergent plants- These are Ipomea, Jussiae which are found floating on the surface and Phragmities, Typha and Acorus, which are rooted plants or sedges.

(iv) Sub-merged plants- These are Vallisneria, Potamogeton, Naias and Otelli, which are rooted to the bottom. Utricularia and Ceratophyllum and rootless sub-merged plants.

(v) Surface- floating plants- These are Pistia, lemnaea, wolffia and Ecichorina.

3. Marco- consumers' organisms-

The macro -consumers represents animal fauna of a pond ecosystem. These are categorized as primary consumers or herbivores, secondary consumers or carnivores and the tertiary consumers. Then primary marco-consumers feed directly upon living plants plat remains and are of the following topics-

(i) Zooplanktons- These animals drift on the water surface through the agencies of water current and include dinoflagellates, hellizoans and copepods.

(ii) **Nektons**- These are free- swimming aquatic animals which swim independent of wave and current action. There for, these possess definite locomotory organs. Insecet and insect larvae which feed upon plants are included in this category.

(iii) Benthos-These are bottom-dwelling forms found crawling or attached to the bottom. These include mollusks and annelids.The secondary consumers or carnivores are predaceous insects and tertiary consumers are game fish.

4. Saprotophic or saprophytic organisms-

The fungi and saprophytic bacteria and flagellates are especially abundant in the mud water and bottoms of the ponds, where dead bodies of plants and animals are deposited. These decompose the dead bodies of the organisms and derive their nourishment. Decomposition is more rapid when temperature conditions are favorable.

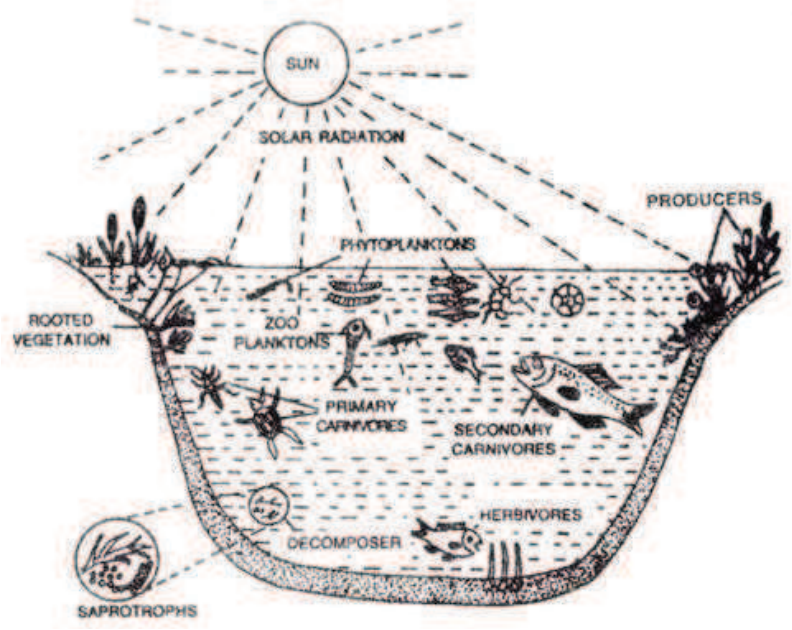


Fig.3.1 Pond ecosystem

3.3.2 MARINE ECOSYSTEM

Marine ecosystem is the biggest ecosystem, which cover around 71%of earth's surface and contain 97% of out planet's water. Water in Marine ecosystems features in high amounts minerals and salts dissolved in them. Each ocean indeed represents a very large and stable ecosystem. Marine environments as compared with fresh water appear to be more stable in their chemical composition due to being saline, and moreover other such physico- chemical as dissolved oxygen content, light and temperature are also different. The biotic components of an ocean ecosystem are of the following orders:

Producers:

These are autotrophs and also designated as primary producers, since they are responsible for trapping the radiant energy of sun with the help of their pigments. Producers are mainly the phytoplankton, such as diatoms, dinoflagellates and some macroscopic algae. Besides them, a number of macroscopic seaweeds, as brown and red algae, also contribute significantly to primary production. These organism show a distinct zonation at different depths of water in the sea.

Consumers: -

These all are heterotrophic macro-consumers, being dependent for their nutrition on the primary producers.

Primary consumer:-

The primary consumers are the herbivores, that feed directly on producers, are chiefly crustaceans, mollusks Fish etc.

Secondary consumer:-

Secondary consumers which are carnivorous fish, as Herring, Shad, Mackerel etc., feeding on the herbivores.

Tertiary consumers: -

Tertiary consumers are other carnivorous fishes like cod haddock, Halibut etc. that feed on other carnivores of the secondary consumers level. Thus these are the top carnivores in the food chain.

Decomposers:

Decomposers are mainly the microbes active in the decay of dead organic matter of producers and macro consumers are chiefly bacteria and some fungi.

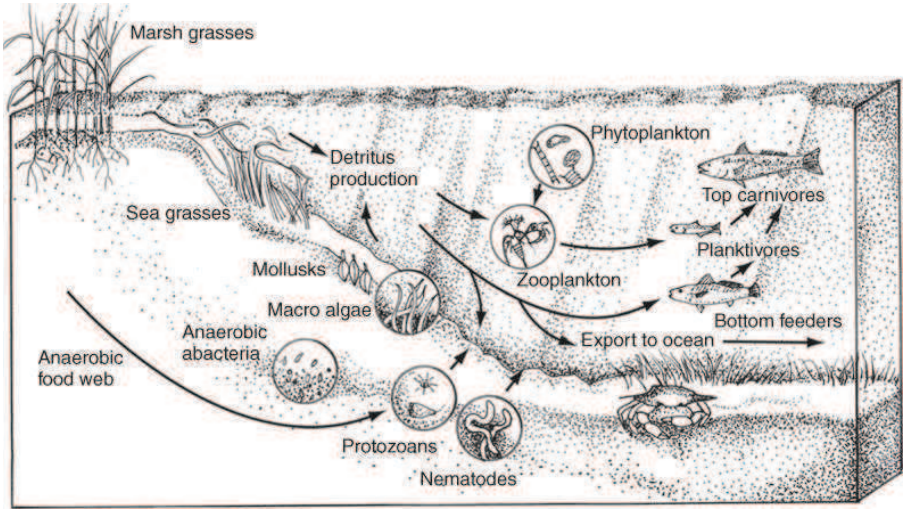


Fig. 3.2 Marine ecosystem

3.3.3 FOREST ECOSYSTEM

Forest occupy roughly 40%of the land in India, the forests occupy roughly one –tenth of the total land area. The different components of a forest ecosystem are abiotic and biotic component.

Abiotic Component:-

These are the inorganic as well as organic substances present in the soil and atmosphere. In addition to the minerals present in forests we find the dead organic debris-the litter accumulation chiefly in temperate climate. The light conditions are different due to complex stratification in the plant communities.

Biotic component:-

The living organisms present in the food chain occur in the following order-

Producers:-

These are mainly trees that show much species diversity and greater degree of stratification especially in tropical moist deciduous forests. The trees are of different kinds depending upon the kind of the forest formation developing in that climate. Besides trees, there are also present shrubs and ground vegetation/grass.In these in forest, dominant members of the flora, the producers, are such trees as Tectona grandis, Butea frondosa. Shorea rubsta and Lagerstromia Parvifioria. In temperate coniferous forest, shrubs and ground flora are insignificant. In temperate deciduous forests the dominant trees are species of Quercus, Acer, Betula,Thuja, Picea etc., whereas in a temperature coniferous forest, the producer tress are species of Abies, Picea, Pinus, Cedrus, Juniperus Rhododndron etc.

Consumers:

Consumers are categorized under the followings:

Primary consumers

Primary consumers are the herbivores that include the animals feeding on trees leaves as ants, flies, beetles, leafhoppers, bugs and spiders Etc., and large animals grazing on shoots and/ or fruits of the producers the elephant, nigai, deer, moles, squirrels, shrews, flying foxes, fruit bats, mongooses etc.

Secondary consumers

Secondary consumers are the carnivores like snakes, birds, lizards, fox etc. feeding on the herbivores.

Tertiary consumers

Tertiary consumers are the top carnivores like lion, tiger etc. That eats carnivores of secondary consumers level.

Decomposers:

These are wide variety of microorganism including fungi (species of Aspergillus, Coprinus, Polyporus, Ganoderma, Fusarium, Alternaria, Trichoderma etc.) bacteria (species of Bacillus, Clostridium, Pseudomonas, Angiococcus etc.) and actinomycetes, like speices of streptomyces etc. Rate of decomposition in tropical and subtropical forest is more rapid than that in the temperate ones.

3.3.4 DESERT ECOSYSTEM

The deserts ecosystem are located in regions that receive an annual rainfall less than 25%.They occupy about 17%of all the land on our planet. Due to extremes of temperature, the species composition of desert ecosystem is less varied and typical. The various components of a desert ecosystem are-

1. Producers:-The shrubs, bushes, grass and some trees are the main producer in deserts. The shrubs have extensive and much branched root system with the stems and leaves variously modified. Some succulent cacti are also found in deserts. These store water in their stem to be used during the time of water scarcity. Some lower plants such as lichens, xerophytic mosses and blue green algae are also found there.

2. Consumers:- Only a few animals are found in deserts. The most common animals are those reptiles and insects which are able to live under xeric conditions. Mammals are represented by a few species of nocturnal rodents. Some birds are also present. The camel, called the ship of desert, feeds on tender shoots of the plants and conserves large quantities of water in its stomach.

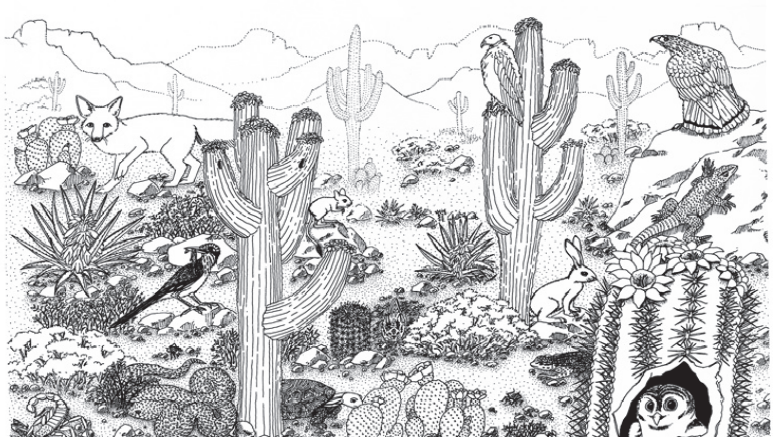


Fig. 3.3 Desert Ecosyste

3.4 CONCEPT

3.4.1 CONCEPT OF ECOSYSTEM

In biology, an ecosystem is a community of organisms and their physical environment. The notion of an ecosystem recognizes the many ways that an organism interacts with and depends on various parts of its environment. The ecosystem idea generalizes the "food chain" and "food web" concepts, allowing for more relationships than just consumption. For example, plants provide not just food for animals but also shelter, shade, moisture, etc.

While organisms in an ecosystem may be engaged in competition or predation, the concept focuses on interdependence - one organism's reliance on another or on the ecosystem as a whole.

The idea of an ecosystem has been adopted for social and economic systems. An "ecosystem" is the environment that a company is part of, including suppliers, partners, consumers, and the underlying structure and behavior of the technology, markets and social context. Framing economic interactions as being an ecosystem promotes establishing alliances with companies that might have been seen as competitors. There are many possible economic relationships, just as there are many possible relationships between organisms in a biological ecosystem.

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

Structure and Function of an Ecosystem:

Each ecosystem has two main components:

(1) Abiotic (2) Biotic

(1) ABIOTIC COMPONENTS:

The non living factors or the physical environment prevailing in an ecosystem form the abiotic components. They have a strong influence on the structure, distribution, behaviour and inter-relationship of organisms. Abiotic components are mainly of two types:

(a) Climatic Factors: Which include rain, temperature, light, wind, humidity etc.

(b) Edaphic Factors: Which include soil, pH, topography minerals etc.

The functions of important factors in abiotic components are given below:-

Soils are much more complex than simple sediments. They contain a mixture of weathered rock fragments, highly altered soil mineral particles, organic matter, and living organisms. Soils provide nutrients, water, a home, and a structural growing medium for organisms. The vegetation found growing on top of a soil is closely linked to this component of an ecosystem through nutrient cycling.

The atmosphere provides organisms found within ecosystems with carbon dioxide for photosynthesis and oxygen for respiration. The processes of evaporation, transpiration and precipitation cycle water 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.

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.

(2) BIOTIC COMPONENTS:

The living organisms including plants, animals and micro-organisms (Bacteria and Fungi) that are present in an ecosystem form the biotic components.

On the basis of their role in the ecosystem the biotic components can be classified into three main groups:

(A) Producers

(B) Consumers

(C) Decomposers or Reducers.

(A) Producers:

The green plants have chlorophyll with the help of which they trap solar energy and change it into chemical energy of carbohydrates using simple inorganic compounds namely water and carbon dioxide. This process is known as photosynthesis. As the green plants manufacture their own food they are known as Autotrophs.

(B) Consumers:

The animals lack chlorophyll and are unable to synthesize their own food. Therefore, they depend on the producers for their food. They are known as Heterotrophs (i.e. heteros = other, trophos = feeder)

The consumers are of four types:

(a) Primary Consumers or Herbivores:-

These are the animals which feed on plants or the producers. They are called herbivores. Examples are rabbit, deer, goat, cattle etc.

(b) Secondary Consumers or Primary Carnivores:-

The animals which feed on the herbivores are called the primary carnivores. Examples are cats, foxes, snakes etc.

(c) Tertiary Consumers:-

These are the large carnivores which feed on the secondary consumers. Example Wolves.

(d) Omnivores:-

These are the largest carnivores which feed on the tertiary consumers and are not eaten up by any other animal. Examples are lions and tigers.

(C) Decomposers or Reducers:-

Bacteria and fungi belong to this category. They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food and release to the environment the simple inorganic and organic substances produced as by-products of their metabolisms.

These simple substances are reused by the producers resulting in a cyclic exchange of materials between the biotic community and the abiotic environment of the ecosystem. The decomposers are known as Saprotrophs (i.e., sapros = rotten, trophos = feeder).

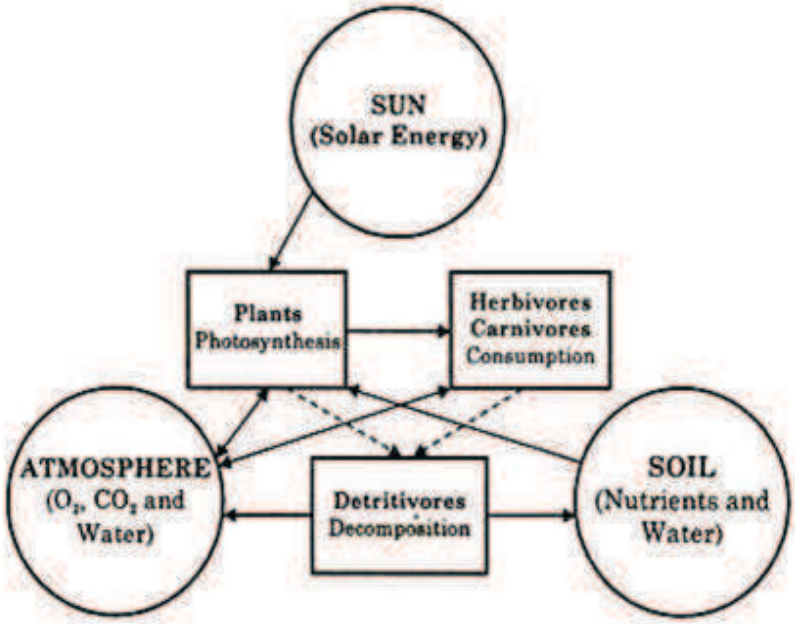


Fig. 3.4 Relationship within an Ecosystem

3.4.2 ENERGY FLOW

Energy flow (also called calorific flow) refers to the flow of energy in ecosystems through the food chain. It generally occurs in the following sequence:

Solar energy (an abiotic factor) is converted to chemical energy, when green plants convert carbon dioxide from the air and water from the earth, into glucose. Solar energy enters the ecosystem through the process of photosynthesis, which takes place in green plants, algae and bacteria, which are called primary producers.

These producers form the first tropic level of the pyramid. The producers obtain 100% of their energy from the sun. The plants are consumed by plant eating animals known as herbivores. Such herbivorous animals are the primary consumers, which form the next

trophic level of the pyramid. The primary consumers are able to obtain only 10% of the total solar energy that was initially obtained by the plants.

Secondary consumers are those that feed on the primary consumers. They are the predators and form the next trophic level. They are either carnivorous or omnivorous. Carnivores only feed on other animals, while omnivores consume both animals and plants. The secondary consumers obtain only 1% of the solar energy. The secondary consumers are eaten by the tertiary consumers, which get about 0.1% of the energy.

The final role in the energy chain is played by decomposers, whose primary function is to break down all organic matter belonging to both the producers and consumers, both the cases, and undigested food excreted by these organisms. The decomposed organic matter is released back into the soil as nutrients or into the air as gases.

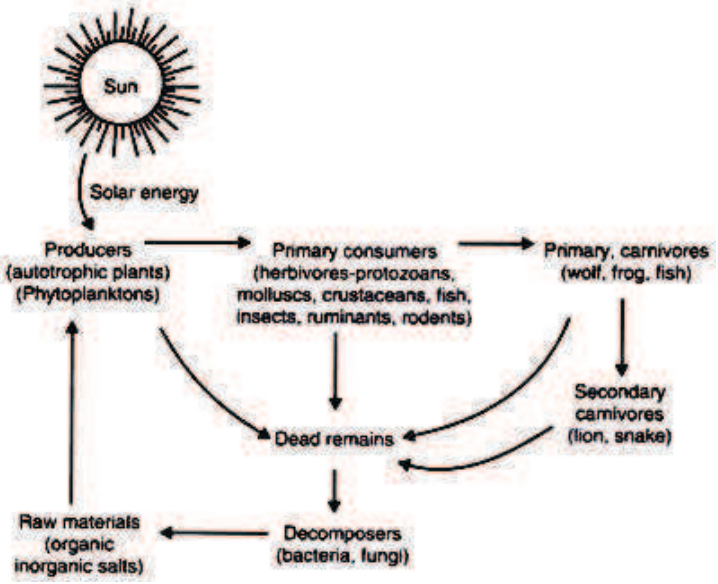


Fig. 3.5 Flow of energy at different levels of ecosystem

3.4.3 FOOD CHAIN

The feeding relationship between different organisms through which energy is transferred step-by-step from producers to the consumers is called the food chain.

In the ecosystem, green plants alone are able to trap in solar energy and convert it into chemical energy. The chemical energy is locked up in the various organic compounds, such as carbohydrates, fats and proteins, present in the green plants. Since virtually all other living organisms depend upon green plants for their energy, the efficiency of plants in any given

area in capturing solar energy sets the upper limit to long-term energy flow and biological activity in the community.

The food manufactured by the green plants is utilized by themselves and also by herbivores. Animals feed repeatedly. Herbivores fall prey to some carnivorous animals. In this way one form of life supports the other form. Thus, food from one trophic level reaches to the other trophic level and in this way a chain is established. This is known as food chain.

A food chain may be defined as the transfer of energy and nutrients through a succession of organisms through repeated process of eating and being eaten. In food chain initial link is a green plant or producer which produces chemical energy available to consumers. For example, marsh grass is consumed by grasshopper, the grasshopper is consumed by a bird and that bird is consumed by hawk.

Marsh grass → grasshopper → bird → hawk

grass→ grasshopper→ mouse → owl

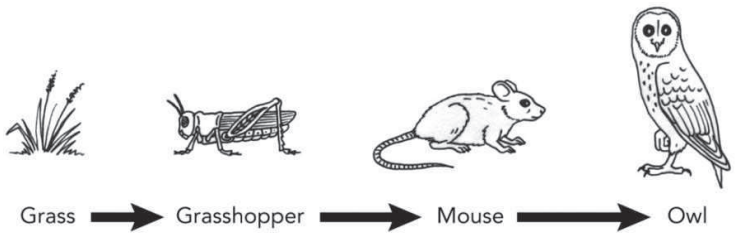


Fig .3.6 Food chain

3.4.4 FOOD WEB

Many food chains exist in an ecosystem, but as a matter of fact these food chains are not independent. In ecosystem, one organism does not depend on another. The resources are shared specially at the beginning of the chain. The marsh plants are eaten by variety of insects, birds, mammals and fishes and some of the animals are eaten by several predators.

Similarly, in the food chain grass → mouse → snakes → owls, sometimes mice are not eaten by snakes but directly by owls. This type of interrelationship interlinks the individuals of the whole community. In this way, food chains become interlinked. A complex of interrelated food chains makes up a food web. Food web maintains the stability of the ecosystem. The greater the number of alternative pathways the more stable is the community of living things. Fig. --- illustrates a food web in ecosystem.

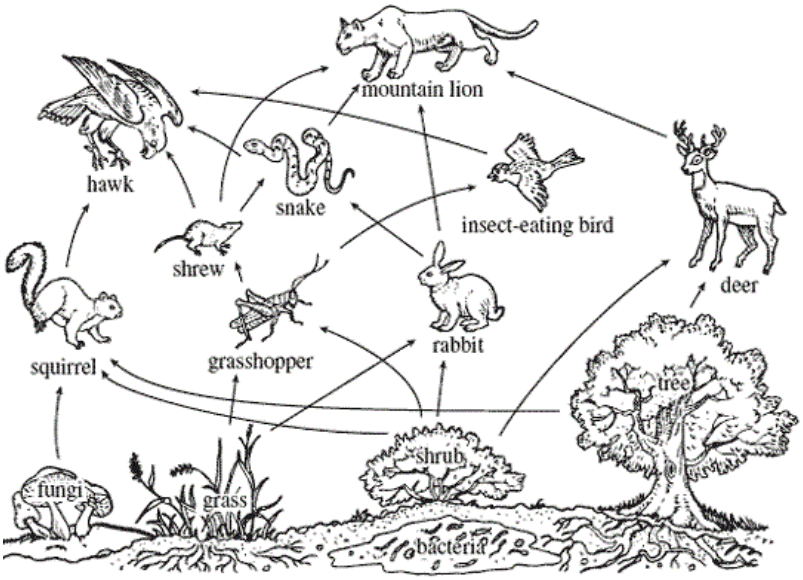


Fig. 3.7 Food web

3.4.5 TROPIC STRUCTURE

Tropic structure is a tiered structure of the organism in an ecosystem, with each level representing those organisms that share a similar function and food source. Trophic structure diagrams also depict the energy transfer from on trophic level to the next. By organizing the estuary into a trophic structure, we are given an indication of the productivity of the estuary. Productivity is basically the ability of the estuary to yield organic matter. A productive estuary is one that has high diversity, high survival rates, little to no invasive species, and

whose organisms continually carry out life processes; in other words, the estuary is sustainable. Freshwater inflows are fundamentally linked to estuarine productivity.

This trophic structure looks at the aquatic ecosystem from a bottom up point of view. The bottom tier organisms, or primary producers, are the most energy efficient, while the top tiger, or top predators, are the least energy efficient. Primary producers produce their own food, making them more energy efficient, while top fish or predators require many organisms, making them less energy efficient. Another way to say this is that predators have a much higher energy demand than do phytoplankton. The trophic structure in the figure below shows an ecosystem functioning by interrelationships and life processes. Freshwater inflows balance the estuaries by providing hydrological requirements for the organisms.

3.4.6 ECOLOGICAL PYRAMIDS

The trophic structure of an ecosystem can be indicated by means of ecological pyramid. At each step in the food chain a considerable fraction of the potential energy is lost as heat. As a result, organisms in each trophic level pass on lesser energy to the next trophic level than they actually receive. This limits the number of steps in any food chain to 4 or 5. Longer the food chain the lesser energy is available for final members. Because of this tapering off of available energy in the food chain a pyramid is formed that is known as ecological pyramid. The higher the steps in the ecological pyramid the lower will be the number of individuals and the larger their size.

The idea of ecological pyramids was advanced by C.E. Elton (1927). There are different types of ecological pyramids. In each ecological pyramid, producer level forms the base and successive levels make up the apex. Three types of pyramidal relations may be found among the organisms at different levels in the ecosystem.

These pyramids are three types

1. Pyramid of numbers
2. Pyramid of biomass (biomass is the weight of living organisms), and
3. Pyramid of energy

1. Pyramid of numbers:

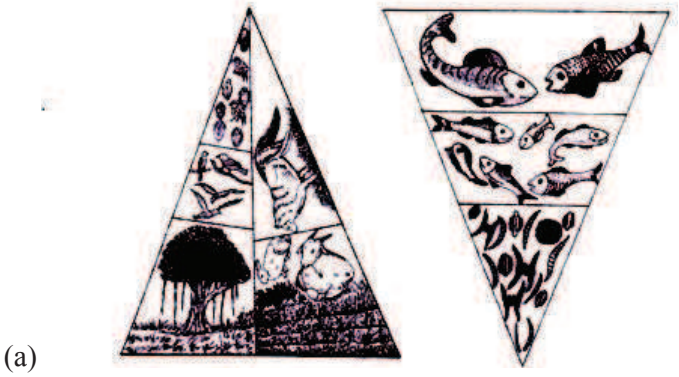
It depicts the numbers of individuals in producers and in different orders of consumers in an ecosystem. The base of pyramid is represented by producers which are the most abundant. In the successive levels of consumers, the number of organisms goes on decreasing rapidly until there are a few carnivores.

The pyramid of numbers of an ecosystem indicates that the producers are ingested in large numbers by smaller numbers of primary consumers. These primary consumers are eaten by relatively smaller number of secondary consumers and these secondary consumers, in turn, are consumed by only a few tertiary consumers (Fig. 3.8, 3.9,).

Fig .3.8 Pyramid of numbers of a lake ecosystem

This type of pyramid is best presented by taking an example of Lake Ecosystem. In this type of pyramid the base trophic level is occupied by producer elements—algae, diatoms and other hydrophytes which are most abundant. At the second trophic level come the herbivores or zooplanktons which are lesser in number than producers.

The third trophic level is occupied by carnivores which are still smaller in number than the herbivores and the top is occupied by a few top carnivores. Thus, in the ecological pyramid of numbers there is a relative reduction in number of organisms and an increase in the size of body from base to apex of the pyramid. In parasitic food chain starting from tree, the pyramid of numbers will be inverted (Fig. 3.9).



(a) (b)

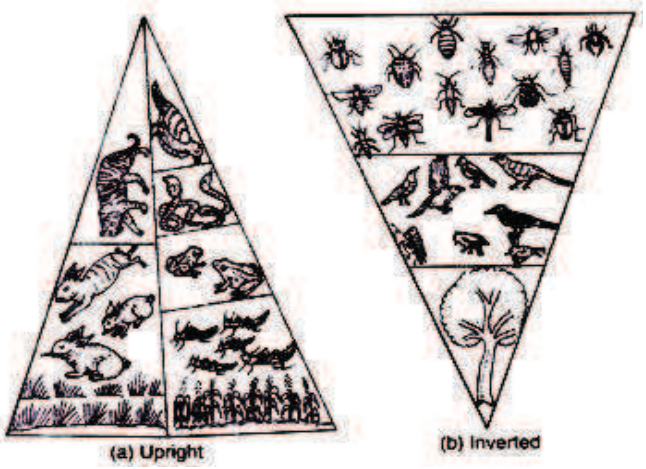
Fig .3. 9 Pyramid of numbers grassland and cultivated field (up-right) Pyramid of numbers of (Parasitic ecosystem)

2. Pyramid of biomass of organisms:

The living weights or biomass of the members of the food chain present at any one time form the pyramid of biomass of organisms. This indicates, by weight or other means of measuring materials, the total bulk of organisms or fixed energy present at one time. Pyramid of biomass indicates the decrease of biomass in each tropic level from base to apex, e.g., total biomass of producers is more than the total biomass of the herbivores.

Likewise, the total biomass of secondary consumers will be lesser than that of herbivores and so on (Fig. 3.11 a, 3.11 b). Since some energy and material are lost in each successive link, the total mass supported at each level is limited by the rate at which the energy is being stored below. This usually gives sloping pyramid for most of the communities in terrestrial and shallow water ecosystems. The pyramid of biomass in a pond ecosystem will be inverted as shown in Fig. 3.10.

Fig. 3.10 Pyramid of biomass



(a) Grass land Ecosystem (b) Aquatic Ecosystem

Fig.3.11 Pyramid of biomass

3. Pyramid of energy:

This depicts not only the amount of total energy utilized by the organisms at each trophic level of food chain but more important, the actual role of various organisms in transfer of energy. At the producer level the total energy will be much greater than the energy at the successive higher trophic level.

Some producer organisms may have small biomass but the total energy they assimilate and pass on to consumers may be greater than that of organisms with much larger biomass. Higher trophic levels are more efficient in energy utilization but much heat is lost in energy transfer. Energy loss by respiration also progressively increases from lower to higher trophic states (Fig.3.12).

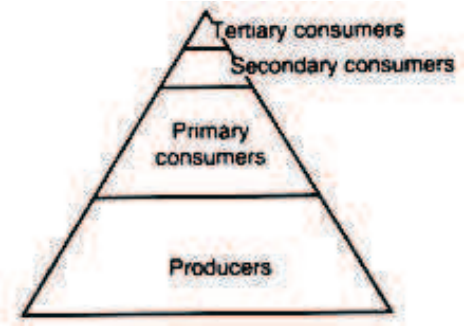


Fig .3.12 Pyramid of energy

In the energy flow process, two things become obvious. Firstly there is one way along which energy moves i.e. unidirectional flow of energy. Energy comes in the ecosystem from outside source i.e. sun. The energy captured by autotrophs does not go back to the sun, the energy that passes from autotrophs to herbivores does not revert back and as it moves progressively through the various trophic levels, it is no longer available to the previous levels.

Thus due to unidirectional flow of energy, the system would collapse if the supply from primary source, the sun is cut off. Secondly, there occurs a progressive decrease in energy level at each trophic level which is accounted largely by the energy dissipated as heat in metabolic activities.

3.5 INTRODUCTION OF LAW OF LIMITING FACTORS

All living organism, plants and animals have a range of tolerance for every environmental factor such as temperature, humidity, or salt contents of the aquatic environment. If an environment factor exceeds the maximum tolerable level or it comes down to the minimum tolerance in any given area, it becomes a limiting factor preventing the distribution of particular animals or animal groups in that area. For example, in aquatic medium the concentration of salts is often a limiting factor. Just us Liebig and V.E. Shelford have propounded two different laws governing the distribution of animals and growth of organisms.

The effect of limiting factors was studied by Blackman in 1905. He formulated the principle of limiting factors which states that when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor. In other words the rate of a physiological process is limited at a given time by one and only one factor which is deficient.

Blackman (1905) studied the effect of CO_2 concentration, light intensity and temperature on rate of photosynthesis. All other factors were maintained in optimum concentration. Initially the photosynthetic material was kept at 20°C in an environment having 0.01% CO_2.

When no light was provided to photosynthetic material, it did not perform photosynthesis. Instead, it evolved CO_2 and absorbed $O_2$from its environment. Blackman provided light of low intensity (say 150 foot candles) and found photosynthesis to occur.

When light intensity was increased (say 800 foot candles), the rate of photosynthesis increased initially but soon it levelled off. The rate of photosynthesis could be further enhanced only on the increase in availability of CO_2. Thus, initially light intensity was limiting the rate of photosynthesis.When the same was available in sufficiency, CO_2 became, Limiting. (Fig. 3.13).

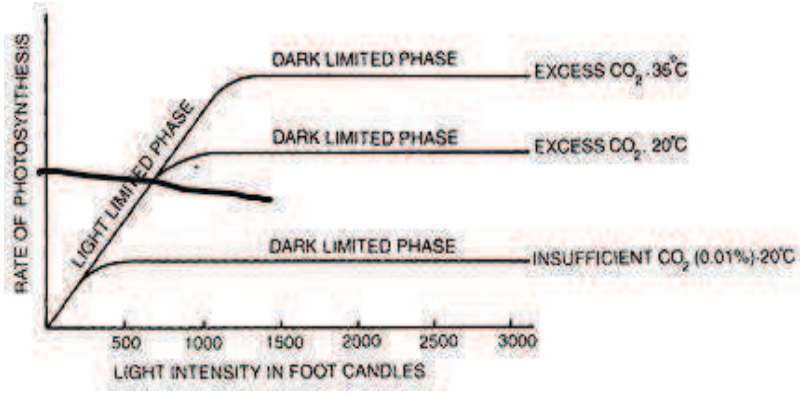


Fig.3.13 Blackman's law of limiting factors

When both were provided in sufficient quantity, the rate of photosynthesis rose initially but again reached a peak. It could not be increased further.

At this time, it was found that increase in temperature could raise the rate of photosynthesis up to 35°C. Further increase was not possible. At this stage, some other factor became limiting. Therefore, at one time only one factor limits the rate of a physiological process.

3.6 PRODUCTIVITY

In ecosystem the rate of energy trapping by green plant is related to the rate of production of organic material from inorganic substance (in a given area over a given period of time).This rate of production of biomass is called primary productivity. Primary productivity is affected by respiratory metabolism of animals & plant. Productivity is responsible for increases in weight in all parts i.e.: leaves, stem, fruits & roots, as against the agricultural productivity which refers to useful part of grain fooder part. The functional efficiency of ecosystem depends upon the production rate of primary producers. The productivity depends upon the climatic region of an ecosystem. For examples on sea shore productivity may be 2 to 4 grams/square meter/day and in deep sea only .5 to 1 gm. In Lake Ecosystem the productivity value varies from 6 to 10 gm/m^2/day and even up to 50gm in highly productive lake. The net production rate of crop plant ranges from .30 to 1 kg /square meter/year. Sugar cane and bamboo poles are efficient converter of solar energy, its net primary productivity range from 2 to 4 kg/m^2/year.

3.7 SUMMARY

Ecosystems are self-maintaining and self-regulating bodies, even then the role of cybernetic in ecology ecosystem is not ruled out. Man for his benefit must control and run the various

natural and artificial ecosystems.The various habitats, such as the forest, pond and sea the desert, grass, land and Lake Etc. have their own environmental characteristic and flora and fauna.

3.8 GLOSSARY

- **Trophic level** –The position that an organism occupies within a food chain or an ecological pyramid, such as a producer, or a primary consumer. Many animals feed at several different trophic levels.
- **Species** – A group of organisms that exhibit common characteristics and can breed among themselves to produce fertile offspring.
- **Ecosystem** – A community of interdependent living organisms in association with the nonliving elements surrounding them. The way the living organisms and the physical environment interact is by exchange of nutrients and energy.
- **Food web** – A system of food chains that are interlocked with one another. Unlike in food chains, an organism in a food web can occupy several different trophic levels
- **Primary producers**, which are usually plants and other photo synthesizers, are the gateway through which energy enters food webs.
- **Productivity** is the rate at which energy is added to the bodies of a group of organisms, such as primary producers, in the form of biomass.
- **Gross productivity** is the overall rate of energy capture.
- **Net productivity** is lower: it's gross productivity adjusted for the energy used by the organisms in respiration/metabolism, so it reflects the amount of energy stored as biomass.
- **Ecological pyramids** are visual representations of energy flow, biomass accumulation, and number of individuals at different trophic levels.
- **Trophic level** – The position that an organism occupies within a food chain or an ecological pyramid, such as a producer, or a primary consumer. Many animals feed at several different trophic levels.
- **Species** – A group of organisms that exhibit common characteristics and can breed among themselves to produce fertile offspring.
- **Ecosystem** – A community of interdependent living organisms in association with the nonliving elements surrounding them. The way the living organisms and the physical environment interact is by exchange of nutrients and energy.

- **Food web** – A system of food chains that are interlocked with one another. Unlike in food chains, an organism in a food web can occupy several different trophic levels.
- **Primary Production** – The process of converting inorganic energy, such as sunlight, into biological energy, usually glucose.
- **Niche** – A role or position that a creature can role within an ecosystem.
- **Nutrient cycling** – The process through which different elements pass from organism to organism, and are used in different ways or returned to the environment.
- **Biosphere** – The sum of all ecosystems on the planet, acting as one ecosystem.

3.9 SELF ASSESSMENT QUESTIONS

1. Describe the structure of a freshwater ecosystem?
2. Describe the abiotic component of ecosystem?
3. Describe the marine ecosystem?
4. Give an account of fresh-water ecosystem**?**
5. Define ecosystem. Give an account of the structure and function of an ecosystem?
6. Explain the following:-

a. Ecological pyramids.

b. Food web.

c. Productivity.

7. What is limiting factors?
8. Describe the biotic components of an ecosystem?
9. Describe the food chain and food web?
10. Explain the following:

a. Pyramid of Biomass

b. Pyramid of numbers-

3.10 REFERENCES/SUGGESTED READINGS

1. P.D. Sharma: Ecology and Environment
2. R.L. Kotpal &N.P. Bali: Concepts of Ecology
3. P.S.Verma &V.K. Agarwal : Principle of ecology
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UNIT 4 BIOSPHERE

CONTENTS

4.1 OBJECTIVES

Understanding the concept of Biosphere and Functioning of Biosphere and its importance, concept of Hydrosphere, Lithosphere, and Atmosphere. Functioning of Hydrosphere, Lithosphere, and Atmosphere their importance.

4.2 INTRODUCTION

The Earth occupied by living (Plants, Animals, Phytoplankton, Zooplankton and Microbes etc) entity is known as the 'biosphere' also known as the 'ecosphere' due to the interaction between living and nonliving factor within earth. The Term 'Biosphere' was introduced by geologist Eduard Sues. The biosphere includes every individual organism and species within the earth, it also includes those that can on the ground or lives in the crevices of rock and within in the soil, those that swim in rivers, ponds, streams and oceans, and those that move in and out of the atmosphere. In addition, Biosphere is part of the earth's space in which organisms live, interact, and form ecosystems. It includes the primary producers, consumers, decomposers, transformers and the total global biomass of living matter, etc.

Biosphere term is taken from two different languages, *Bios* from Greek, meaning, life; and "*sphere*" is from the Latin sphaera, which means essentially the "circuit or range. All the organisms viz: plants, animals, phytoplankton, zooplankton microbes living in a particular area can be described collectively as the 'biota. Most of the biota occurs to or very close to the surface of land or water, and the extremely thin layer on the Earth at also in the soil, organisms inhabit the upper horizons, where they feed on organic material. Organic matter reaching to the soil inhabitants by the process of decomposition of above ground inhabitants forms the parts of the biosphere. According to G. Piel biosphere, dry weight can be estimated 1,200–1,800 billion tons, 99% is plant material and remaining other four taxons. From an ecological point of view, the biosphere is the "global ecosystem", comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification.

The biosphere can also be subdivided into biomes, a biome combine a set of biotic communities within a particular region exposed to similar climatic conditions and which have dominant species with similar life cycles, adaptations, and organizations. Grasslands,

temperate deciduous forests, coniferous forests, tundra, tropical rain forests, tropical seasonal forests, freshwater biomes, estuaries, wetlands, Deserts, and marine biomes, are examples of specific terrestrial or aquatic biomes and their interactions make up a Biosphere.

Origin of biosphere starts from 3.5 billion years ago under adverse atmospheric conditions. Billions of years of primary production by plants released oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing present day oxygen rich atmosphere. Free oxygen both for breathing (O_2, respiration) and in the stratospheric ozone (O^3) that protects us from harmful UV radiation has made possible life and transforms the chemistry of earth systems forever. As a result of long term interactions between the biosphere and the other earth systems, almost every part of the earth's surface, profoundly altered by living organisms.

The biosphere is much diverse and complex; the accumulated human knowledge of its workings is remarkable but even more notable is the immense unawareness of that complexity. So far about 1.5 million living members have been identified from the biosphere and thus have some knowledge about how much it is diverse and complex. Estimates of the actual number of species on the biosphere are 3 or 3.5 – 5 million species from biological community. However, due to lack of awareness the diversity of the biosphere going to diminishing rapidly.

The biosphere concept is common to many scientific disciplines including astronomy, geophysics, geology, hydrology, biogeography and, evolution, it is a core concept in ecology, earth science and physical geography.

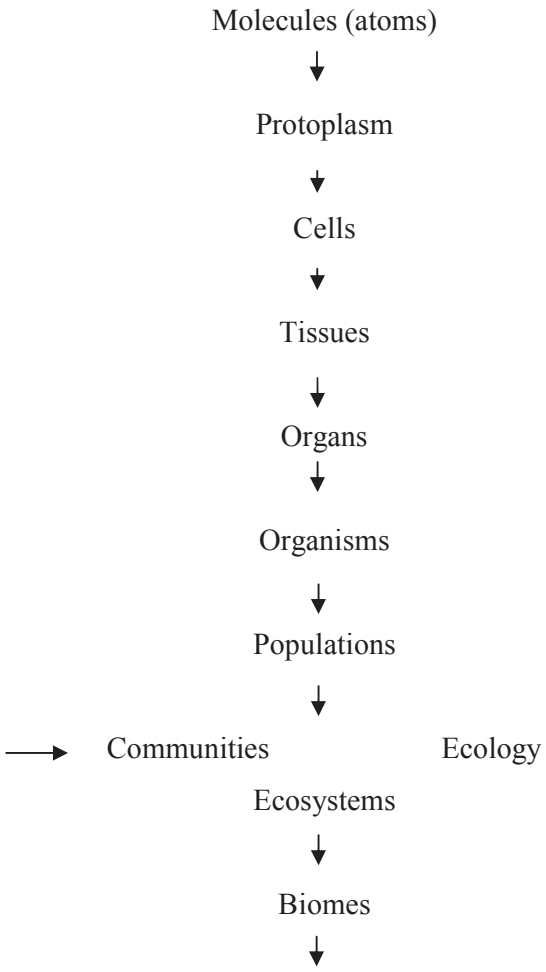
FUNCTIONING OF BIOSPHERE

The biosphere interacts with and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements these all cycles are interdependent to each other. It is key component for the smooth functioning of earth planet systems. Levels of organization by Erle Ellis within the Biosphere on the Earth are given in a flow diagram.

The biosphere is dynamic in nature, undergoing strong seasonal cycles in primary productivity and the many biological processes driven by the energy captured by

photosynthesis. Seasonal cycles in the solar irradiation of the hemispheres are the main driver of this dynamic, especially by its strong effect on terrestrial primary productivity in the temperate and boreal biomes, which essentially cease productivity in the winter time. Taxonomically, the biosphere can also be organized into five kingdoms: Monera, Protista, Fungi, Animalia, and Plantae, which includes millions of species within the earth and responsible for proper functioning of the Biosphere.

So ultimately, the biosphere is the biological component of earth systems, from different spheres, which includes the lithosphere, hydrosphere, atmosphere and other "spheres" (e.g. cryosphere, anthrosphere, etc.). It includes all living organisms on earth, together with the dead organic matter produced by them. The Biosphere can be divided into three main components, Atmosphere, Hydrosphere and Lithosphere which are described in detail in following separate sections. Fig 1 showing the Biosphere which includes Atmosphere, Hydrosphere and Lithosphere.



Biospheres

↓

Earth

↓

Solar systems

↓

Galaxies (Universe)

Flow diagram of Levels of organization with in the Earth

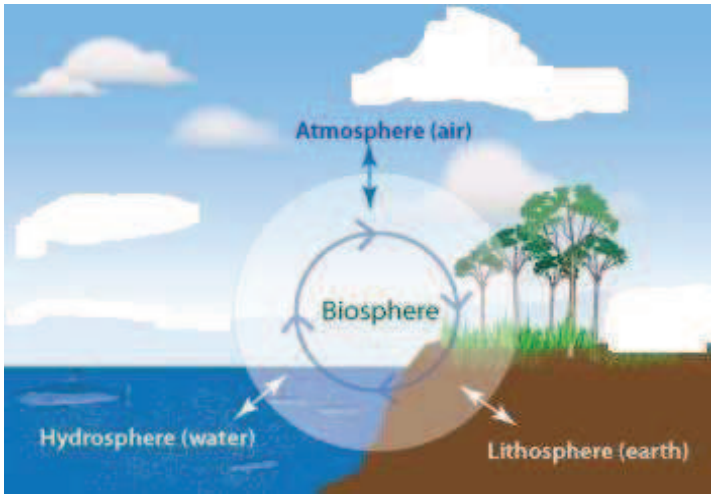


Fig: 4.1 Showing the Biosphere

4.3 ATMOSPHERE

Earth is a unique planet because life only exists on this planet. For vitality and survival of existence of life, the presence of the air plays an essential role among the conditions necessary for life. The atmosphere is a mixture of several gases which makes air. The air surrounds the earth from all sides and creates atmosphere. The air is essential for the survival of all forms of life on the earth. It is connected with the earth due to the gravitational force of the earth. It helps in stopping the ultraviolet rays harmful to the life and maintains the suitable temperature necessary for life. The atmospheres are like a large protective cover of the globe. Besides many gases, water vapour and dust particles are also found in the atmosphere. Due to this atmosphere is dynamic in nature and all kinds of changes take place in the atmosphere. Without suitable atmospheric conditions and absence of air, life is not possible in Biosphere.

COMPOSITION OF ATMOSPHERE:

The atmosphere is made up of different types of gases, water vapour, and dust particles. The composition of the atmosphere is very dynamic and changes according to the time and place.

Gases of the atmosphere: The atmosphere is the mixture of different types of gases; Nitrogen and Oxygen are the two main gases of the atmosphere. These gases contributed 99 percent and remaining gases are an organ, carbon dioxide, hydrogen, nion, helium etc only 0.99%. The details of different gases in the atmosphere are given in table 1.

Another very important gas in the atmosphere is Ozone, though the quantity of ozone gas in the atmosphere is very little and limited to the ozone layer. It has a very protective role to the living beings by absorbing the ultraviolet rays of the sun. Life cannot be imagined without ozone gas in the atmosphere on the earth.

Water vapour: Gaseous forms of water present in the atmosphere are called water vapour. It is the source of all kinds of precipitation and made life possible on the earth. Water vapour reaches in the atmosphere through evaporation and transpiration. Evaporation takes place in the oceans, seas, rivers, ponds, and lakes while transpiration takes place from the plants, trees and living beings. Water vapour percentage different from different regions in the earth Maximum amount to hot-wet regions and its least amount is found in the dry regions.

Dust Particles: The lower layers of the atmosphere are surrounded by sand, smoke and oceanic salt and known as Dust particles. Water vapour gets condensed in the form of droplets around dust particles during condensation process. Condensation is essential process of clouds and precipitation formation.

S.N.	**Gases**	**Amount (in percentage)**	
Primary gases			
1.	Nitrogen	78.1	} 99 %
2.	Oxygen	20.9	
Secondary gases			
3.	Organ	0.9	} 0.99
4.	Carbon dioxide	0.03	
5.	hydrogen	0.01	
6.	Nion	0.0018	
7.	Helium	0.0005	
8.	Ozone and others	0.00006	

Table 1: Showing percentage of different gases in the Atmosphere

STRUCTURE OF THE ATMOSPHERE:

As described earlier the atmosphere surrounds the earth from all sides and play vital roles in life on earth. The atmosphere generally extends upto about 1600 kilometers from the earth, surface. But around 97 percent of the total amount of weight of the atmosphere is limited to the height of about 30 kilometers only. Different strata of the atmosphere are presented in Fig 2. The atmosphere can be divided into five major layers due to the difference in temperature and density these are (i) Troposphere (ii) Stratosphere (iii) Mesosphere (iv) Ionosphere and (v) Exosphere**.**

(a) TROPOSPHERE: This is the lowest layer of the atmosphere which extends to the height about 18 km on the equator and 8 km on the poles. Due to the presence of hot convection currents, push the gases upward results of the higher height of the equator than poles. Troposphere the most important layer of the atmosphere because all kinds of weather change take place consequently the development of living world possible on the earth. This layer is also known as changing sphere or troposphere because the air is in always at dynamic state. The environmental temperature decreases with increasing height of atmosphere at the rate of 10 degree centigrade at the height of 165 meters and known as normal lapse rate. The transitional zone of upper limit of the troposphere is known as tropopause, has characteristics of both the troposphere and ionosphere.

(b) STRATOSPHERE: This layer lying just above of troposphere and extended upto the height of 50 km from the Earth's surface. Its, average extent around 40 km. Initially, upto the height of 20 kms, the temperature remains almost the same, later than the temperature increases slowly with the increase in the height. The temperature increases due to the presence of ozone gas in the upper part of this layer. The air flows horizontally and weather related incidents do not take place in this layer, so this layer is considered ideal for flying of aircraft.

(c) MESOSPHERE. It is the third layer of the atmosphere spreading over stratosphere upto the height of 80 km. From the surface of the earth its extent is 30 km. Temperature goes on decreasing and drops upto – 1000^{C}. 'Meteors' or falling stars occur to this layer.

(d) IONOSPHERE: This is the fourth layer of the atmosphere. It is located above the mesosphere and extended upto the height of 400 km from the surface of the earth. As the height increasing in this layer, the temperature also starts increasing. Activities like

electrically charged currents flow in the air in this sphere. Radio waves are reflected back on the earth from this sphere and due to this radio broadcasting has become possible.

(e) EXOSPHERE: It is the last layer of the atmosphere located above ionosphere and extends to over 400 km above the earth. Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.

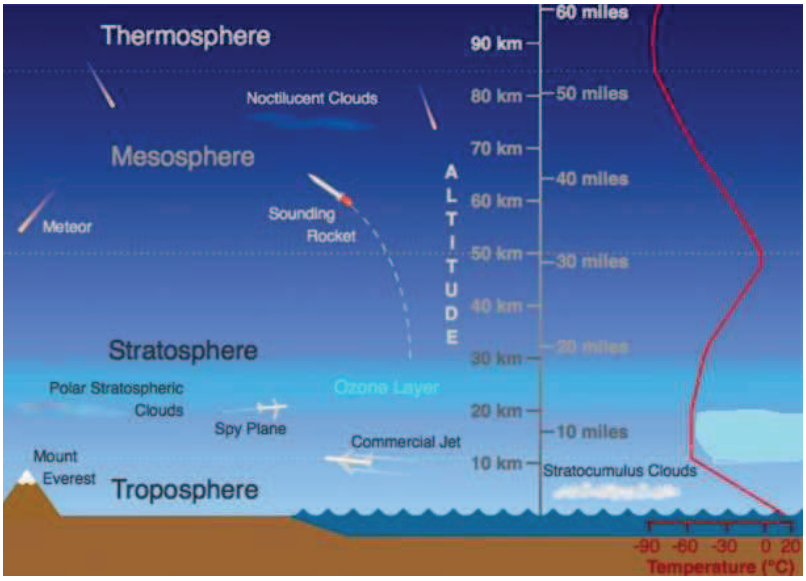


Fig 4.2: Showing the different strata of the Atmosphere

4.4 HYDROSPHERE

The hydrosphere, Greek *hydor* meaning water and *sphere* meaning sphere includes the water on or surrounding the surface of the earth, all the earth's liquid water, frozen and floating ice, water in the upper layer of soil, and the small amounts of water vapour in the earth's atmosphere. It is one of the most important divisions of Biosphere. It is responsible for the earth's hydrological cycle. The planet earth becomes the most vital due to the presence of abundance of water that covers more than two-thirds of the planet's surface, as compared to other neighboring planets like Mars, Saturn and Venus etc. The Origin of water on the Earth came about during the early days of the formation of the Earth, when the earth's surface cools down and the oxygen and hydroxides contained in the accreted material, diffused toward the surface. These gases then cooled and condensed to form the Earth's oceans. It is believed that since then, there has been little loss or gain in the overall quantity of the hydrosphere, despite minor fluctuations like gain from continued degassing and in falling comets; and loss at the upper layers of the atmosphere due to ultraviolet light breaking up of water molecules.

Quantity and Distribution of water across the earth

The earth has six major reservoirs in which water resides. These include the oceans, the atmosphere, surface water (including water in lakes, streams, and the water held in the soil), groundwater (water held in the pore spaces of rocks below the surface), and snow and ice. The Hydrosphere and how water cycle takes place, presented in Figure 3.

Availability of water in the earth: Ocean 96.5%, Ground water 1.7%, Predominantly fresh ground water 0.76, Glaciers and permanent snow cover 1.74%, water in lakes 0.013%, River water 0.0002 and water in atmosphere 0.001%, from them Only 2.53% fresh water available to the living beings. Of this freshwater, nearly 70 percent is considered to occur to the ice sheets and glaciers in the Antarctic, Greenland and in mountainous areas, while a little less than 30 percent of it is calculated to be stored as groundwater in the world's aquifers.

The biogeochemistry of the water: The biogeochemistry water depends on a number of interrelated factors like biological processes, geology, climate of the area, topography, etc which determine the quality of natural water in the various reservoirs of the hydrosphere.

Rainwater originates as evaporated water vapour and remains for relatively short time in the atmosphere. So, the lowest concentration of nutrients present in rainwater as compared to the other reservoirs. Still rainwater has some impurities, which comes from dissolution of aerosol particles, which are formed from natural processes, like evaporation of sea spray or human activities, like burning of fossil fuels. Naturally rain water has slightly acid pH (about 5.5) due to reaction of rainwater with atmospheric carbon dioxide and formation of mild carbonic acid. Increasing pollution level particularly high emission of sulphur dioxide or nitrogen oxide gases from vehicle emission, industrial activities or fossil fuel burning, hydrolysis with rain water may result in more acidic rain and pH as low as 4., results, Acid rain.

River water has an intermediate concentration of ions compared to that of rainwater and oceans. Due to weathering reactions between rainfall and rocks from which water flows, controls composition of river water, like calcite in lime stone, which reacts with carbonic acid of rainfall and determine the concentration of River water.

Lakes waters constitute a reservoir of freshwater and also have an intermediate concentration of ions as compared to river and sea water. The natural and manmade factors like the hydrology of the area (e.g. concentration of groundwater or surface water inputs, evaporation); surrounding geology (e.g. carbonate rocks or granite), temperature-driven

circulation patterns, and anthropogenic factors (e.g. acid rain, agricultural fertilizers). Determine the concentration and composition of lake water.

Sea and ocean waters are one of the most concentrated by sodium, chlorine, sulphate and magnesium etc. Surface sea water is slightly alkaline; it tends to have a more or less uniformity in composition as compared to others. The concentrations of trace and heavy meals, nutrients and other elements vary with depth and location, consequently differences in biological productivity and diversity of different types of animals particularly invertebrates and marine fishes.

Ground water quality totally depends on the chemical processes of dissolution, hydrolysis, oxidation reduction and biological processes and more important the rock type it is confined in. In addition, anthropogenic activities like sewage treatment and storage plant, industrial effluents to that particular area and contaminants like excess fertilizers and heavy metals may also affect the composition of ground water.

Effect of human beings on the hydrosphere: Over the last 50 to 100 years different man made processes like sharp rise in population, urbanization, industrial development and intensification of agricultural practices, largely affect most natural water bodies of the earth affects surface water, groundwater, and the atmosphere. Different area of the earth the intensity and scale of pollution varies considerably in the hydrosphere e.g. Presence of heavy metals effects hydrosphere globally some countries affecting by acid rain, groundwater contamination, organic material from domestic sewage, (contains pathogens which lead to disease and mortality among) municipal waste and agro-industrial effluent (main cause of groundwater contamination) is the most widespread pollutant. The populations by using this water suffering from life-threatening diseases like cancer. In addition, Excess fertilizers, from agricultural production and other organic material has also high concentrations of nutrients, particularly nitrogen and phosphorus, causing nutrient enrichment of lakes, ponds, and reservoirs known as, eutrophication. Eutrophication of water reservoirs causes promotion of abnormal plant growth consequently oxygen depletion, which totally annihilates aquatic ecosystems. So, for the proper functioning of Biosphere, hydrosphere cycles should be unaffected from anthropogenic activities.

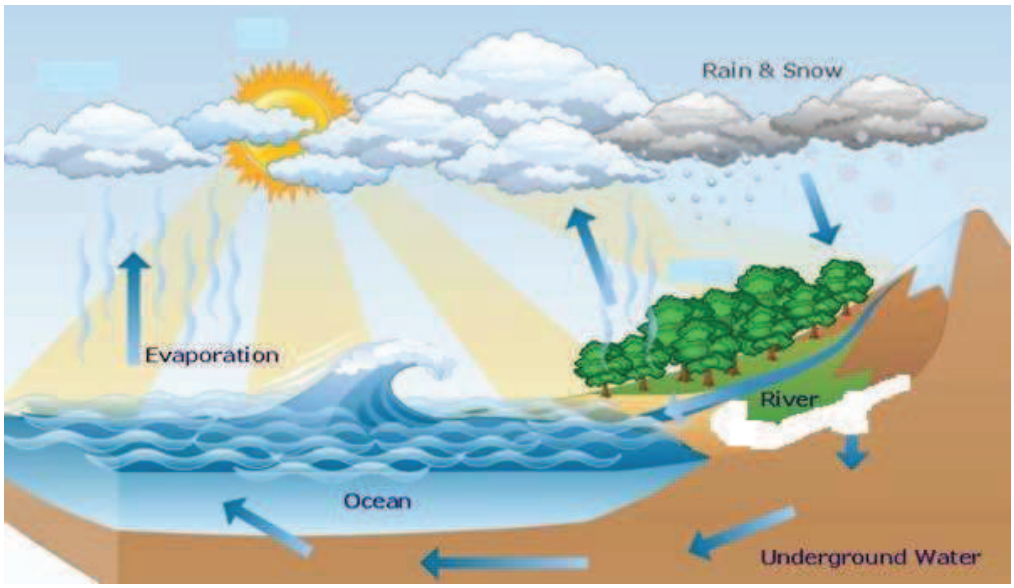


Fig 4.3. Showing the water cycle and Hydrosphere.

4.5 LITHOSPHERE

The lithosphere is the solid outermost shell of our Earth around 100 km thick. The lithosphere provides the surface on which we not only live but also very important because humans gain many valuable resources like soil, organic and inorganic substances, iron, aluminum, calcium, copper, and magnesium etc and many more yet to be described things from this part of the planet. The products of the lithosphere are also important in meeting our energy demands.

The lithosphere is divided into 15 major tectonic plates, in these places where major tectonic activities occur like earthquakes and volcanoes. The lithosphere is the coolest layer of the Earth in terms of temperature, with the heat from the lower layers generating the plate movements. In addition, lithosphere contains oceanic and continental crust that varies in age and thickness across locations and geologic time.

Structure of Lithosphere: The Lithosphere can be divided into three main layers: the crust (1 percent of Earth's volume), the mantle (84 percent), and the core (inner and outer combined, 15 percent).

Crust: It is solid and the outermost and thinnest layer of the earth. Its thickness averages 25 miles (40 kilometers) and is divided into fifteen major tectonic plates that are rigid in the center and have geologic activity at the boundaries, such as earthquakes and volcanism. The

most abundant elements in the Earth's crust include oxygen, silicon, aluminum, iron, and calcium. All three rock types (igneous, sedimentary, and metamorphic) can be found in Earth's crust. Igneous rocks are formed by solidification of magma or lava, sedimentary rocks are formed by lithification of sediments or by precipitation from solution and consolidation of remnants of plants and animals, and metamorphic rocks are formed from preexisting rocks by the changing temperature and pressure in the solid state. The Composition of different elements in the Earth is given in Table 2.

Mantle: Mantle material is hot 500 to 900 degrees Celsius and dense and moves as the semi-solid rock. The mantle is 2,900 km thick and is composed of silicate minerals that are similar to ones found in the crust, except with more magnesium and iron and less silicon and aluminum.

Outer Core: The outer core is composed mostly of iron and nickel, found in liquid form. The temperature outer core reaches between 4,000 and 5,000 degrees Celsius and is estimated 2,300 thick. The movements of the liquid within the outer core responsible for generating Earth's magnetic field.

Inner Core: The inner core is solid and hottest part of our earth, it is believed, formed recently, around half a billion years ago and has temperatures between 5,000 and 7,000 degrees Celsius. This solid layer is 1,200 km thick and is composed mostly of iron. Due to so much pressure from the overlying layer cannot melt and remain in a solid state. The Different strata of the Earth interiors have been presented in fig 4.

Elements	**Percent by weight**
Oxygen	46.6
Silicon	27.7
Aluminum	8.1
Iron	5.0
Calcium	3.6
Sodium	2.8
Magnesium	2.1

Table 2: Different elemental composition of the Earth

Compounds of Lithosphere: Lithosphere interacts with the atmosphere, hydrosphere, and biosphere and produces the pedosphere (the soil with its biotic and abiotic components) and responsible for life on the biosphere. The lithosphere contains rocks, minerals, and soils. It is made up with more than 100 chemical elements, only eight elements predominately occurs are, oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg), constitute more than 99% of its volume and remaining are rare and constitute only 1% percent. By the different types of a chemical process between these elements, crystalline solid compounds of the definite chemical composition are formed and known as minerals. Minerals formed during solidification of magma or lava is called primary minerals, and minerals formed by alteration of the primary minerals and by resynthesis and recrystallization during weathering are called secondary minerals. Chemically, minerals may be sulfides, sulfosalts, oxides and hydroxides, halides, carbonates, nitrates, borates, sulfates, phosphates, and silicates. Minerals are aggregated into rocks, different rock-forming minerals are, aluminosilicates of Ca, Mg, Na, and K.

Oil is another product of the lithosphere which is critical in meeting our fuel needs. Oil, like coal, is organic in origin and normally forms from organic deposits on the ocean floor. Oil requires unique geological and geochemical conditions in order to be produced. Part of this process involves the burial of organic-rich sediments under extremely high temperatures and pressures.

Ore An ore is a volume of rock that contains minerals which make it valuable for mining. A gemstone is a highly attractive and valuable piece of mineral which used in jewelry and other adornments like a diamond, cat's eye, and sapphire.

Coal is formed from the organic material when plants and animals decompose, leaving behind organic remains that accumulate and become compacted over millions of years under a sedimentary rock. One of the most useful fuels used in the production of electricity.

Another very noteworthy element is uranium found on earth crust. It produces energy through the process of nuclear fission and useful to meet our energy demands.

The processes weathering also occur in lithosphere by the action of natural forces over geological time, rocks and minerals are disintegrated and decomposed into new minerals and compounds such as salts, acids, bases, and soluble substances.

Hence, lithosphere plays an important role for a proper functioning of Biosphere. All ecological cycles and ecosystems are dependent on interdependence and interaction of Lithosphere, Atmosphere, and Hydrosphere.

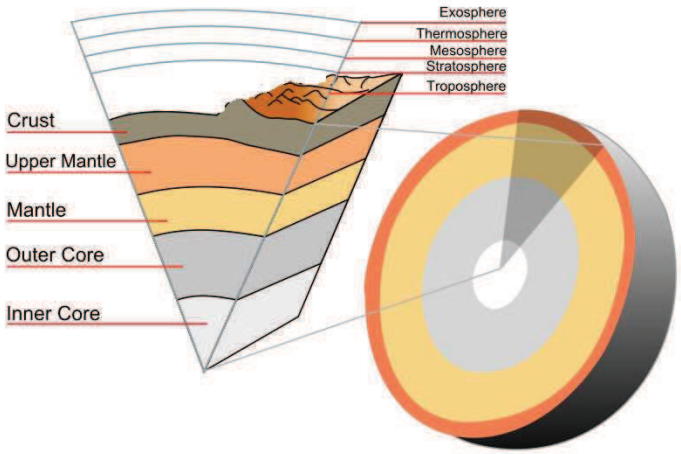


Fig4. 4: Showing different layers in Earth interiors.

4.6 SUMMARY

The Earth occupied by all living entity is known as the Biosphere. It includes every individual organism and species within the earth, those that can on the ground or lives in the crevices of rock and within in the soil, that swim in rivers, ponds, streams and oceans, and those that move in and out of the atmosphere. They interact with each other with a living and nonliving form within the earth and form ecosystems, which includes the primary producers, consumers, decomposers, transformers and the total global biomass of living matter, etc.

Origin of biosphere starts from 3.5 billion years ago under adverse atmospheric conditions. Billions of years of primary production by plants released oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing present day oxygen rich atmosphere. Organic matter reaching to the soil inhabitants by the process of decomposition of above ground inhabitants; can also form the parts of the biosphere.

Ecologically, the biosphere is the "global ecosystem", comprising the totality of biodiversity on earth and performing all manner of biological functions, including photosynthesis, respiration, decomposition, nitrogen fixation and denitrification. The dry weight of Biosphere can be estimated 1,200–1,800 billion. So far about 1.5 million living members have been identified and give an idea how much it is diverse and complex. However, estimates of the actual number of species on the biosphere at 3 or 3.5– 5 million species from biological community.

Biodiversity of the biosphere can be specified in different regions, can be divided into biomes, a biome combines set similar climatic conditions and which have dominant species with similar life cycles, adaptations, and organizations like Grasslands, temperate deciduous forests, deserts, , and marine biomes etc.

The biosphere interacts and exchanges matter and energy with the other spheres, helping to drive the global biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur and other elements, these all cycles are interdependent to each other and a key component for the functioning of earth planet systems. The biosphere is dynamic in nature, undergoing strong seasonal changes.

The atmosphere is made up of different kinds of gases and other components which are essential for life and surrounds the earth. Different gases like Oxygen; is very important for breathing and for the burning of fuels. Carbon dioxide is found in the form of carbon dio-oxide gas in the Atmosphere. The main sources of carbon are petroleum, wood, coal. Nitrogen gas is produced by decomposition of plants and animals and goes back to the atmosphere. Ozone protects all kinds of life on the earth from the harmful ultra violet rays of the sun. The amount of water vapour in the atmosphere goes on changing and directly affects the plants and living beings Dust particles present in the atmosphere create suitable conditions for the precipitation. The atmosphere can be change into different layers according to reactions takes place in them. Change of weather changing patterns only takes place in troposphere. While stratosphere is an ideal zone for flying aeroplanes due to absence of change in weather conditions. Ionosphere reflects back the radio waves to the earth and makes possible the communication system. Density of air is the least in the exosphere. Hence, atmosphere is very critical for function of Biosphere.

The hydrosphere includes all the water on or surrounding the surface of the earth, all the earth's liquid water, frozen and floating ice, water in the upper layer of soil, and the small amounts of water vapour in the earth's atmosphere. The planet earth becomes the most vital just because of the presence of abundance of water. Origin of water on the earth came about during the early days of the formation of the Earth when the earth's surface cools down and the oxygen and hydroxides contained in the accreted material, diffused toward the surface. These gases then cooled and condensed to form the Earth's oceans. Hydrosphere is one of the most important divisions of Biosphere and responsible for the earth's hydrologic cycle.

The earth has six major reservoirs in which water resides. These include the oceans, the atmosphere, surface water, groundwater and snow or ice. About 97 percent of our marine water presents in oceans and only 3% in freshwater forms. The biological processes like geology, the climate of the area, topography, etc determine the quality water in the various reservoirs of the hydrosphere.

Rainwater originates as evaporated water vapour and remains for a relatively short time in the atmosphere and sometimes pure. But due to increasing pollution level particularly high emission of sulphur dioxide or nitrogen oxide gases from vehicle emission, industrial activities, rain water may result in Acid Rain. River water has an intermediate concentration of ions compared to that of rainwater and oceans. Lakes waters constitute a reservoir of freshwater. The natural and manmade factors determine the hydrology of the lakes. Groundwater quality totally depends on the chemical processes and anthropogenic activities in that particular region. Sea and ocean waters are one of the most concentrated by sodium, chlorine, sulphate and magnesium etc. In different depths, the difference in biological productivity and diversity of animals particularly invertebrates and marine fishes can occur.
Over the last 50 to 100 years different man-made processes like sharp rise in population, urbanization, industrial development and intensification of agricultural practices, largely affect most natural water bodies of the Earth. Hence, affecting many hydrological cycles in the Biosphere.

4.7 GLOSSARY

Acid rain atmospheric rainwater polluted by acid that has been released into the atmosphere from factories and other industrial processes.
Anthropogenic caused or produced by humans.
Anthrosphere is the part of the Earth made by, modified by, or operated by Humans.
Biomass the total quantity or weight of organisms in a given area or volume.
Cryosphere that region of the earth in which the surface is perennially frozen.
Denitrification reduction of nitrates or nitrites commonly by bacteria in soil results in the escape of nitrogen into the air.
Dissolution is the process by which a solid, gas, or liquid is dispersed homogeneously in a gas, solid, or, especially, a liquid.
Eutrophication the process by which a body of water becomes enriched in dissolved nutrients such as phosphates.

Gemstone a precious stone that can be cut and polished for use as a gem.

Hydrolysis chemical decomposition in which a compound is split into other compounds by reacting with water.

Nitrogen oxide a colourless, slightly water-soluble gas, formed by the action of dilute nitric acid on copper, and other methods too

Pedosphere The earth's soil layer.

Photosynthesis the processes by which green plants use sunlight to synthesize foods from carbon dioxide and water.

Phytoplankton a flora (minute plant) freely floating with water currents like Diatoms.

Sparse thinly scattered or distributed.

Species a group of individuals having some common characteristics.

Sphere the place or environment within which a person or thing exists; a field of activity or operation.

Sulphur dioxide a colourless soluble pungent gas produced by burning sulphur.

Water vapour water in the gaseous state.

Zooplankton a small floating or swimming organisms floating with water currents like Radiolaria.

4.8 TERMINAL QUESTION

Question 1: Give detail about Biosphere and its functions.

Question 2: what is Hydrosphere, explain in detail .

Question 3: Give detail account of availability of water on in Earth.

Question 4: Distinguish between troposphere, stratosphere, and hydrosphere.

Question 5: What is Lithosphere give its structure in detail.

Question 6: Explain Lithosphere and its elemental composition.

Question 7: Explain the composition and characteristics of different layers of the atmosphere.

Question 8: Explain the importance of atmosphere.

Multiple Choice Questions Answers

Q1. On Earth, portion of upper mantle and crust are together known as its

a. Biosphere b. Lithosphere

c. Hydrosphere d. Ecosphere

Q2. Pedosphere is sum of

a. Organisms b. Soil and water

c. Air d. All of above

Q3. Layer which exists at interface of hydrosphere, lithosphere and biosphere is known as

a. Pedosphere b. Lithosphere

d. Hydrosphere d. Cryosphere

Q4. Ice mass that covers more than fifty-thousand square kilometers of land area is classified as

a. Ice sheet b. Ice field

c. Glacier erosions d. Ice cap

Q5. The atmosphere extends upto a height of about 10,000 km. It is divided into the following layers

a. Mesosphere b. Stratosphere

c. Thermosphere d. Troposphere

The correct sequence of these layers starting from the surface of the Earth upwards is:

(a) 2, 4, 1, 3 (b) 4, 2, 1, 3

(c) 4, 2, 3, 1 (d) 2, 4, 3, 1

Q. 6. Eutrophication is:

a. An improved water quality status of lakes

b. The result of accumulation of plant nutrients in water bodies like phosphorus

c. A process in the carbon cycle

d. A water purification technique

Q7. The largest reservoir of nitrogen on the Earth is:

a. Ocean b. Atmosphere

c. Biosphere d. Fossil fuels

Q8. Pollutants concentrated in successive trophic levels, phenomenon is known as:

a. Biomagnification b. Biorhythm

c. Bioremediation d. Biopiracy

Q.9. The organisms which feed on dead organisms and excreta of living organisms are known

a. Decomposers b. Consumers

c. Producers d. Carnivores

Q10. Physical and chemical components of an ecosystem constitute

a. Biotic structure b. A biotic structure

c. Both a and b these d. None of these

Q11. Biosphere is a term used to represent the:

a. Entire atmosphere consisting of troposphere, stratosphere, mesosphere, and thermosphere

b. Entire hydrosphere-representing the entire collection of water over the Earth as well as inside the Earth

c. A zone of Earth, where the lithosphere, hydrosphere, and atmosphere come in contact with one another

d. Entire lithosphere representing the solid Earth and its interior

Q.12. Weather occurs in the Earths:

a. Troposhere b. Mesophere

c. Ionosphere d. Thermosphere

Q13. Which of the following sphere of the environment is having the least storage capacity for matter?

a. Atmosphere b. Lithosphere

c. Hydrosphere d. Biosphere

Q14. Biosphere is

a. The solid shell of inorganic materials on the surface of the Earth

b. The thin shell of organic matter on the surface of earth comprising of all the living things

c. The sphere which occupies the maximum volume of all the spheres

d. All of the above

Q15. The Earth is composed of a complex set of cycles, parts and processes that all work together as a

a. Unit b. Planet

c. System d. Factory

Q16. Sum of all ecosystems is classified as

a. Aero sphere b. Ionosphere

c. Biosphere d. Ozonosphere

Q17. Physical and biological components of planet are known as its

a. Hydrosphere b. Atmosphere

c. Ecosphere d. Biosphere

Q18. Cryosphere plays an important role in

a. Global climate b. Global warming

c. Greenhouse effect d. all of above

Q19. Term 'Biosphere' was introduced by geologist

a. Eduard Sues b. Charles Darwin

c.Matthew Maury d. Arthur Tinsley

Q20. Portion of Earth's surface where water is available in its frozen form is classified as

a. Lithosphere b. Hydrosphere

c. Cryosphere d. Pedosphere

Q21. Earth's largest ice volume is present in

a. Himalayas b. South America

c. Antarctica d. North America

Answers

1. b, **2.** d, **3**.a, **4** a, **5** b, **6.** b, **7**. b, **8**. a, **9**. a, **10.** c, **11** .c, **12.** a, **13.** a, **14.** b, **15.** c, **16**.c, **17.** c, **18.** a,**19**. a, **20.** c, **21**. c.

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UNIT 5 BIOGEOCHEMICAL CYCLE

CONTENTS

5.1 OBJECTIVE

We will understand the definition of biogeochemical cycle and Identify the process involve in the different biogeochemical cycle. Compare and contrast how Carbon, Hydrogen, Nitrogen, and Oxygen cycles through the environment. Identify and describe the flow of nutrient in each biogeochemical cycle.

5.2 INTRODUCTION

The element recycles through the living component of ecosystems. During the cycle of the elements, they may be combining within complex organic or inorganic molecule and can be broken down in decomposition to simpler organic and inorganic form which can be used again and again to make the living material of an organism. As well as this activity, cycling pool of an element, all cycle have a larger reservoir pool which is usually abiotic. Exchanges between the reservoir and active cycling pool are typically limited and often slow processes. For example, the chemical weathering of phosphate rock, and fixation by the lightning of nitrogen into nitrate during thunderstorms.

5.3 BIOGEOCHEMICAL CYCLE

A biogeochemical cycle or substance turnover or cycling of substances is a pathway by which a chemical substance moves through biotic (biosphere) and abiotic (lithosphere, atmosphere, and hydrosphere) compartments of Earth. Biogeochemical cycling is the major feature of an ecosystem (along with energy flow). There are two types of biogeochemical cycles, 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 involve biotic and abiotic agents, both are driven by the flow of energy and both are tied to the water cycle.

5.3.1. THE NITROGEN CYCLE

Nitrogen is an essential constituent of different biologically significant organic molecules such as amino acids and proteins, pigments, nucleic acids, and vitamins. It is also the major constituent of the atmosphere, comprising about 79 percent of it. The paradox is that in its gaseous state, N_2 is abundant but is unavailable to most life. Before it can be utilized it must be converted to some chemically usable form. To be used biologically, the free molecular nitrogen has to be fixed and fixation requires an input of energy. In the first step molecular nitrogen, N_2 has to be split into two atoms: $N_2 \rightarrow$ 2N. The free nitrogen atoms then must be combined with hydrogen to form ammonia, with the release of some energy.

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

This fixation comes about in two ways. One is by high-energy fixation such as cosmic radiation, meteorite trails, and lightning that provide the high energy needed to combine nitrogen with oxygen and hydrogen of water. The resulting ammonia and nitrates are carried to the earth in rainwater.

The second method of nitrogen- fixation which contributes about 90 percent of fixed nitrogen of earth is biological. Some bacteria, fungi, and blue-green algae can extract molecular nitrogen from the atmosphere and combine it with hydrogen to form ammonia.

Some of this ammonia is excreted by the nitrogen-fixing organism, and, thus, becomes directly available to other autotrophs. Some of these nitrogen-fixing organisms may be free-living, either in the soil (e.g. bacteria, *Azotobacter* and *Clostridium*) or in water (e.g. blue-green algae *Nostoc, Calothrix,* and *Anabaena)* and produce vast quantities of fixed nitrogen.

In other cases, certain symbiotic bacteria of genus *Rhizobium*, although unable to fix atmospheric nitrogen themselves, can do this when in combination with cells either from the roots of legumes (e.g. peas, beans, clover and alfalfa) and of other angiosperms such as *Alnus, Ceanothus, Shepherdia, Elaeagnus,* and *Myrica* or from the leaves of African genera of *Rubiaceae* and *Pavetta)*.

The bacteria invade the roots or leaves and stimulate the formation of root-nodules or leaf-nodules, a sort of a harmless tumour. The combination of symbiotic bacteria and host cells remains able to fix atmospheric nitrogen and for this reason, legumes are often planted to restore soil fertility by increasing the content of fixed nitrogen.

Recently, certain lichens *(Collema tunaeforme* and *Peltigera rufescens*) were also implicated in nitrogen fixation (Henriksson, 1971). Lichens with nitrogen-fixing ability possess nitrogen-fixing blue green species as their algal component.

Nitrogen fixed by symbiotic and non- symbiot*ic* microorganisms in soil and water is one source of nitrogen. Another source is organic matter. The nitrogenous wastes and carrion of animals are degraded by the detritus organisms; nitrogen is converted to the amino form (e.g. L- Alanine). The amino group ($-NH_2$) is liberated from organic molecules to form ammonia; this process is called deamination. Certain specific bacteria, most notably of the genus Nitrosomonas, can oxidize ammonia to nitrate (NO_2) by the reaction.

$$2NH_3 + 3O_2 \longrightarrow 2NO_2^- + 2H_2O + 2H^+$$

This reaction takes place in the soil, in a lake or sea water or sediments, and whenever ammonia is being released and oxygen is present. As fast as nitrite is produced, other bacteria, such as Nitrobacter, can combine nitrite with oxygen to form nitrite (NO_3) by the reaction:

$$2NO_2^- + O_2 \longrightarrow 2NO_3^-$$

Both of these reactions which are performed by two nitrifying bacteria like Nitrosomonas and Nitrobacter are the parts of a single biological process called nitrification. In nitrification process, thus, ammonia is oxidized to nitrate and nitrite yielding energy. This energy is used by the bacteria to make their organic materials directly from carbon dioxide and water. Nitrate can be taken up by autotrophs at the beginning of food chain. Under certain circumstances, nitrate is either not produced in the nitrogen cycle or it is degraded before it can be utilized by autotrophs. Degradation of nitrate is called denitrification and may be important when the oxygen concentration is low. Denitrifying bacteria such as Pseudomonas can use the energy of the nitrate ion to drive their metabolism, and in so doing, they break the nitrate down to nitrite, ammonia, or molecular nitrogen:

$$C_6H_{12}O_6 + 12NO_3^- \longrightarrow 12NO_2 + 6CO_2 + 6H_2O$$

$$C_6H_{12}O_6 + 8NO_2 \longrightarrow 4N_2 + 2CO_2 + 4CO_3^{=} + 6H$$

$$C_6H_{12}O_6 + 3NO_3^- \longrightarrow 3NH_3 + 6CO_2 + 3OH^-$$

If denitrification is signification in an ecosystem, nitrite is transitory and is also degraded into either ammonia or molecular nitrogen.

Cycling of nitrogen in the ecosystem. The sources of inputs of nitrogen under natural conditions are the bacterial fixation of atmospheric nitrogen, addition of inorganic nitrogen in rain from such sources as lightning fixation and fixed "juvenile" nitrogen from volcanic activities, ammonia absorption from the atmosphere by plants and soil, and nitrogen accretion from windblown aerosols, which contain both organic and inorganic forms of nitrogen.

In terrestrial ecosystems, nitrogen, largely in the form of ammonia and nitrates is taken up by plants, which convert it into amino acids and proteins. Animals (primary macro-consumers) may eat the plants and utilize the amino acid from the plant proteins in the synthesis of their own proteins and other cellular constituents. When animals and plants die, the bacteria convert the nitrogen of their proteins and other compounds into ammonia.

Animals excrete several kinds of nitrogen-containing wastes like urea, uric acid, creatinine, and ammonia and the decaying bacteria convert these wastes to ammonia.

Ammonia may be lost as gas to the atmosphere, may be acted upon by nitrifying bacteria, or may be taken up directly by plants. The nitrates may be utilized by plants, immobilized by microbes, stored in decomposing humus, or leached away. This material is carried to streams, lakes, and eventually into the sea, where it is available for use in aquatic ecosystems. Their nitrogen is cycled in a similar manner, except that the large reserves contained in the soil humus are largely lacking. Life in the water contributes organic matter and dead organisms that undergo decomposition and subsequent release of ammonia and ultimately nitrates.

In an aquatic ecosystem atmospheric nitrogen is fixed by numerous blue-green algae. Under natural conditions nitrogen lost from ecosystem by denitrification, volatilization, leaching, erosion, windblown aerosols, and transportation out of the system is balanced by biological fixation and other sources. Both chemically and biologically, terrestrial and aquatic ecosystems constitute dynamic equilibrium system in which a change in one phase affects the other. The cycling of the Nitrogen in the ecosystem has been presented in Fig 5.1.

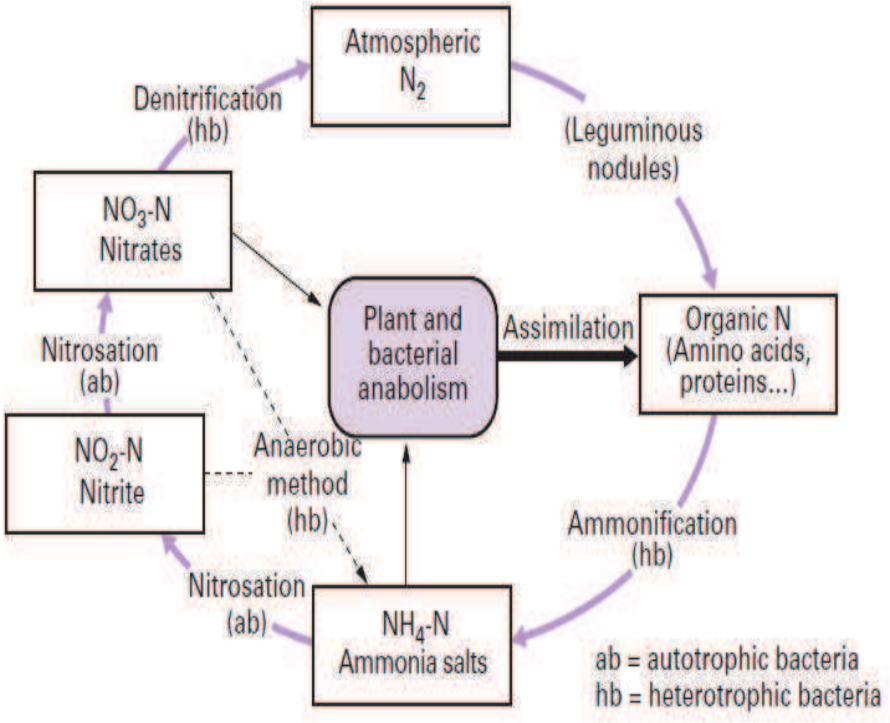

Figure 5.1. Nitrogen Cycle

5.3.2 CARBON CYCLE

The carbon being a basic constituent of all organic compounds and a major element involved in the fixation of energy by photosynthesis is so closely tied to energy flow that the two are inseparable. The source of all the fixed carbon both in living organisms and fossil deposits is carbon dioxide CO_2, found in the atmosphere and dissolved in the waters of the earth. During photosynthesis, carbon from atmospheric CO_2 is incorporated into the production of the carbohydrate, glucose ($C_6H_{12}O_6$) that subsequently may be converted to other organic compounds such as polysaccharides (sucrose, starch, cellulose, etc) proteins and lipids. All the polymeric organic compounds containing carbon are stored in different plant-tissues as food and from them the carbon is passed on to the trophic levels of herbivores or phytoparasites or retained by the plant until it serves as food for decay organisms (viz., decomposers). Some of the carbon is returned to the atmosphere (or the enveloping aqueous medium) in the form of CO_2, a by-product of plant respiration, in which, a considerable portion of glucose is oxidized to yield CO_2, H_2O and energy as follows:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6\,H_2O + \text{Energy}$$

The CO_2 which is released as the by-product of plant respiration is again used by plants in photosynthesis. This is the basic carbon cycle which is simple and complete. Decomposing microorganisms are important in breaking down dead material with the release of carbon back into the carbon cycle.

Similarly, carbon taken up by herbivores or phytoparasites may travel a number of routes. It may be incorporated into protoplasm (assimilation) and stored until the organism dies, whereupon it is utilized by decomposers; it may be released through animal respiration; it may serve as live food for other organisms or finally it may be stored in the environment as CO_2.

However, all the carbon of plants, herbivores, carnivores and decomposers is not respired but some are fermented and some are stored.

The carbon compounds that are lost to the food chain after fermentation, such as methane, are readily oxidized to carbon dioxide by inorganic reactions in the atmosphere. As for the storage of carbon in sediments, just as deposition works to store materials, erosion may uncover them, and inorganic chemical weathering of rock can oxide the carbon contained there. Some carbon is permanently stored in sediments and not uncovered by weathering; it may be replaced by carbon dioxide released from volcanoes and other similar examples of intense geological activity.

In the modern age, man has greatly increased the rate at which carbon is passing from sedimentary from to carbon dioxide. The combustion of fossil fuels is a significant means of recycling sedimentary carbon much faster than natural weathering. A small portion of carbon, especially in the sea, found not as organically fixed carbon, but as carbonate (CO_3^{-2}), especially calcium carbonate ($CaCO_3$). $CaCO_3$ is very commonly used for shell construction by such animals as clams, oysters, some protozoa, and some algae. Carbon dioxide reacts with water to form carbonate in the following three-step reaction:

$$CO_2 + H_2O \rightarrow \underset{\text{Carbonic acid}}{H_2CO_3} \rightarrow \underset{\text{Bicarbonate}}{H^+ + HCO_3^-} \rightarrow \underset{\text{Carbonate}}{2H^+ + CO_3}$$

The precise amount of each of these constituents in the water depends on the pH of the water. Organisms such as clams can combine bicarbonate or carbonate with calcium dissolved in the water to produce calcium carbonate. After the death of the animal, this calcium carbonate may either dissolve or remain in sedimentary form.

Certain control mechanisms are inherent in the carbon cycle. The rate of carbon utilization is dependent on its availability.

If excessive amounts of carbon are taken up in any one phase of the cycle, other phases of activity may be inhibited or slowed down. For example, if the pH of water is alkaline, more carbon is tied up in a carbonate and less is in solution. This removal of carbon in solution would upset the equilibrium established between the atmospheric and the dissolved CO_2 and the net effect would be a movement of CO_2 into the solution until equilibrium was reached peculiarities of carbon cycle. Though carbon-cycle exhibits basic similarity with other biogeochemical cycles, yet it is unusual in that the organic phase is not essentially a complete cycle within itself.

The organic (biotic) and atmospheric (abiotic) phases, however, are so closely intertwined that the rapid cycling typical of the organic phase is present.

The multiplicity of paths along which carbon can flow is typical of biogeochemical cycles in general and provides a well-buffered system with adequate feedback mechanisms to ensure an adequate supply of the carbon. It is significant that all phases of the cycle yield carbon dioxide at some time and carbon dioxide is the raw material for them. Thus, despite its relatively low concentration in the atmosphere (0.03 percent), carbon in a form in which it can be used by living organisms is virtually always present.

There is some human impact on biospheres carbon. Removal of vegetation reduces absorption of carbon dioxide for photosynthesis; Burning of fossil fuels increases atmospheric CO_2. Increase in atmospheric CO_2 leads to increased Greenhouse Effect and Global Warming. The cycling of the Carbon in the ecosystem has been presented in Fig 5.2.

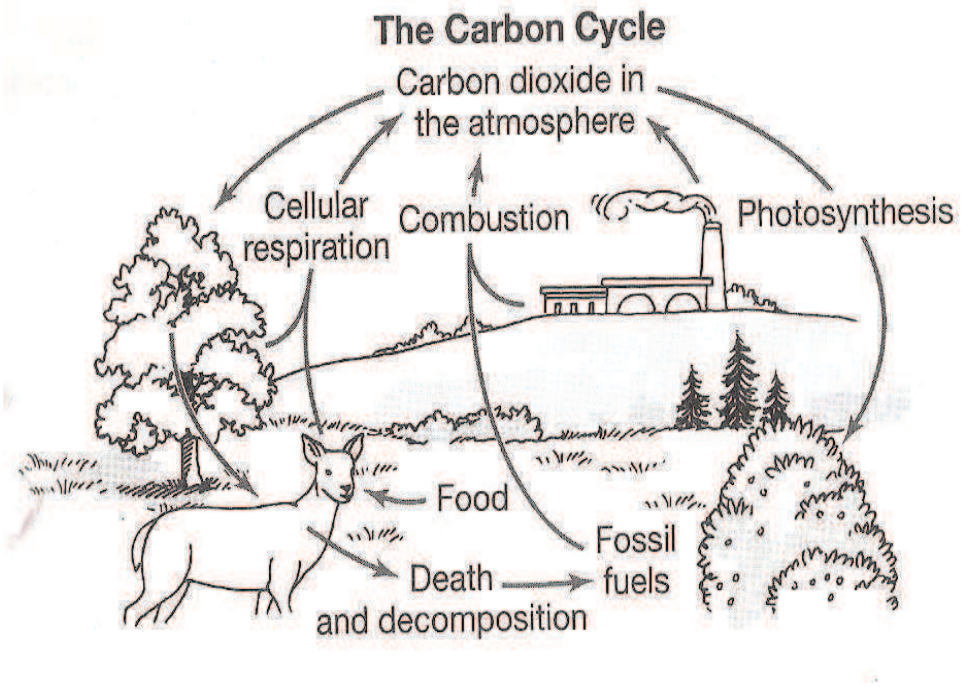

Figure 5.2. Carbon Cycle

5.3.3. HYDROGEN CYCLE

The transmission of hydrogen from water to carbohydrates and other compounds and back to water by living organisms is known as hydrogen cycle.

It involves the electrolysis or solar photolysis of water to give hydrogen and oxygen which are then recombined in a fuel cell to produce electricity. Anaerobic fermentation of organic substances to carbon dioxide and methane is a collaborative effort involving many different biochemical reactions, processes and species of microorganisms. One of these many processes that occur is termed "interspecies hydrogen transfer".

This process has been described as integral to the symbiosis between certain methane-producing archaea (methanogens) and nonmethanogenic anaerobes. In this symbiosis, the nonmethanogenic anaerobes degrade the organic substance and produce, among other things, molecular hydrogen (H_2).

This hydrogen is then taken up by methanogens and converted to methane via methanogenesis. One important characteristic of interspecies hydrogen transfer is that the H_2 concentration in the microbial environment is very low. Maintaining a low hydrogen concentration is important because the anaerobic fermentative process

becomes increasingly thermodynamically unfavourable as the partial pressure of hydrogen increases. A key difference compared to other biogeochemical cycles is that because of its low molecular weight hydrogen can leave the Earth's atmosphere. It has been suggested that this occurred on a grand scale in the past and that this is why today the Earth is mostly irreversibly oxidised. Both biological and a biological process contribute significantly to the global H_2 cycle.

The largest sources of environmental H_2 are the atmospheric photochemical process of hydrocarbon dissociation and microbial H_2 production. Biological processes are the dominant sink for atmospheric H_2 illustrating that overall the most important physiological role of H_2 is as a biological fuel. Within microbial environments, cellular processes which results in H_2 production are nearly always linked with either inter or intracellular H_2 uptake. The cycling of the hydrogen in the ecosystem has been presented in Fig 5.3.

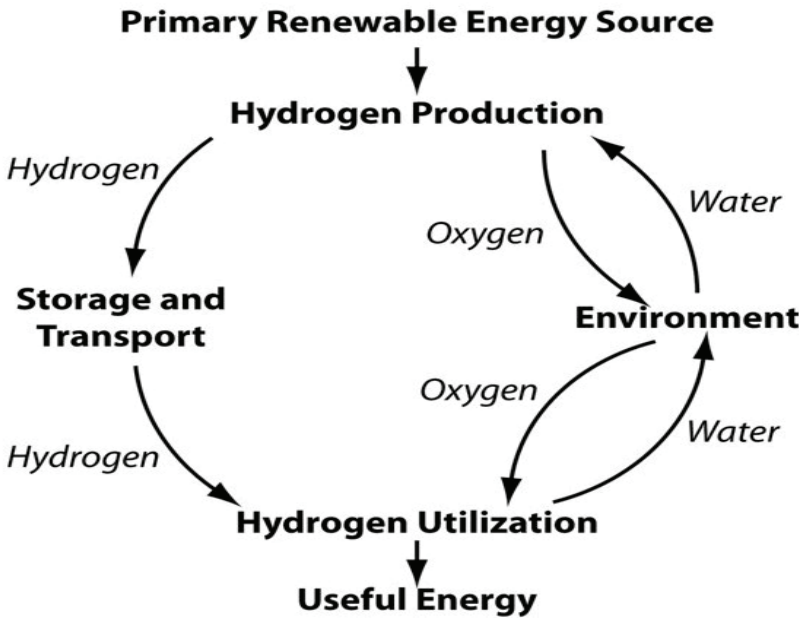

Figure 5.3. Hydrogen Cycle

5.3.4 OXYGEN CYCLE

Oxygen (O_2), the by-product of photosynthesis, is involved in the oxidation of carbohydrates with the release of energy, carbon dioxide and water. Its primary role in biological oxidation is that of a hydrogen acceptor.

The break- down and decomposition of organic molecules proceeds primarily by dehydrogenation. Hydrogen is removed by enzymatic activity from organic molecules in a series of reactions and is finally accepted by the oxygen, forming water. Though oxygen is necessary for life, being very active chemically, molecular O_2 may be toxic to living body cells. Therefore, for the protection from toxic effects of molecular O_2, cells possess the cellular organelles called peroxisomes which mediate oxidative reaction resulting in the production of hydrogen peroxide which in turn is used through the mediation of other enzymes as an acceptor in oxidizing other compounds. The major supply of free oxygen which supports life occurs in the atmosphere. There are two significant sources of atmospheric oxygen. One is the photo dissociation of water vapour in which most of the hydrogen released escapes into outer space.

The other source is photosynthesis, active only since life began on earth. Because photosynthesis and respiration are cyclic, involving both the release and utilization of oxygen, one would seem to balance the other, and no significant quantity of oxygen would accumulate in the atmosphere.

However, at some time in the earth's history, the amount of oxygen introduced into the atmosphere had to exceed the amount used in the decay of organic matter and that tied up in the oxidation of sedimentary rocks.

Part of the atmospheric oxygen represents that portion remaining from the unoxidized reserves of photosynthesis- coal, oil, gas, and organic carbon in sedimentary rocks. The amount of stored carbon in the earth suggests that 150 x 1020 g of oxygen has been available to the atmosphere, over 10 times as much as now present, 10 x 1020 g (Johnson, 1970).

The main non-living (abiotic) oxygen pool consists of molecular oxygen, water, and carbon dioxide, all intimately linked to each other in photosynthesis and other oxidation-reduction reactions, and all exchangeable in such compounds as nitrates and sulphates utilized by organisms that reduce them to ammonia and hydrogen sulphide. The cycling of oxygen is very complex. As a constituent of CO_2, it circulates freely throughout the biosphere. Some carbon dioxide combines with calcium to form carbonates. Oxygen combines with nitrogen compounds to form nitrates, with iron to ferric oxide, and with many other minerals to form various other oxides. In these states, oxygen is temporarily withdrawn from circulation.

In photosynthesis, the oxygen freed is split from the water molecule. This oxygen is then reconstituted into the water during plant and animal respiration. Some part of the

atmospheric oxygen that reaches the higher levels of the troposphere is reduced to ozone (O_3) by high energy ultraviolet radiation. The cycling of the Oxygen in the ecosystem has been presented in Fig 5.4.

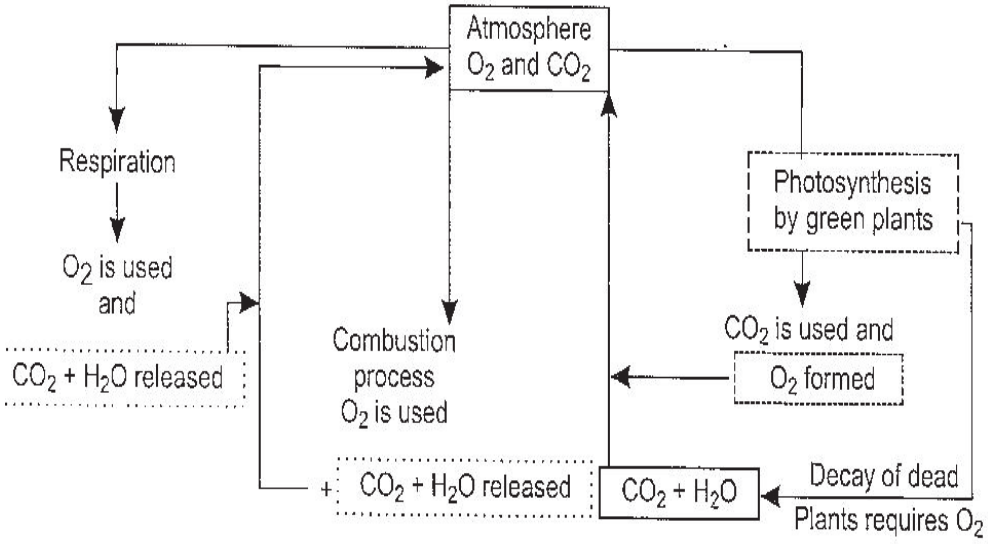

Figure 5.4. Oxygen Cycle

5.4 SUMMARY

A biogeochemical cycle is one of several natural cycles, in which CONSERVED MATTER moves through the BIOTIC and ABIOTIC parts of an ecosystem. The main chemical elements that are cycled are carbon (C), hydrogen (H), nitrogen (N), oxygen (O), phosphorous (P), and sulfur (S). These are the building blocks of life and are used for essential processes, such as METABOLISM, the formation of AMINO ACIDS, CELL RESPIRATION and the building of tissues.

The Nitrogen Cycle is an atmospheric cycle. Plants and animals cannot use free nitrogen gas in the atmosphere. They must have nitrogen in "fixed" form. Nitrogen is required for proteins, nucleic acids in living things. Free N_2 in the atmosphere is "fixed" by nitrogen-fixing bacteria to NH_3 (ammonia):

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Nitrogen-fixing bacteria live in nodules on the roots of leguminous plants (soybeans, peas, clover, and alfalfa). Water in the soil reacts with ammonia to form NH_4^+

(ammonium ion). Another species of bacteria can perform nitrification once ammonium has formed:

$NH_4^+ \longrightarrow NO_2^-$ (nitrite; toxic) $\longrightarrow NO_3^-$ (nitrate; plant nutrient)

Tissues absorption of ammonia, ammonium ion, nitrate for use by plants to make nucleic acids, proteins. Animals get fixed nitrogen by eating plants or other animals. Plants and animals are broken down by still other bacteria that convert nitrogen-containing organic molecules in organisms to an inorganic form of nitrogen (ammonia or ammonium ion) = ammonification. Once this ammonia has formed, still another group of bacteria can perform denitrification:

NH_3 or $NH_4^+ \longrightarrow NO_2^-$ and/or $NO_3^- \longrightarrow N_2$ and N_2O (nitrous oxide)

Nitrogen is often limiting factor in plant growth because ammonia, ammonium ion, nitrate are water-soluble: can be leached from the soil.

Carbon cycle, it is an important atmospheric cycle. Carbon is required for formation of organic compounds in living things. Carbon in carbon dioxide in the atmosphere and in water is moved to Carbon in glucose by photosynthesis by producers.

C in glucose is moved to C in carbon dioxide by cellular respiration. C in glucose is moved to C in organic molecules by synthesis reactions in living things. C in organic molecules is moved to C in carbon dioxide by combustion. C in organic molecules in organisms is moved to C in fossil fuels over millions of years by pressure, heat, and bacterial action. C in limestone ($CaCO_3$) is released slowly to C in carbon dioxide when exposed to oxygen and/or water.

Largest reservoir of carbon - sedimentary rocks (limestone) Second largest reservoir of carbon - ocean (dissolved carbon dioxide), living things in ocean.

In water:

$CO_2 + H_2O \longrightarrow HCO_3^-$ (bicarbonate ions) + CO_3^{2-} (carbonate ions)

$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3$ (calcium carbonate) in shells/skeletons of aquatic organisms.

The Hydrogen cycle starts with evaporation from the surface of the water. Then, the moist air is lifted and cooled and water vapour condenses to form clouds. The moisture is transported than returns as precipitation. Once water reaches the ground, it may evaporate back into the atmosphere or penetrate the surface and become groundwater. Groundwater finds its way into oceans, streams, lakes, rivers, ponds,

and etc by transpiration. The balance of water that remains on the earth's surface is the runoff, which empties into lakes, rivers, and streams and is carried back to the ocean where the cycle begins again.

The oxygen cycle, oxygen is an important element of life on Earth. It is the most common element of the human body. It makes up about 65% of the mass of the human body. Most of this is in the form of water (H_2O). Oxygen also makes up about 30% of the Earth and 20% of the atmosphere.

Plants are the main makers of oxygen in the atmosphere through the process of photosynthesis. The tree uses sunlight and carbon dioxide to produce energy and releases oxygen. When plants and animals die, they decompose they use up oxygen and releases carbon dioxide. Rusting is also called oxidation when things rust they use up oxygen. During combustion, there are three things needed for fire: oxygen, fuel, and heat. Without oxygen, we can't have a fire. When things burn, they use up oxygen and replace it with carbon dioxide.

Plants create the majority of the oxygen we breathe through a process called photosynthesis. In this process, plants use carbon dioxide, sunlight, and water to create energy.

Some oxygen is produced when sunlight reacts with water vapor in the atmosphere. There is a lot of oxygen stored up in the oxide minerals of the Earth's crust. However, this oxygen isn't available for us to breathe. One of the biggest sources of oxygen is phytoplankton that lives near the surface of the ocean.

5.5 GLOSSARY

Abiotic	is a term used to categorize anything that is not derived directly from living organisms.
Aerosols	an aerosol is a suspension of fine solid particles or liquid droplets, in air or another gas. Aerosols can be natural or anthropogenic.
Anaerobes	microorganisms that are able to, or can only, live in the absence of oxygen.
Atmosphere	an atmosphere is a layer or a set of layers of gases surrounding a planet or other material body that is held in place by the gravity of that body.

Biogeochemical Cycle is one of several natural CYCLES, in which conserved matter moves through the biotic and abiotic parts of an ecosystem.

Biotic describes living or once living components of a community; for example organisms, such as plants and animals.

Deamination is the removal of an amino group from a molecule.

Decomposition is the process by which organic substances are broken down into simpler matter.

Denitrification is a microbial facilitated process where nitrate is reduced and ultimately produces molecular nitrogen (N_2) through a series of intermediate gaseous nitrogen oxide products.

Detritus any form of non-living organic matter, including different types of plant tissue, animal tissue, dead microbes, faeces, as well as products secreted excreted or exuded from organisms.

Ecosystem is all the plants and animals that live in a particular area together with the complex relationship that exists between them and their environment.

Electrolysis is the passing of a direct electric current through an ionic substance that is either molten or dissolved in a suitable solvent, producing chemical reactions at the electrodes and separation of materials.

Erosion is the gradual destruction and removal of rock or soil in a particular area by rivers, the sea, or the weather.

Evaporation is the process of a substance in a liquid state changing to a gaseous state due to an increase in temperature and/or pressure.

Food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another.

Fossil is the naturally preserved remains or traces of animals or plants that lived in the geologic past.

Geological Activity deformational events are often also associated with volcanism and igneous activity.

Herbivores are considered primary consumers and are the first consumers on the food chain.

Leaching natural process by which water soluble substances (such as calcium, fertilizers, and pesticides) are washed out from soil or wastes.

METABOLISM IS the sum of the chemical reactions that take place within each cell of a living organism and that provide energy for vital processes and for synthesizing new organic material.

Nucleic acids are molecules that allow organisms to transfer genetic information from one generation to the next.

Nutrients are substance that provides nourishment essential for the maintenance of life and for growth.

Nitrogen- Fixation is a process by which nitrogen (N_2) in the atmosphere is converted into ammonia (NH_3).

Oxidation- Reduction Reactions in which one molecule is reduced and another is oxidized.

Peroxisomes a small organelle present in the cytoplasm of many cells, which contains the reducing enzyme catalase and usually some oxidases.

pH is a measure of the hydrogen ion concentration of a solution.

Photosynthesis is the process through which plants use water and carbon dioxide to create their food, grow and release excess oxygen into the air.

Phytoparasites a parasitic plants.

Phytoplankton very small plants that float near the surface of water and on which sea creatures feed.

Polysaccharides are long chains of monosaccharides linked by glycosidic bonds.

Precipitation a form of water, such as rain, snow, or sleet that condenses from the atmosphere becomes too heavy to remain suspended, and falls to the Earth's surface.

Radiation the emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which causes ionization.

Respiration a process in living organisms involving the production of energy, typically with the intake of oxygen and the release of carbon dioxide from the oxidation of complex organic substances.

Tissue	is an ensemble of similar cells from the same origin that together carry out a specific function.
Transpiration	is process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers.
Vitamin	is an organic compound and an essential nutrient that an organism requires in limited amounts.

5.6 SELF ASSESSMENT QUESTION

5.6.1 SHORT ANSWER QUESTIONS

1. Name 3 ways in which carbon can enter the atmosphere?

2. Name 3 ways in which carbon can leave the atmosphere?

3. Explain how photosynthesis works?

4. What is the importance of plants in the carbon cycle?

5. In what form can you find carbon in the atmosphere?

6. How many possible paths are there for carbon to move through the environment?

7. What are two ways in which nitrogen can get into the ground?

8. What role do plants have in the nitrogen cycle?

9. What role do decomposers have in the nitrogen cycle?

10. What is the role of bacteria in the nitrogen cycle?

11. Does the nitrogen cycle ever end? Explain why or why?

12. Explained the Oxygen cycle?

5.6.2 MULTIPLE ANSWERS QUESTIONS

Q1. The hydrologic cycle involves the movement of

a) Carbon **b)** Nitrogen. **c)** Water **d)** Phosphorus

Q2. Which biogeochemical cycles are driven primarily by physical processes?

a) Hydrologic cycle **b)** Nitrogen cycle **c)** Carbon cycle **d)** Phosphorus cycle

Q3. Nitrogen fixation

a) Increases soil phosphate levels.

b) Results in the loss of nitrogen from the soil back to the atmosphere.

c) Is performed by bacteria in most systems.

d) All of the above

Q4. Photosynthesis and respiration belong to which cycle?

a) Nitrogen cycle **b)** Carbon cycle

c) Phosphorus cycle **d)** Hydrologic cycle

Q5. Process by which atmospheric nitrogen gas is changed to forms that plants can use:

a) Biogeochemical Fixation **b)** Hydrologic Fixation

c) Nitrogen Fixation **d)** Carbon Fixation **e)** Phosphorus Fixation

Q6. The two major pathways by which molecular nitrogen is converted to forms, more useful to living organisms are:

a) Evaporation and precipitation **b)** Biological activity and ultraviolet radiation **c)** Ultraviolet radiation and volcanic activity **d)** Freezing and thawing

e) Biological activity and lightning

Q7. What word is another name for rain, snow, sleet, and hail?

a) Evaporation **c)** Surface runoff

b) Condensation **d)** Precipitation

Q8. What word means the change of state from liquid to a gas?

a) Evaporation **c)** Condensation

b) Eutrophication **d)** Precipitation

Q9. Nitrogen is assimilated /absorbed in to plants in what form?

a) NO_2 **b)** NH_3 **c)** NO_X

d) NO_3 **e)** Choices B and D

Q10. The nitrogen cycle, one of the most important biochemical cycles, may cause environmental problems because too much nitrogen can:

a) Results in acid rain **b)** Deplete the ozone layer

c) Contribute to the greenhouse effect **d)** Reduce earthshine

e) Cause eutrophication in bodies of water

Ans: 1.c, 2.a, 3.b, 4.b, 5. c, 6.a, 7.d, 8. a, 9. e, 10.e.

5.6.3. FILL IN THE BLANKS

a. Plants use CO_2 in the process of _____ to make sugar And _____.

b. Animals use oxygen in the process of _____ ___ and make more CO_2.

c. Only special bacteria can directly use nitrogen in our atmosphere and "fix" it so other organisms can benefit. These bacteria are called _____ bacteria.

d. Burning of fossil fuels coupled with deforestation (the cutting down of forests) increases the amount of _____ in the atmosphere.

e. Atmospheric oxygen in the form of _____ provides protection from harmful ultraviolet rays.

5.8 REFERENCE

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UNIT 6: THE CONCEPT OF BIODIVERSITY, CONSERVATION AND MANAGEMENT

CONTENTS

6.1 OBJECTIVES

Develop the understanding of current global issue such as global warming, pollution, environmental deterioration, loss of biodiversity and climate change and study of the various aspect of conservation biology through the study of protected are network.

6.2 INTRODUCTION

In the present time biodiversity of the organism is the main issue regarding their utility as well as conservation. Diversity of animals, plants and microbial life has been evolving billions of years. As more and more forms of life evolve, replacing some and helping the development of others, the networking of life becomes more encompassing and complicated. The evolving nature of natural organism was the resultant of their diversification. In the same way biodiversity spans the whole spectrum of life from microorganism to plants and animals. In present time there are many causes which are directly or indirectly responsible for the loss of biological organism in order to their flora and fauna. Exact number of exiting species on earth is still unknown. The estimated global species diversity contains approximately 13-14 million species. In which 1.75 species are described so far and many more still being discovered. Today's need to focus on this aspect of life science. And in the same way a lot of conservational programmers and resource management is necessary for the benefit of flora.

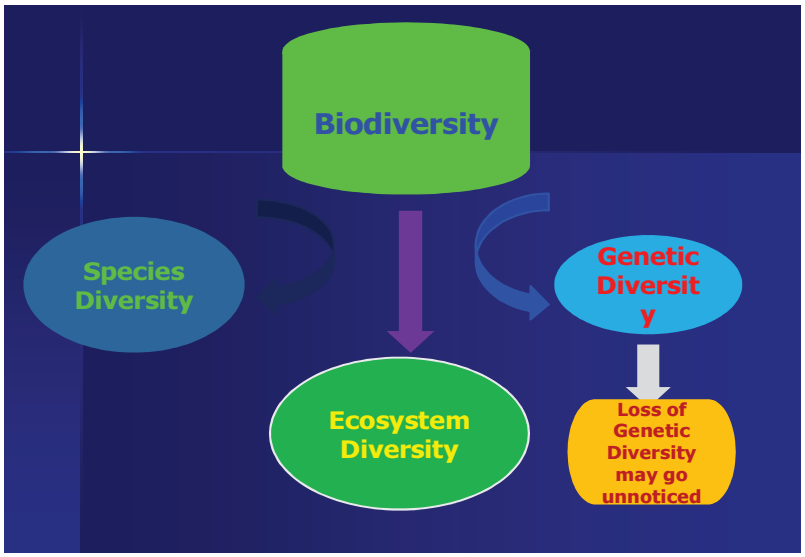

Fig 6.1. Combination of biodiversity

6.3 BASIC CONCEPT OF BIODIVERSITY

6.3.1 DEFINITION OF BIODIVERSITY

Variability of biological organism is called biodiversity. Bio- diversity is interrelatedness of genes, species, and ecosystems and in turn, their interactions with the environment. In present time biodiversity of the organism is the main issue regarding their utility as well as conservation. Diversity of animals, plants and microbial life has been evolving billions of years. As more and more forms of life evolve, replacing some and helping the development of others, the networking of life becomes more encompassing and complicated. The evolving nature of natural organism was the resultant of their diversification. In the same way biodiversity spans the whole spectrum of life from microorganism to plants and animals. In fishes morphological variations are the resultant of either environment or genetic or the combination of both. Biological diversity is the fundamental interest of biology in which intraspecific diversity is considered as a component of biological diversity. Biodiversity can be measured in term of species, genes ecosystem. Species diversity can be classified into two type's i.e. interspecific and intraspecific diversity. According to the article 2 of conventions of biodiversity, *Biological diversity"* means the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.*"Biological resources'* includes genetic resources, organisms or parts of their populations, or any other biotic component of ecosystems with actual or potential use or value for humanity.

6.3.2 TYPES OF BIODIVERSITY (GENETIC, SPECIES & ECOSYSTEM BIODIVERSITY)

Biodiversity can exemplify in term of species, level of genes and at broad level ecosystems.

1) Species diversity is the combination of the different species, as well as the differences within and between different species.
2) Genetic diversity is all the different genes contained in all the living species, including individual plants, animals, fungi, and microorganisms
3) Ecosystem diversity is all the different habitats, biological communities and ecological processes, as well as variation within individual ecosystems.

Genetic Diversity

Simply Genes are the segments of DNA, but their complexity is increases from prokaryotes to eukaryotes. In prokaryotes a set of genes are regulated by single promoters and operator's on the other hand eukaryotic gene is regulated by each promoter and operator. Genes regulated the overall process of organism including morphological traits, physiological traits in combination with the environmental plasticity. Genetic polymorphism has important implications for the conservation and evolution of species. Genetic diversity is blue print of the species in order to their single nucleotide (SNPs) variation. The number of genes is variable in the organism which exhibit by the genome of the organisms. Genetic diversity retains a variety of genetic information of all the individual plants, animals and microorganisms.

Fig 6.2 Total No. of genetic characteristic of a specific species within a population

Simply it is the variation of genes in their promoter region as well as in the coding sequence, with in species and populations. Species evolution is driven by a number of different factors, including migration and settlement in different environments, genetic mutation, natural selection, and genetic drift. The product of these different forces is genetic diversity within a population. The genetic variability in the organism is driven by the many factors as fig2. These factors are crossing over which is the primary source of variation for evolution while the mutation is the ultimate source of evolution. The other factors such as independent segregation of alleles (alleles are the alternative forms of genes), random fertilization. These factors lead to the sexual recombination as resultant genetic reshuffling occurs.

Genetic Variation can be measured by Several Methods

Genetic variation can be measured by the different markers such as single nucleotide polymorphism(SNPs) are the preferred markers for measuring genetic variation, other markers also have been used for the quantification of genetic variation. Including microsatellites. These are variable number tandem repeat (VNTR) sequences in the genome. VNTRs can be "short" (involving two to five nucleotide repeats) or "long" (involving more substantial repeat sequences). VNTRs are still used in studies today and are especially useful where the candidate gene is known or a specific region is being scanned. Earlier studies used restriction enzymes to identify different VNTRs and SNPs. To determine VNTR genotypes, one or more restriction enzymes that cut the DNA sequence above and below the region encoding the VNTR sequences can be used and DNA fragments of different sizes can be obtained. After digestion with the appropriate enzyme(s), the DNA sample can be run by electrophoresis on either an agarose gel or a polyacrylamide gel to reveal the size(s) of the fragments and thus the number of sequence repeats in each individual sample. Genotypes can be assigned based on the pattern obtained on the gel. This method is known as restriction fragment length polymorphism (RFLP) analysis. RFLP analysis was also used to detect SNPs where the differences in the DNA sequence can be detected by use of restriction enzymes that cut the DNA at a particular sequence encoded by one allele, but not the other. Multiple enzymes were often used when genotyping SNPs in order to obtain readable accurate results. Different enzymes are used to detect different polymorphisms. Later studies substituted RFLP genotyping for more reliable polymerase chain reaction (PCR) genotyping using primers specific for the gene sequence of interest. This method uses a polymerase enzyme purified from the hot-springs "thermophilic" bacteria Thermus aquaticus to amplify multiple copies of the gene sequence. These amplified sequences are then run out on a gel using the same process as that used with RFLP fragments and genotypes can be assigned from the specific banding patterns obtained for each sample.

Species Diversity

Diversification of species is known as species diversity. Species diversity can be measured as either within the species or between the species. Species diversity and genetic diversity are influenced by a complex set of processes across a range of spatial and temporal scales (Huston 1994; Rosenzweig 1995; Hedrick 2000; Frankham et al. 2002) Species diversity can be classified into two types: i.e. Intraspecific and Interspecific diversity. Species diversity

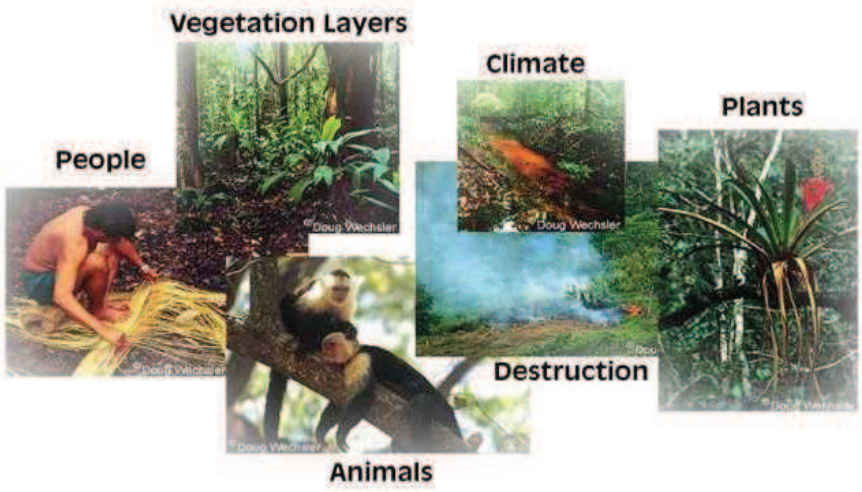

Fig 6.3 Species diversity

also described by the following ways, *Species Richness* – Species richness may defined as the total numbers of species defined in area. Various indices are used including the Mangalet and Menhink index. This refers to the total count/number of species in a defined area. Various indices are used including the Mangalet index and Menhink index.

Species Abundance:-

Species abundance may be defined as the relative numbers among species. If all the species have the same equal abundance, this means that the variation is high hence high diversity, Taxonomic or phylogenetic diversity - This considers the genetic relationships between the different groups of species. The measures are based on analysis, resulting into a hierarchical classification representing the phylogenetic evolution of the taxa concerned.

Ecosystem Diversity

Ecosystem is the unit of environment. Diversity of organism in relation to ecosystem is considered as ecosystem diversity. This relates to the variety of habitats, biotic communities and ecological processes in the biosphere. The variety of ecosystem found on Earth-the forest, desert, lakes, costal coral and other ecosystem. "Ecosystem"i. e. a dynamic complex of plant, animal and micro-organismal communities and their non-living environment interacting as a functional unit. **(Article 2 of the Convention on Biological Diversity).**The Ecosystem Approach is the primary framework for action under the Convention on Biological Diversity and is defined as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on levels of

biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognises that humans, with their cultural diversity, are an integral component of ecosystems. This approach will be implemented over time in management practices in relation to key ecosystems. India has very diverse terrestrial and aquatic ecosystems ranging from ice-capped Himalayas to deserts, from arid scrub to grassland to wetlands and tropical rainforests, from coral reefs to the deep sea. Each of these comprises a great variety of habitats and interactions between and within biotic and abiotic components. The most diversity-rich are western-ghats and the north-eastern region. A very large number of species found in these ecosystems are **endemic** or found in these areas only in India i.e. they are found nowhere else except in India. The endemics are concentrated mainly in north-east, western-ghats, north-west Himalaya, and Andaman and Nicobar Islands. About 33% of the flowering plants recorded in India are endemic to our country. Indian region is also notable for endemic fauna. For example, out of recorded vertebrates, 53% freshwater fish, 60% amphibians, 36% reptiles and 10% mammalian fauna are endemic.

6.3.3 IMPORTANCE OF BIODIVERSITY

Biodiversity has a great importance because it includes a variety of plant, animal life and microorganisms, and the variety of these types of Earth's ecosystems supports life. It supports the survival strategy of human either directly or indirectly. Biodiversity is the very stuff that supports the evolution and differentiation among the varying species. Resource management is an important aspect for proper utilization of resources and energy transfer across the ecosystem. Biodiversity contained ecosystems of forest, grassland, desert marine lake, river, and pond even our aquarium also which retains and supports many organism in term of shelter and food .Nature and its natural things has a great importance. Biodiversity has a direct value in food, agriculture, medicine and in industry also. Biodiversity maintains an ecological balance and continues as evolutionary process.

6.3.4 HOT SPOTS OF BIODIVERSITY

The constant diversity of organism is not throughout across the green planet.Certain regions of the earth are very rich in biodiversity; such biodiversity rich regions are called “mega diversity zones According to him, the hot spots are the richest and the most threatened reservoirs of biodiversity on the earth. The criteria for determining a hot spot are:

A. The area should support >1500 endemic species

B. It must have lost over 70 % of the original habitat

There are thirty four identified hot spots of the world in which four are found in India. These four are Eastern Himalaya, Indo-Burma, Western Ghats and Sri Lanka, and Sundaland. The endemic species are those species which are confined in a specific geographic area or a particular area The hotpots of the worlds are shown in the figure no 6.3.

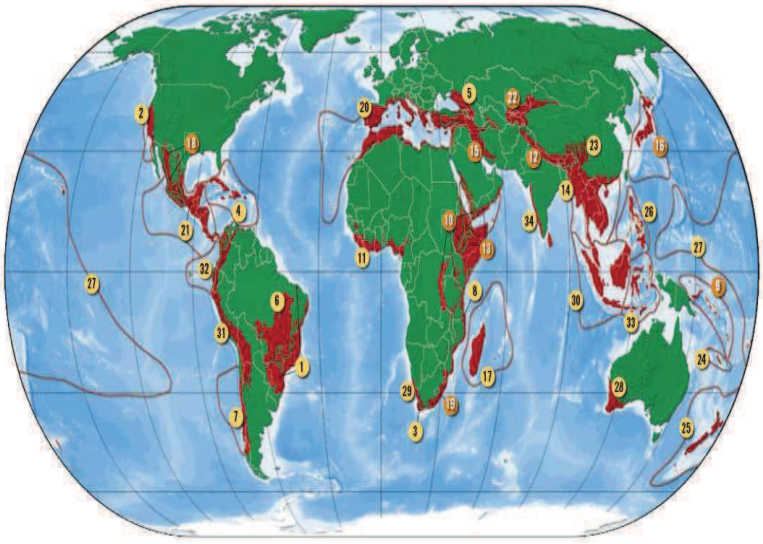

Fig.6.3 Hot –spot area

1) Atlantic Forest
(2) California Floristic Province
(3) Cape Floristic Region
(4) Carribbean Islands
(5) Caucasus
(6) Cerrado
(7) Chilean Winter Rainfall
(8) Valdivian Forest
(9) Coastal Forest of Eastern Africa
(10) East Melanesian Islands
(11) Eastern Afromontane
(12) Guinean Forests of West Africa
(13) Eastern Himalaya
(14) Horn of Africa
(15) Indo Burma
(16) Irano Anatolian
(17) Japan
(18) Madagascar and Indian Ocean Islands
(19) Maderan Pine-oak woodlands
(20) Maputaland-Pondoland Albany
(21) Mediterranean Basin
(22) Mesoamerica
(23)Mountains of central Asia
(24) Mountains of southwest China
(25) Wallace
(26) New celedonia
(27) New Zealand
(28) Philippines
(29) Polynesisa Micronesia
(30) Southwest Australia

(31) Succulent caro (32) Sunderland

(33) Tropical Andes (34) Southwest Australia

Thirty four biodiversity hot spots have been identified in the world. These hot spots are characterized by posing exceptionally high biodiversity. For example the total area of these 25 hot spots cover 1.4% of the total land area, support 44% of plant and 35% terrestrial vertebrates. (Refer to the Fig. 15.3) Among the 25 hot spots of the world, 2 are found in India namely Western Ghats and the eastern Himalayas. These two areas of the country are exceptionally rich in flowering plants, reptiles, amphibians, butterflies and some species of mammals. The eastern Himalayan hot spot extends to the north – eastern India and Bhutan. The temperate forests are found at an altitude of 1780 to 3500 m. Many deep and semi isolated valleys are exceptionally rich in endemic plant species. The Western Ghat region lies parallel to the western coast of Indian peninsula for almost 1600 km, in Maharashtra, Karnataka, Tamil Nadu and Kerala. These forests at low elevation (500 m above mean sea level) are mostly evergreen, while those at 500- 1500 m height are generally semi-evergreen forests.

1. Tropical Andes, 2. Mesoamerica, 3. Caribbean, 4. Brazil's Atlantic Forests, 5. Choco/Darien/Western Ecuad
6. Brazil's Cerrado, 7. Central Chile, 8. California Floristic Province, 9. Madagascar, 10. Eastern Arc & Coastal Fore
of Tanzania/Kenya, 11. West African Forests, 12. Cape Floristic Province, 13. Succulent Karoo, 14. Mediterrane
Basin, 15. Caucasus, 16. Sundland, 17. Wallacea, 18. Philippines, 19. Indo-Burma, 20. South-Central Chir
21. Western Ghats/Sri Lanka, 22. Southwest Australia, 23. New Caledonia, 24. New Zealand, 25. Polynesia/Microne

Biodiversity hotspots in India

1. Himalaya: Includes the entire Indian Himalayan region.

2. Indo-Burma: Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)

3. Sunderland's: Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)

4. Western Ghats and Sri Lanka: Includes entire Western Ghats (and Sri Lanka)

HIMALAYA

The Himalaya Hotspot is the home of the world's highest mountains, including Mt. Everest. The mountains rise abruptly, resulting in a diversity of ecosystems that range from alluvial grasslands and subtropical broadleaf forests to alpine meadows above the tree line. Vascular plants have even been recorded at more than 6,000 m. The hotspot is home to important populations of numerous large birds and mammals, including vultures, tigers, elephants, rhinos and wild water buffalo.

INDO-BURMA

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures. Six large mammal species have been discovered in the last 12 years: the large-antlered muntjac, the Annamite muntjac, the grey-shanked douc, the Annamite striped rabbit, the leaf deer, and the saola. This hotspot also holds remarkable endemism in freshwater turtle species, most of which are threatened with extinction, due to over-harvesting and extensive habitat loss. Bird life in Indo- Burma is also incredibly diverse, holding almost 1,300 different bird species, including the threatened white-eared night-heron, the grey-crowned crocias, and the orange-necked partridge.

SUNDERALAND

The spectacular flora and fauna of the Sunderland Hotspot are succumbing to the explosive growth of industrial forestry in these islands and to the international animal trade that claims tigers, monkeys, and turtle species for food and medicine in other countries. Populations of the orang-utan, found only in this hotspot, are in dramatic decline. Some of the last refuges of two Southeast Asia rhino species are also found on the islands of Java and Sumatra. Like many tropical areas, the forests are being cleared for commercial uses. Rubber, oil palm, and pulp production are three of the most detrimental forces facing biodiversity in the Sunderland Hotspot

WESTERN GHATS AND SRI LANKA

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land. Remaining forests of the Western Ghats are heavily fragmented; in Sri Lanka, only 1.5% of the original forest remains. Population levels are also applying increased stress on the fringes of protected areas where many farms, loggers, and poachers use the resources illegally. Due in part to the varying effect of the yearly monsoons and the high mountain regions, this hotspot is home to a rich endemic assemblage of plants, reptiles, and amphibians. Sir Lanka alone may be home to as many as 140 endemic species of amphibians. The region also houses important populations of Asian Elephants, Indian Tigers, and the Endangered Lion-tailed Macaque. Freshwater fish endemism is extremely high as well, with over 140 native species.

6.3.5 THREATS TO BIODIVERSITY

Losses in biodiversity Today's threats to species and ecosystems are the greatest recorded in recent history and virtually all of them are caused by human mismanagement of biological resources often stimulated by misguided economic policies and faulty institutions. Principal threats to biodiversity A threat by definition refers to any process or event whether natural or human induced that is likely to cause adverse effects upon the status or sustainable use of any component of biological diversity. Habitat alteration / destruction Increased insatiable demand for resources results to land use changes hence loss to genetic diversity, species reduction and increased ecosystem changes such as random population changes, disease outcrops, habitat fragmentation among others resulting in biodiversity losses. Overharvesting/over-exploitation of biological resources. This results when individuals of a particular species are taken at a higher rate than can be sustained by the natural reproductive capacity of the population being harvested.

This can be through hunting, fishing, trade, food gathering etc. Overharvesting will lead to extinction of resources or the biological resources, eventually leading to loss of species. Pollution Chemical or thermal pollution is a threat to biodiversity. Species in habitats are increasingly being harmed by industrial activities and pollution from excessive use of agro-chemicals such as DDT, oil spills, acid precipitation etc. Introduced species / biological invasions This can be intentional or accidental. Species introduced in an ecosystem will cause changes in the ecosystem. Introduced species are organisms arising in areas/ habitats in which they were previously not native. Such introduced species are usually referred to as biological pollutants. Some of the ecological impacts of the invasion include hybridization, out competition, disruption of original ecosystem, plant pathogenic influences, disease

transmission, and disruption of food webs and to some situations extinction. Species may be introduced intentionally for Ornamental concerns; Agriculture; Hunting and spotting activities; Biotechnology for scientific research.

This is of great concern especially when global CO2 increases in the atmosphere resulting to global warming. Most species originate within a very narrow physiological limit; hence nature has a range of tolerance maintained for ecosystem stability. Changes may be gradual or abrupt such that if the limit is exceeded the upper or lower species suffers extinction.

Population As the human population is increasing; there exists insatiable demand for raw materials which is bound to cause changes in biodiversity. It is therefore vital to control human population which will result in biodiversity conservation. Institutional / policy failure Some institutions are created to manage biological resources. However, the institutions/policy fail to internalize the values of biodiversity within the decision making process of their Nations and individuals. Such institutions/policies in place should have a holistic approach towards biodiversity conservation rather than part conservation.

6.3.6 CONSERVATION OF BIODIVERSITY

Conservation of biodiversity is must for ensuring the future generation. Each organism in nature has its specific significance in order to their priority in ecosystem.

This incorporates the preservation, maintenance, sustainable use (conservation), recovery and enhancement of the components of biological diversity, where. Conservation - is the sustainable use of resources and encompasses protection as well as exploitation and Preservation is an aspect of conservation meaning to keep something without altering or changing it. A balance between the environment, development and society results to sustainable development which ensures biodiversity conservation. This is only possible in the presence of good enforced and implemented policies/ conventions, environmental institutions (e.g. NEMA for Kenya) and political stability among others (Figure 1).Conservation measures of biodiversity Ex-situ conservation, Refers to conservation of components of biodiversity outside their natural habitats, e.g. zoos, museums, gene banks, botanic gardens/arboretums; Used for threatened and endangered species to avoid their extinction; also known as captive conservation. In-situ conservation, Refers to conservation of ecosystems and natural habitats including maintenance and recovery of viable populations of species in their natural habitats.

Convention on biological diversity (CBD) Conservation of biological diversity and sustainable use of its components came into the limelight in 1972 (United Nations Conference on Human Environment; Stockholm). In 1973, UNEP identified conservation of biodiversity as a priority area, hence there was need to get the legal mandate for conservation of world resources. There were negotiations for a legally binding instrument to address biological diversity and its loss to enhance fairness and equity in sharing of the benefits of biodiversity; this led to the opening of the Convention on Biological Diversity in 1992; Rio de Janeiro under the United Nations Conference on Environment and Development (UNCED)/ Earth Summit. The convention was inspired by the growing concern all over the world for sustainable development. The convention objectives were Conservation of the biological diversity; Sustainable use of its components; A fair and equitable sharing of its benefits. This was the first global comprehensive agreement that addressed all the aspects of biological diversity; genetic resources, species diversity and ecosystem diversity. Figure 1, Concept of sustainable development. Biodiversity conservation other international biodiversity conventions and conservation organizations African Convention on Conservation of nature and natural resources. The Ramsar Convention on Wetlands of international importance. International Union for the Conservation of nature (World Conservation Union). Convention on International trade for endangered species (CITES). International Convention for the Protection on birds.

International Board for Plant genetic resources. World Resources Institute. World Wide Fund for Nature. Convention on Conservation of migratory species of wild animals. International Convention for the Regulation of whaling. UNESCO programme on Man and biosphere. Existing Measures for Conserving Biodiversity in Kenya Zoological gardens - These are refuge areas for rare animals that could disappear without captive breeding e.g. zoos and aquariums. They are conservation areas for preservation of genetic stocks for re-introduction to the wild when conditions become favourable. They are also used for educational and scientific research. Botanical gardens/Arboretums - These are areas for research and exhibition of plants, documentation of local flora, preserving samples of rare and endangered species and maintenance of specimen collections for future use. It acts like a museum for plants e.g. the East African Botanical Garden in Nairobi. Seed banks - Ex-Situ approach where storage of conservation materials in form of seeds is monitored with regard to viability through germination tests and purity analysis. The objective is to ensure that genetic continuity is maintained. National parks and game reserves - These are different from

zoological gardens and are established on terrestrial and aquatic ecosystems with the objective to preserve wildlife that cannot co-exist with human beings and human activities. National parks are under the jurisdiction of central government while game reserves are managed by the local county council.

6.4 PRINCIPLES WILDLIFE

Protected Area Network in India India is one of the 17 mega diverse countries of the world. With only 2.4% of the world's land area, 16.7% of the world's human population and 18% livestock, it contributes about 8% of the known global biodiversity, however, putting enormous demands on our natural resources. India is home to world's largest wild tigers population and has got unique assemblage of globally important endangered species like Asiatic lion, Asian Elephant, One-horned Rhinoceros, Gangetic River Dolphin, Snow Leopard, Kashmir Stag, Dugong, Gharial, Great Indian Bustard, Lion Tailed Macaque etc. Protected Area Network in India: A National Board for Wildlife (NBWL), chaired by the Prime Minister of India provides for policy framework for wildlife conservation in the country. The National Wildlife Action Plan (2002-2016) was adopted in 2002, emphasizing the people's participation and their support for wildlife conservation.

India's conservation planning is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. The Indian Constitution entails the subject of forests and wildlife in the Concurrent list. The Federal Ministry acts as a guiding torch dealing with the policies and planning on wildlife conservation, while the provincial Forest Departments are vested with the responsibility of implementation of national policies and plans. A network of 668 Protected Areas (PAs) has been established, extending over 1,61,221.57 sq. kms. (4.90% of total geographic area), comprising 102 National Parks, 515 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves. The State/Union Territory wise details of PAs in the country with year of notification and area is given at Annexure-I. 39 Tiger Reserves (Annexure-II) and 28 Elephant Reserves (Annexure-III) have been designated for species specific management of tiger and elephant habitats. UNESCO has designated 5 Protected Areas as World Heritage Sites.

As the ecosystems and species do not recognise political borders, the concept of Transboundary Protected Areas has been initiated for coordinated conservation of ecological units and corridors with bilateral and/or multilateral cooperation of the neighbouring nations. There are 4 categories of the Protected Areas viz, National Parks, Sanctuaries, Conservation

Reserves and Community Reserves. Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance.

The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary. National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary.

The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary, the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (However, as per orders of Hon'ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife).

Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected. Community Reserves can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural conservation values and practices. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected. Regulations/ laws relating to Protected Areas (PAs): The PAs are constituted and governed under the provisions of the Wild Life (Protection) Act,

1972, which has been amended from time to time, with the changing ground realities concerning wildlife crime control and PAs management. Implementation of this Act is further complemented by other Acts viz. Indian Forest Act, 1927, Forest (Conservation) Act, 1980, Environment (Protection) Act, 1986 and Biological Diversity Act, 2002 and the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The Wildlife Crime Control Bureau of the Central Government supplements the efforts of provincial governments in wildlife crime control through enforcement of CITES and control of wildlife crimes having cross-border, interstate and international ramifications. In order to strengthen and synergise global wildlife conservation efforts, India is a party to major international conventions viz. Convention on International Trade in Endangered Species of wild fauna and flora (CITES), International Union for Conservation of Nature (IUCN), International Convention for the Regulation of Whaling, UNESCO-World Heritage Committee and Convention on Migratory Species (CMS). Main issues concerning the management of Protected Areas.

Wildlife conservation and management in India is currently facing a myriad of complex challenges that are both ecological and social in nature. Issues such as habitat loss/fragmentation, overuse of biomass resources in the context of biotic pressures, increasing human-wildlife conflicts, livelihood dependence on forests and wildlife resources, poaching and illegal trade in wildlife parts and products, need for maintaining a broad base of public support for wildlife conservation exemplify and characterize the contemporary wildlife conservation scenario in India. The government and the civil society are taking several measures to address these issues. Improved synergies and better coordination amongst the wide array of stakeholders are needed to meet the challenges of conserving India's diverse wilderness resources.

6.4.1 PROTECTED AREAS

Protected Areas of India from 2000 to 2017 (as on January, 2017)

Year	No. of National Parks	Area Under National Parks	No. of Wild Life Sanctuaries	Area Under Wild Life Sanctuaries	No. of Community Reserves	Area Under Community Reserves	No. of Conservation Reserves	Area Under Conservation Reserves	No. of Protected Areas	Total Area under Protected Areas
2000	89	37593.94	489	117881.68	-	-	-	-	578	155475.63
200	96	38183.	506	120244.	-	-	4	42.87	606	158470

6		01		39						.27
2007	98	38219.72	510	120543.95	4	20.69	7	94.82	619	158879.19
2008	99	39232.58	513	122138.33	4	20.69	45	1259.84	661	162651.45
2009	99	39232.58	513	122138.33	4	20.69	45	1259.84	661	162651.45
2010	102	40074.46	516	122585.56	4	20.69	47	1382.28	669	164062.99
2011	102	40074.46	517	122615.94	4	20.69	52	1801.29	675	164512.37
2012	102	40074.46	524	123548.33	4	20.69	56	1998.15	686	165641.62
2013	102	40074.46	526	124234.52	4	20.69	57	2017.94	689	166347.6
2014	103	40332.89	525	116254.36	4	20.69	60	2037.11	692	158645.05
2015	103	40500.13	531	117607.72	26	46.93	66	2344.53	726	160499.31
2016	103	40500.13	537	118005.30	26	46.93	67	2349.38	733	160901.74
2017	103	40500.13	537	118005.33	26	46.93	67	2349.38	733	160901.77

Source: National Wildlife Database Cell, Wildlife Institute of India

6.5 REFERNCES

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2. Kenya Electricity Generating Co., Ltd. GEOTHERMAL TRAINING PROGRAMME Geothermal Development Company BIODIVERSITY CONSERVATION Thecla M.
3. Mutia Geothermal Development Company Limited P.O. Box 100746-00101, Nairobi KENYRelated Links

UNIT 7: PROTECTED AREA NETWORK IN UTTARAKHAND

7.1. OBJECTIVES

After reading this unit the readers will be able to:

- Define protected area
- About geographical position of Uttarakhand
- Biodiversity of Uttarakhand
- What are National Parks? National Parks of Uttarakhand
- What are Wildlife sanctuaries? Wildlife sanctuaries of Uttarakhand
- What are Biosphere reserves? Biosphere reserve of Uttarakhand
- What are conservation sites? Conservation sites in Uttarakhand

7.2. INTRODUCTION

As you know that, our environment is fully blessed with variety of plants, animals and microbes. These are collectively called biological diversity or biodiversity. According to Convention on Biological Diversity (CBD) bio- diversity may defined as ""*Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*." As you know that human being totally depend on biodiversity for different purposes such as food (*Oryza sativa, Triticum aestivum, Solanum tuberosum* etc.), medicines (*Emblica officinalis, Saraca asoca, Withania somnifera* etc.). Beside this, Honey, silk, lac, poultry, dairy industries are also depend on biodiversity. In last few decades many species of plants and animals have extinct from this planet. Many valuable species of plants and animals also verge to extinction due to different types of manmade activities such as urbanization, industrialization, pollution, poaching and hunting, over exploitation of natural resources etc. As you know that habitat fragmentation/destruction is main threat to biodiversity. Habitat fragmentation is often caused by humans when native plants are cleared for human activities such as agriculture, urbanization, construction of hydropower projects etc. After destruction of habitats, the habitat become separate and many species isolated from each other. Therefore, scientists, policy makers, researchers scare about the loss of biodiversity. Governments of different Nations all over the world now established protected areas for the protection of habitats (both

terrestrial and aquatic), flora and fauna. In this unit you will learn about protected area, biodiversity of Uttarakhand and protected area network of Uttarakhand state.

7.3. PROTECTED AREAS

Protected areas are areas or locations which receive protection because of their recognized natural, ecological values. There are several kinds of protected areas such as **National Parks, Wildlife Sanctuaries, Biosphere reserves, and conservation sites** etc. which vary by level of protection depending on the permitting laws of each country or the regulations of the international organizations. Protected areas are essential for biological diversity conservation, often providing habitat and protection from hunting and poaching. Protection helps maintain ecological processes within ecosystems.

7.3.1. MEANING AND DEFINITION OF PROTECTED AREAS

According to International Union for Conservation of Nature (IUCN) Protected area may defined as "Protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".

Protected areas provide various social, environmental and economic benefits to people and communities at local and global level. Protected areas are very important to react to present environmental problems and these areas provide food and water security, human health and welfare, disaster risk reduction and climate change.

As you now that the world continues to develop at a rapid speed consequently, pressure on ecosystems and natural resources increases. Protected areas, when administered and managed properly and embedded in development strategies, may provide nature-based solutions to this pressure. Protected areas are important in following terms:

- These protected areas provide habitat to wildlife
- Protected areas provide drinking water to communities.
- Store the same amount of carbon as the tropical rainforests,
- Protected areas keep human being and wildlife healthy by being the source of clean air and water.
- Protected areas protect endangered plants and animals in their habitats.
- Protected areas help to reduce the risks and consequences of extreme events such as floods, storm-surges, and drought.

- Protected areas Provide homes, jobs and livelihoods to millions of people around the world.

In-situ and Ex-Situ conservation methods of biodiversity Conservation: As you know that biodiversity conservation basically done by two methods and these methods are In-situ and Ex-Situ Conservation. In-situ method of conservation is type of conservation method of biodiversity in which organisms protected in their own or natural habitats. National parks, wildlife sanctuary, biosphere reserves, biodiversity spots, sacred grooves and conservation sites are examples of In-situ conservation methods of biodiversity. On the other hand, Ex-situ conservation methods are conservation methods of biodiversity in which organisms are protected outside the natural habitats. Zoological parks, botanical gardens, seed banks, tissue culture, cryopreservation etc. are the examples of ex-situ conservation methods of biodiversity conservation methods.

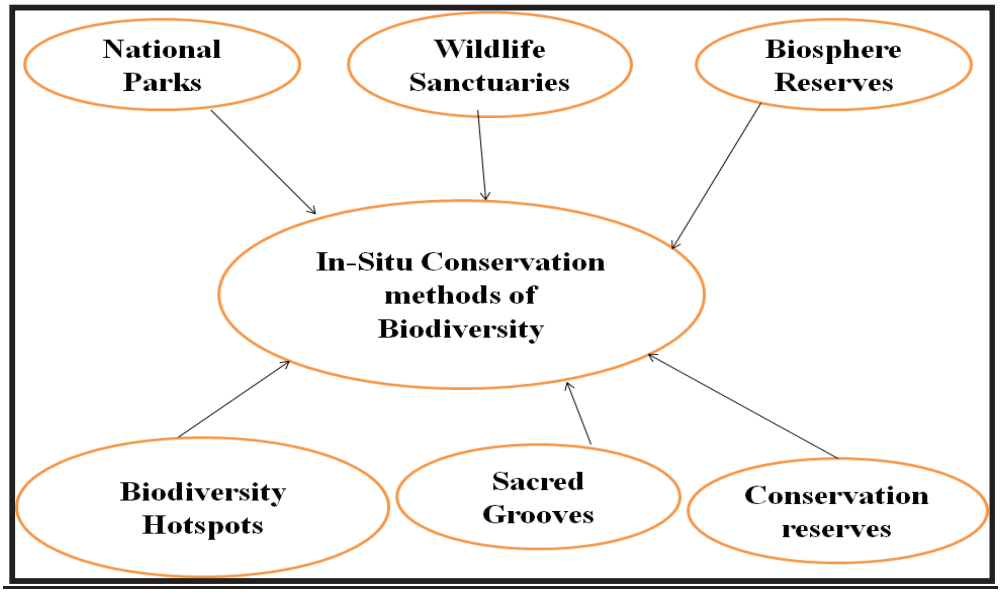

Fig-1: Showing different In-situ conservation methods of biodiversity

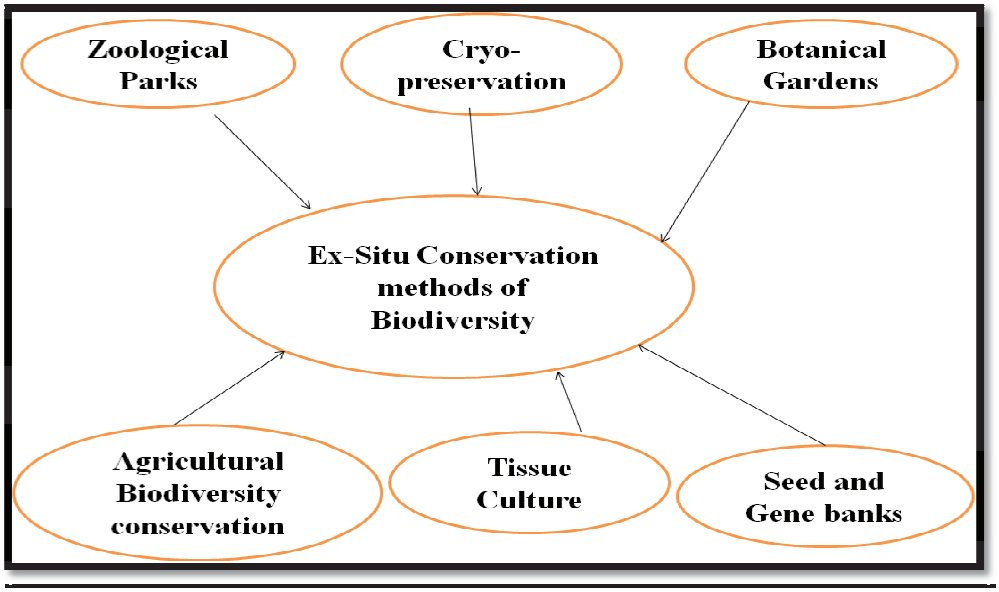

Fig-2: Showing different Ex-situ conservation methods of biodiversity

7.4. ABOUT UTTARAKHAND

Uttarakhand previously known as Uttaranchal is a northern state of India. It is also called Dev Bhoomi (Land of Gods). Uttarakhand is known for the natural beauty of the Himalayas, Bhabhar and Tarai and it was formed on 9 November 2000, from the State Uttar Pradesh. The state is divided into two divisions namely Kumaun and Garhwal with thirteen districts. Its temporary Capital is Dehradun and High Court at Nainital. As per 2011 Census of India Uttarakhand has a population about 1 crore eight six lakh and it is twentieth most populous state of India.

7.4.1. *GEOGRAPHICAL POSITION OF UTTARAKHAND*

Uttarakhand has a total area of 53,483 sq.km (1.6% of total geographical area of country) out of which 46035 sq. km (About 86%) is mountainous or hilly. Most of the northern part of Uttarakhand is covered by high Himalaya peaks and glaciers. Physiographically, state has three zones namely: The Himalaya, Shivalik and Tarai range. The total forest cover in Uttarakhand is about 67.10%. Two very important rivers of India originate in the glaciers of Uttarakhand, the Ganga and the Yamuna. They are fed by numerous lakes, glacial melts and streams.

The forest cover diversity comprises in following types:

1. Tropical moist forests (500-1000m)
2. Himalayan moist temperate forest (2000-3000 m)
3. Sub alpine forests (3400-4000m)
4. Alpine forests (4000-5000m)

7.4.2. *BIODIVERSITY OF UTTARAKHAND*

As you know that biodiversity is the basis of the life on this planet. Each and every species of globe is important for maintaining balance in ecosystems. Biodiversity is extremely complex, dynamic and varied. Its innumerable plants, animals and microbes physically and chemically unite the atmosphere, geosphere (lithosphere) and hydrosphere into one environmental system that makes it possible for millions of species to exist. But on the other hand human activities influenced the biodiversity as well as other factors of environment. Due to loss of biodiversity, human being and other living creature are severely affected.

Biodiversity is the result of over 3.5 million years of evolutionary process. Therefore, conservation of biodiversity is the basis for our survival. India is one of the 12^{th} mega diversity Nations of the world. India has two hotspots namely Western Ghats and Eastern Himalayas.

Uttarakhand is a part of Indian Himalayan region is home to great variety and unique range of floral and faunal diversity. Uttarakhand state is bestowed with great faunal diversity also. It is a home for many species of birds, mammals, and reptiles. Uttarakhand is home to the faunal biodiversity of 3748 species belonging to 1848 genera of both vertebrates and invertebrates. To be precise, there are 499 genera with 1060 vertebrates 35 species reported from Uttarakhand are endemic to the state while one is even endemic to India.

The enormous faunal diversity is represented by 93 species of Mammals (which is about 25 % of the known Indian species), 743 species of birds, (representing 60% of the Indian avifauna, second to the Assam State), 72 species of reptiles and about 439 species of butterflies. It is evident that the endemism is very high in the species found in Uttarakhand also there are other species which has a high threat status.

According to Biodiversity Board of Uttarakhand many species of plants such as *Aconitum balfourii, A. heterophyllum, Eremostachys superb, Diplomesis hirsute, Turpenia napalensis, Pinguicula alpina* are verge to extinction. Certain animals such as *Murina grisea, Cervus duvaucelli, Panthera tigiris tigiris, Gyps bangalensis, Ophryusia supercioliosa, Sacogyps*

calvus, Hyaena hyaena, Moschus chrysogaster, Uncia uncial, Tragopan melanocepalus, T. styra also verge to extinction.

Table-2: Showing important state biodiversity of Uttrakhand

S.N		Scientific name	Common Name
1.	**State Animal**	*Moschus chrysogaster*	Alpine musk deer
2.	**State flower**	*Saussurea obvallata*	Brahma Kamal
3.	**State Bird**	*Lophophorus impejanus*	Himalayan Monal
4.	**State Fruits**	*Myrica esculenta*	Kaphal
5.	**State Tree**	*Rhododendron arboretum*	Burans

7.5. PROTECTED AREA NETWORK IN UTTARAKHAND

7.5.1. NATIONAL PARKS IN UTTARAKHAND

National Parks: National Parks are very important protected areas which declared by IUCN. These National parks provides habitat to wildlife and very few human activities are allowed in the buffer zone of National park. The plantation, cultivation, grazing, hunting and predating of animals, destruction of flowers are highly prohibited in National Parks. International Union of Conservation of Nature (IUCN) has declared National Parks in Category II of the protected areas. IUCN is global authority which works for conservation of Nature. It was established in 1948 in France. It is officially called International Union of Conservation of Nature and Natural Resources. If you want visit in a National Park you must take permission from the relevant authorities. There are six National parks (Gangotri National Park, Govind Pashu Vihar National Park and Sanctuary, Jim Corbett National Park, Nanda Devi National Park, Valley of Flower National Park, Rajaji National Park) in Uttarakhand which are described below:

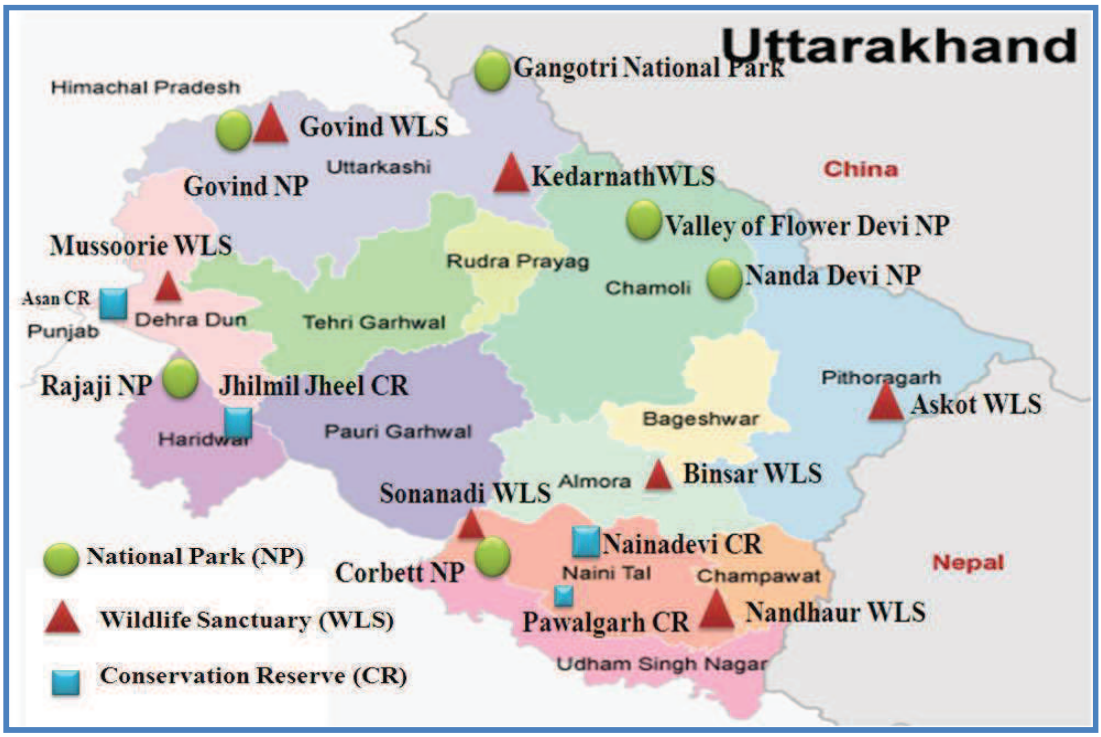

Fig: 3: showing the protected area network in uttarakhand

Table-2: List of National Parks, their location, establishment year and area covered

S.N.	Name of National Park	Location	Establishment Year	Total Area (sq km)
1.	Gangotri National Park	Uttarkashi	1989	2390.02
2.	Govind Pashu Vihar National Park and Sanctuary	Uttarkashi	1990	957.96
3.	Jim Corbett National Park	Nainital	1936	520.82
4.	Nanda Devi National Park	Chamoli	1982	624.60
5.	Valley of Flower National Park	Chamoli	1982	87.50
6.	Rajaji National Park (Declared as Rajaji Tiger reserve in 2015)	Dehradun, Pauri Garhwal and Haridwar	1983	820.42

Gangotri National Park: This National Park is located in the District Uttarkashi of Uttarakhand. It has area about 2,390.02 sq. km. It was established in the year 1989. This National park is home to floral diversity such as: Alpine shrubs, meadows, chirpine, deodar, rhododendrons and oak and fauna like snow leopard, tahr, Himalayan barbet, pheasant birds, pigeons etc. According to scientists about 15 species of mammals and 150 bird species have discovered in this park.

Govind Pashu vihar National park and Sanctuary: This is also located in Uttarkashi district of Uttarakhand. It was established initially as a wildlife sanctuary in 1955, and later converted into a national park. It has an area about 958 Sq.km. It is named after a renowned Indian freedom fighter and politician Govind Ballabh Pant, who became Home Minister in 1950 and is remembered for his achievement in establishing Hindi as an official language. This NP is home to various flora like chir, pine, deodar, oak, conifers, rhododendrons etc. Thi National Park is home to Snow leopard species which categorized as endangered under IUCN category. Other mammals found in the NP/sanctuary include the musk deer, bharal, brown bear, Himalayan tahr, porcupine, wild boar etc. Birds found here include several endangered species such as the golden eagle, black eagle, monal, finches cuckoos, parakeets, bulbul etc.

Jim Corbett National Park: It is is the first national park of India which established in the year 1936 as Hailey National Park to protect the endangered Bengal tiger. It is located in district Nainital and was named after Jim Corbett who played a key role in establishment of this National park. Corbett National Park comprises 520.8 sq.km area of hills, riverine belts, marshy depressions, grasslands and a large lake. A total of 488 different species of plants have been recorded in the park. About 586 species of resident and migratory birds, 33 species of reptiles, 07 species of amphibians, seven species of fish and 36 species of dragon flies have also been recorded from this National Park. Bengal tigers, leopards, jungle cats, fishing cat, otters, owls, barking deer, sambhar deer, langur, Elephant, python etc are common fauna of this National Park.

Nanda devi National Park: It was established in 1988 in the district chamoli of uttarakhand. it is a situated around the peak of nanda devi (goddess of hindu religion). This is world heritage site by unesco. the national park has an area about 624.60 sq. km in nanda devi biosphere reserve. This NP is home to a wide variety of flora such as fir, birch, rhododendron, and juniper. Common fauna of national park are himalayan musk deer, snow leopard, himalayan black bear, brown bear etc.

Valley of National Park: It was established in the year 1982 in the District Chamoli of Uttarakhand. It has an area about 87.50 sq.km. This National Park and Nanda Devi National Park are lies under the Nanda Devi Biosphere reserve. We will discuss Nanda Devi Biosphere reserve in later. This National park is famous for different flowers like orchids, poppies, marigold etc. Common flora of National parks are *Abies pindrow*, *Betula utilis*, and *Rhododendron campanulatum*, *Taxus wallichiana*, *Syringa emodi*, *Arisaema jacquemontii*, *Boschniakia himalaica*, *Corydalis cashmeriana*, *Polemonium caerulium*, *Polygonum polystachyum*, *Impatiens sulcata*, *Geranium wallichianum*, *Galium aparine*, *Morina longifolia*, *Inula grandiflora*. The common fauna of this park are *Semnopithecus entellus* (langur), *Petaurista petaurista (*flying squirrel*)*, *Ursus thibetanus (*Himalayan black bear) *Vulpes vulpes (*red fox*)*, *Mustela sibirica (*Himalayan weasel*)*, and *Martes flavigula* (Himalayan yellow-throated marten), *Naemorhedus goral* (Himalayan goral), *Moschus leucogaster* (Himalayan musk deer), *Moschiola indica* (Indian chevrotain), *Hemitragus jemlahicus a*nd serow *Capricornis sumatraensis*.

Rajaji National Park: Thi National Park is spread over 820 sq. km. in the area of three districts namely Haridwar, Dehradun and Pauri Garhwal. It was established in 1983, when three wildlife sanctuaries (Chill, Motichur and Rajaji) merged in to one. It has been named after C. Rajagopalachari, a prominent leader of the Freedom Struggle and first recipients of India's highest civilian award Bharat Ratna in 1954. Rajaji National Park declared as tiger reserve in 2015. Rajaji National Park is home to various plant species such as *Cassia fistula* (amaltash), *Shorea robusta* (sal), *Butea monosperma* (palash), *Terminalia arjuna* (arjun), *Aegle marmelos* (bel) etc. Common fauna of National parks are elephant, tiger, chital, leopard,sambhar, jackal, barking deer, Indian porcupine, Himalayan black bear, striped hyena, monitor lizard, python, pea fowl, kingfisher, great pied hornbill etc.

7.5.2. WILDLIFE SANCTUARIES IN UTTARAKHAND

Wildlife Sanctuary: Wildlife makes the primary natural heritage, all around the world. Constant industrialization and deforestation, has been threat of extinction to the wildlife. International Union of Conservation of Nature grouped wildlife sanctuaries in Category IV of protected areas**. Wildlife sanctuary** refers to an area which provides protection and favourable living conditions to the wild animals. Wildlife Sanctuary, as the name imply, is the place that is reserved exclusively for the wildlife protection. It provides habitat and safe

living conditions to the wild animals especially to the endangered. For proper management of the sanctuary, rangers or guards are appointed to patrol the region. Governments ensure the safety of animals, from poaching, predating or harassing.

Table-3: List of Wildlife sanctuary, their location, establishment year and area covered

S.N.	Name of Wildlife sanctuary	Location	Establishment Year	Total Area ((Sq.km))
1.	Askot Wildlife Sanctuary	Pithoragarh	1986	599.93
2.	Binsar Wildlife Sanctuary	Almora	1988	45.59
3.	Kedarnath Wildlife Sanctuary	Chamoli and Rudraprayag	1972	975.20
4.	Nandhaur Wildlife Sanctuary	Nainital, Champawat	2012	269.96
5.	Sonanadi Wildlife sanctuary	Nainital	1987	301.18
6.	Benog Mussoorie Wildlife sanctuary	Dehradun	1993	3.39

Askot Wildlife Sanctuary: This sanctuary was established in the year 1986 with objective of conserving Himalayan Musk deer (*Moschus leucogaster*). As you know that, poaching of musk deer is very common in hilly states of India. Intensive efforts have been initiated to conserve this rare species. Therefore, this sanctuary is also called Askot Musk deer Sanctuary. It has an area about 600 sq. km. Beside, musk deer this sanctuary is home to Bengal tiger, Indian leopard, Jungle cat, Himalayan brown bear etc. Religious spots under the sanctuary are Chota Kailash, Bhanar etc. The famous peaks of area are Panchchuli, Neodhura, Chiplakot etc.

Binsar Wildlife Sanctuary: It is located in the Almora district of Uttarakhand and 33 km north of the Almora. It has an area about 45.59 sq. km. It was established in 1988 for the conservation and protection of the oak forests of the Central Himalayan region, and it has over 200 bird species. The fauna of sanctuary include Himalayan goral, leopard, chital, musk deer, Jungle cat, red fox, forktail bird, woodpecker, monal, parakeet etc. It is also home to many reptiles and a wide range of butterflies

Kedarnath Wildlife Sanctuary: It is also called the Kedarnath Musk Deer Sanctuary established in 1972 for the protection of Himalayan Musk deer. It consists of an area of 975 sq. km. The sanctuary takes its name from the famous Hindu Shrine Kedarnath which is just outside its northern border. The whole route (14km) from Gauri Kund to Kedarnath Temple lies under this wildlife sanctuary. Flora of sanctuary includes high-altitude bugyal dense forests of Chir pine, oak, rhododendron. Common fauna of sanctuary are Himalayan Musk deer, Red fox, snow leopard, flying squirrel, rhesus mazaque, langur, Himalayan Monal, pheasants, grey cheeked warbler, Himalayan pit viper etc.

Nandhaur wildlife sanctuary: It is located in the district nainital and champawat and was established in 2012. it lies between gola river and sharda river in haldwani forest division. It has an area about 269.96 sq. km. nandhaur wls is important for the protection of tigers. Main floras of this sanctuary are shisham, bamboo and chir pine. forest department of uttarakhand found a tree in this sanctuary, which is called “king of trees”.This tree is expected 200 year with 54 feet wide and 120 feet height.This sanctuary is also home to about 25 species of mammals, 250 species of birds, 15 species of reptiles and 20 species of fishes. The major mammalian species include leopards, asian elephants, tigers and sloth bears.

Sonanadi Wildlife sanctuary: It is pread in district Nainital of Uttarakhand State. It has an area about 301.18 sq. km. It is an undisturbed wildlife haven, tucked between the Corbett and Rajaji national parks. It was established in 1987 to protect the biodiversity-rich region between these important wildlife conservation destinations. Main flora of sanctuary are Sal, Shisham, Khair, Asna and bamboo species. Fauna of this sanctuary are Asiatic Elephant, tiger, leopard, lbar, cheetal, sambar, ghariyal, king Cobra and otter. This wildlife sanctuary is also famous for bird population that includes about 550 avian species like Pied Hornbill, Hawk Eagle, Kaleej Pheasant and Fishing Eagle.

Benog Mussoorie Wildlife sanctuary: It is part of famous Rajaji National Park and was established in the year 1993. It has an area about 3.39sq.km. The sanctuary is home to several species of exotic birds such as White Capped Water Redstart and Red Billed Blue Magpie to name a few. The Mountain Quail (Pahari Bater) was spotted in this sanctuary in 1876, but now considered extinct. Common fauna of sanctuary are Himalayan goat, panther, leopard, deer and bear. Flora of this sanctuary includes pine trees, several medicinal plants.

Table-4: Difference between Wildlife sanctuary and National Park

Base of Comparison	National Park (NP)	Wildlife Sanctuary (WLS)
Category In IUCN	Category II	Category IV
Meaning	National park is the protected area, which is established by the government, to conserve wildlife and also develop them. It also protects natural habitats, cultural and heritage sites.	Wildlife Sanctuary is a natural habitat, owned by the government or private agency that protects particular species of animal.
Preservation	Flora, fauna, landscape, historic objects, etc.	Animals, birds, insects, reptiles, etc.
Aim/Objective	To protect the natural and historic objects and wildlife of an area.	To maintain population of the wildlife and their habitats.
Restriction	Highly restricted, random access to people is not allowed.	Restrictions are less and it is open to public.
Permission to visit	Required for Officials	Not required
Boundaries	Fixed by legislation	Not fixed
Human activity	Not allowed at all.	Allowed but up to a certain limit.

7.5.3. BIOSPHERE RESERVE IN UTTARAKHAND

Biosphere Reserve: Biosphere reserves are protected area established by different countries and recognized under Man and Biosphere Programme of United Nations Educational, Scientific and Cultural Organization (UNESCO). Biosphere Reserves are excellent locations to examine how to implement the sustainable development Goals. Three zones are characteristic of Biosphere reserve, the core area(s) and sometimes buffer zone(s) of all biosphere reserves which are protected areas as recognised by IUCN.

Three zone of Biosphere Reserve: There are three zones of biosphere reserves which are described below:

1. **The core Zone/area:** It is long term protected area and it act as a reference point of biosphere reserve. This area is indication of biosphere reserve. It is strictly protected area that contributes to conservation of landscape, species and genetic variation.
2. **Buffer Zone/Area:** This zone is adjoining area of core area and may used for several activities such as scientific research, monitoring, training and education.
3. **Transition Zone:** Transition zone is part of biosphere reserve where maximum human activities are allowed. Such activities may for fostering economic and human development that is socio-culturally and ecologically sustainable.

There are 669 Biosphere reserves in all over the world out of which 18 Biosphere reserves are established in India. One biosphere reserve established in Uttarakhand which is described below:

Nanda Devi Biosphere Reserve: The Nanda Devi Biosphere Reserve is an important protected area of Uttarakhand. It was established in 1988 NDBR Its name was named after famous peak of that area i. Nanda Devi (7817 m) which is second highest peak of India. The total area of this biosphere reserve is about 6384.49 sq. km. The Nanda Devi biosphere reserve has divided in to three zones: Core zone (National Parks), Buffer Zone and transition zone. There, are two core zone in Nanda Devi Biosphere Reserve, these are Core zone 1 of Nanda National Park and core zone-2 of Valley of Flower National Park. Both the core zones of this biosphere reserve are declared as world heritage sites of UNESCO. Common flora of this biosphere reserve are include fir, birch, rhododendron, and juniper, ramani, alpine, prone mosses and lichens. Common fauna of this biosphere reserve are Leopards, Himalayan Musk deer, Himalayan tahr, rhesus macaque, brown bear, snow leopards, barking deer etc. Total of 114 bird species are recognized from this biosphere reserve.

7.5.4. CONSERVATION RESERVES IN UTTARAKHAND

Conservation reserves are the protected areas for the protection of animals and their habitats. There are four conservation reserves namely: Naina Devi Himalayan bird conservation reserve, Jhilmil Jeel conservation reserve, Asan wetland conservation reserve, Pawalgarh Conservation reserve in Uttarakhand which are described below:

Table-5: List of Conservation reserve, their location, establishment year and area covered

Name of Conservation Reserve	Location	Establishment Year	Total Area (Sq.km)
Naina Devi Himalayan bird conservation reserve	Nainital	2015	111.9
Jhilmil Jeel conservation reserve	Haridwar	2005	37.84
Asan wetland conservation reserve	Dehradun	2005	4.44
Pawalgarh Conservation reserve	Nainital	2012	58.24

Naina Devi Himalayan bird conservation reserve: It was established in 2015 in the District Nainital of Uttarakhand. It spread in area of 111.95 sq.km. This conservation reserve is home to temperate broad-leaf forests to alpine grasslands to rhododendron shrubberies. Common fauna of Naina Devi Conservation reserve are Koklas pheasants, Kalij pheasants, black throated tit, bearded vulture, Himalayan goral etc.

Jhilmil Jeel conservation Reserve: It is little known marshy grassland just near the Rajaji National Park at Haridwar district of Uttarakhand. It has an area about 37.84 sq. km. It is located between Haridwar-Najibabad Highway. It was declared a Conservation Reserve in the year 2005 on order from renowned scientist and former President Dr. Abdul kalam. Jhilmil Jheel conservation Reserve is rich in fauna and flora diversity including five species of deer as Chital, Sambar, Barking deer, Hog deer and Swamp deer, Elephant, Nilgai, leopard and tiger are also seen in the area. This conservation was established under Sec 36 (a) of Wildlife (Protection) Act, 1972.

Asan wetland conservation Reserve: It is located in Dehradun district is first conservation reserve of India established in 2005. It has an area of 4.44 sq km, this wetland is at the confluence of the Asan and Yamuna Rivers. The conservation reserve supports more than 250 species of birds. Its proximity to Dehradun and the ease of seeing birds makes it a great bird tourism destination. Some of the bird species of Asan conservation reserve are Black francolin, Grey francolin, Ruddy shelduck, Gadwall, Mallard, Northen pintail, Bear's pochard, Common goldeneye, Little Grebe, Glossy ibis, Black-necked stork, Eurasian spoonbill, Indian pond heron, Grey heron, Great cormorant, Osprey, White-tailed fish,

Himalayan vulture etc. This conservation was established under Sec 36 (a) of Wildlife (Protection) Act, 1972.

Pawalgarh Conservation Reserve: It is located in the Nainital District of Uttarakhand state and established on 14 Dec, 2012. It has an area about 58.24 sq.km. Pawalgarh conservation reserve is a network of forest, grassland and riverine ecosystems which provide habitats to many floral and faunal species. The common fauna of conservation reserve are tiger, leopard, spotted deer, nilgai, kakad (goat like deer), hares, langures. It has over 350 species of birds and every year many tourists visit here for bird watching. Great slaty woodpeckers, varieties of hornbills are main attractive birds of this conservation reserve.

7.5.5. SACRED GROOVES IN UTTARAKHAND

As you know that Uttarakahnd is also called Dev bhoomi means land of God and Goddess. State has variety of religious and traditional beliefs, cultural and practices and these play a crucial role in the conservation of environment and biodiversity. According to Hughes and Chandran sacred groves are defined as "segments of landscape containing vegetation, life forms and geographical features, delimited and protected by human societies under the belief that to keep them in a relatively undisturbed state is expression of an important relationship of humans with the divine or with nature.

According to Environmental Education Centre, Chennai which ii body of Ministry of Environmental, Forest and Climate change "sacred groves in Uttarakhand are locally known as Deo Bhumi and Bugyal (sacred alpine meadows and 126 sacred groves have been documented in the state. Uttarakhand has an age-old tradition of protected temple forests near villages, where different God and Goddess are worshipped in these sacred groves. The trees which are growing in these groves are not allowed to destroy and as it is believed that these trees are associated with God and Goddess. Local communities conserve these sacred grooves and sometimes dried parts are seed by them. Communities believe that sudden falling of trees or plants of these sacred grooves are said to be indicator of misfortune or disaster for the villagers. These types of believe in these sacred grooves helped conservation of biodiversity of area. areas. It is expected that many more sacred grooves are found in Uttarakhand. Some important sacred grooves in Uttrakhand are given below:

Table-6 Showing important Sacred Groves in Uttarakhand

S.N	District	Location	Name of the Deity	Name of the Grove (Surrounding forest)
1.	Almora	Chamarkhan	Golu Devta	Chir pine (Pinus roxburghii)
2.	Nainital	Ghorakhal		Banj oak (Quercus leucotrichophora)
3.	Chamoli	Badheth		Ghanteyal ki cheevi, Devika mandi Ghandiyal Devataka van Laxmivan, Nandaaur Ghantakaran Ki Phulwari
4.	Pithoragarh	Ganglihat tehsil	Mahakali Shaktipith	Haat Kali
5.	Pithoragarh	Berinag tehsil	Kokilamata	Lohathal

7.6. ENDANGERED FAUNA OF UTTARAKHAND

Endangered fauna are that species of animals which has been categorized as likely to become extinct in near future. Endangered (EN), as categorized by the IUCN, Red List is second most severe category after critically endangered. Biodiversity extinction is commonly due to habitat destruction, *poaching*, pollution, introduction of exotic (invasive) species, use of insecticides and pesticides. There are many endangered fauna are found in Uttarakhand which are given below:

Table: 7: Table Showing Endangered Fauna of Uttarakhand State

S.N.	Scientific Name	Common/Vernacular/Local Name	IUCN Category
		Endangered Birds	
1.	***Gyps bengalensis***	White-rumped Vulture, Asian White-backed, Vulture, Oriental White-backed Vulture, Whitebacked Vulture	Critically Endangered
2.	***Sarcogyps calvus***	The Red-headed Vulture, Asian King Vulture, Indian Black Vulture	Critically Endangered
3.	***Vanellus gregarius***	Grey-headed Lapwing	Critically Endangered
4.	***Tragopan melanocephalus***	Western Tragopan	Vulnerable
5.	***Tragopan satyra***	Satyr Tragopan	Near Threatened
6.	***Ophrysia superciliosa***	Himalayan Quail (Chota Kala Teetar)	Critically Endangered
		Endangered Mammals	
7.	***Moschus leucogaster***	Himalayan Musk Deer (Kasturi Mrig)	Endangered
8.	***Uncia uncial***	Snow leopard	Endangered
9.	***Ursus arctos isabellinus***	Himalayan brown bear (Lal bhalu or Burra bhalu)	Least Concern
10	***Cervus duvaucelii***	Barasingha	Vulnerable
11	***Melursus ursinus***	Sloth bear (Reech).	Vulnerable
12	***Murina grisea***	Peter's tube nosed bat	Endangered
13	***Amblonyx cinereus***	Asian small clawed otter	Vulnerable
14	***Panthera tigris tigris***	Royal Bengal Tiger	Endangered
15	***Hyaena hyaena***	Striped Hyena	Near Threatened

(Source: Uttarakhand Biodiversity Board)

7.7. SUMMARY

Biodiversity or Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Different Governments of countries established protected area for

the protection of habitats and animals and plants there are various protected areas such as National Parks, Wildlife sanctuaries, biosphere reserves, sacred grooves etc have established for the protection of wildlife and their habitats. Generally conservation of biodiversity has done with the help of two methods. First is In-situ conservation method of biodiversity in which species conserve in their own habitats. National parks, Wildlife sanctuaries, biosphere reserves, conservation reserves are the examples of In-situ conservation. Another method is called Ex-situ conservation method in which species conserve out site of the original habitats. Zoological Parks, botanical gardens, seed banks, gene banks, cryopreservation etc are the common examples of Ex-situ conservation methods of biodiversity. Uttrakhand is fully blessed with variety of natural resources and biodiversity. The state animals of Uttrakhand is Himalayan Musk deer, state flower is Brahmakamal, state fruit is Kaphal, state tree is burans and state bird is monal. Uttarakhand being a part of Indian Himalayan Region is home to vast variety and unique range of floral and faunal diversity of India. According to studies, the diversity under 1503 genera and 213 families of flowering plants, including 93 endemic species is harbored in various vegetation types, ranging from sub-tropical forests in upper Gangetic plain and Shiwaliks zone in the south to arctic-alpine vegetation of trans-Himalayan cold desert in the north in Uttarakhand. Uttarakhand houses the faunal biodiversity of 3748 species belonging to 1848 genera and 427 families of both vertebrates and invertebrates. To be precise, there are 499 genera with 1060 vertebrates and 1349 genera with 2688 species of invertebrates found in Uttarakhand. 743 species of birds, 72 species of reptiles and about 439 species of butterflies. Protected areas of Uttrakhand comprises in 6 National parks (Gangotri National Park, Govind Pashu Vihar National Park and Sanctuary, Jim Corbett National Park, Nanda Devi National Park, Rajaji National Park, Valley of Flower National Park) 7 wildlife sanctuaries (Askot Wildlife Sanctuary, Binsar Wildlife Sanctuary, Kedarnath Wildlife Sanctuary, Nandhaur Wildlife Sanctuary, Sonanadi Wildlife sanctuary and Benog Mussoorie Wildlife sanctuary, Govind Pashu Vihar National Park and Sanctuary), 1 biosphere reserve (Nanda Devi biosphere reserve) and 4 conservation sites (Naina Devi Himalayan bird conservation reserve, Jhilmil Jeel conservation reserve, Asan wetland conservation reserve, Pawalgarh conservation reserve) are established in Uttarakhand.

7.8. GLOSSARY

Protected area: Areas or locations which have developed for the protection due to their recognized natural, ecological values.

Geography: Science devoted to the study of the lands, features, inhabitants, and the phenomena of Earth.

In-situ conservation: This is the method of biodiversity conservation in which species are protected in their natural or own habitats.

Ex-situ conservation: This is the method of biodiversity conservation in which species are protected outside their natural or own habitats**.**

Biodiversity: Biological diversity means the variability among living organisms from all sources.

Fauna: All the animal species are collectively called fauna.

Flora: All the plants species are collectively called flora.

National Park: Protected areas which declared by IUCN declared National Park in Category II

Wildlife Sanctuary: Protected areas which declared by IUCN declared in Category VI

Biosphere Reserves: Protected areas which recognized by Man and Biosphere Programme by UNESCO.

Extinct: Species or organism which is not present in this time in any habitat.

Critically Endangered: Species or organism which are verge to extinction

Endangered: Species or organisms which are verge to Critically Endangered

Core Zone: It is long term protected area and it act as a reference point of biosphere reserve. This area is indication of biosphere reserve. It is strictly protected area that contributes to conservation of landscape, species and genetic variation.

Buffer Zone: This zone is adjoining area of core area and may used for several activities such as scientific research, monitoring, training and education.

Transition Zone: Transition zone is part of biosphere reserve where maximum human activities are allowed. Such activities may for fostering economic and human development that is socio-culturally and ecologically sustainable.

7.9. SELF ASSESSMENT QUESTIONS AND POSSIBLE ANSWERS

7.9.1. MULTIPLE CHOICE QUESTIONS

1. Total area of Uttarakhand is hilly or mountainous:

   (a) 65461 sq. km (b) **46035 sq. km**

   (c) 21872 sq. km (d) 12547 sq. km

2. State tree of Uttarakhand is:

   (a) *Emlica officinalis* (b) Acacia catechu

   (c) ***Rhododendron arboreum*** (d) *Mangifera indica*

3. How many biosphere reserve/s are located in Uttarakhand?

   (a) Two (b) Eight

   (c) **One** (d) Six

4. State animal of Uttarakhand is:

   (a) ***Moschus leucogaster*** (b) *Panthera uncia*

   (c) *Panthera tigiris tigiris* (d) *Axis axis*

5. Rajaji National Park is located in which districts of Uttarakhand?

   (a) **Haridwar, Dehradun, Pauri Garhwal** (b)Haridwar, Dehradun, Chamoli

   (c) Haridwar, Dehradun, Tehri Garhwal (d) Nainital, Almora, US Nagar

6. Askot Wildlife sanctuary was established for the protection of

   (a) Himalayan Quail (b) **Himalayan Musk Deer**

   (c) Tiger (d) snow leopard

7. Which one of the following is first National park of India?

   (a) Rajaji National Park (b) Valley of Flower National Park

   (c) **Corbett National Park** (d) Nanda Devi National Park

8. Scientific name of snow leopard is:

   (a) *Panthera tigiris* (b) ***Panthera uncia***

   (c) *Panthera leopardis* (d) *Panthera indica*

9. IUCN is stands for:

(a) International Union for Conservation of Nature

(b) International Union for Consumption of Nature

(c) International Union for Commercial utilization of Nature

(d) Indian Union of Conservation of Nature

10. Which one of the following is ex-situ method of biodiversity conservation?

(a) National Park (b) Wildlife Sanctuary

(c) Cryopreservation (d) Biosphere reserve

11. Which of the following Wildlife Sanctuary is not established in Uttarakhand?

(a) Askot wildlife Sanctuary

(b) Nandhaur Wildlife Sanctuary

(c) **Kishanpur Wildlife Sanctuary**

(d) Sonanadi Wildlife Sanctuary

12. Valley of flower National Park is located in the district:

(a) Chamoli (b) Champawat

(c) Uttarkashi (d) Pithoragarh

13. Asan conservation reserve is located in the district?

(a) Pauri Garhwal (b) Nainital

(c) Dehradun (d) Pithoragarh

14. Govind Pashu Vihar National Park and Sanctuary is located in the district?

(a) Pithoragarh (b) Almora

(c) Nanital (d) **Uttarkashi**

15. Total area of Corbett National Park is about?

(a) 87.56 sq. km **(b) 520.82 sq. km**

(c) 120.25 sq. km (d) 872.32 sq. km

7.9.2. VERY SHORT QUESTIONS

1. Variety and Variability among living species is called as -
2. The conservation methods in which species are protected within their natural or own habitat is called as
3. Give the common and scientific name of state fruit of Uttarakhand ?
4. Total geographical area of Uttarakhand is about……?
5. The conservation methods in which species are protected outside their natural habitat is called……?
6. Give the common and scientific name of state bird of Uttarakhand ?
7. Give the Expanded form of UNESCO ?
8. Give the name of National Parks which lies in the area of Nanda Devi Biosphere reserve?
9. Binsar Wildlife Sanctuary is located in which district of Uttarakhand?
10. Give the name of the that zone (Biosphere Reserve zone) which is used for several activities such as scientific research, monitoring, training and education ?
11. Jhilmil Jheel conservation reserve was created through which Act?
12. Religious spots like Chota Kailash, bhanar are located in the periphery of this Wildlife sanctuary.
13. Give the name of three wildlife sanctuary of Uttarakhand
14. Give the name of three National Parks of Uttarakhand

ANSWERS

4.8.1. 1.(b); 2.(c); 3.(c); 4.(a); 5.(a); 6.(b); 7.(c); 8.(b); 9.(a); 10.(c); 11.(c); 12.(a); 13.(c); 14.(d); 15.(b)

4.8.2. 1. Biodiversity 2. In-situ-conservation method 3. Kaphal, Myrica esculenta 4. 53483 sq.km 5. Ex-situ conservation method 6. Monal, LOPHOPHORUS IMPEJANUS 7. UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION 8. Nanda Devi NP and Valley of Flower NP 9. Almora 10. Buffer Zone 11. Wildlife (Protection) Act, 1972 12. Askot Wildlife Sanctuary 13. Askot Wildlife Sanctuary, Kedarnath Wildlife Sanctuary, Sonanadi Wildlife Sanctuary, Binsar Wildlife Sanctuary, Nandhaur Wildlife Sanctuary, Benof Mussorrie Wildlife Sanctuary 14. Gangotri NP, Corbett NP, Nanda Devi NP, Rajaji NP, Valley of Flower NP.

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UNIT 8: ENVIRONMENTAL POLLUTION AND MANAGEMENT

CONTENTS

8.1. OBJECTIVES

After reading this unit the readers will be able to:

- Define Environmental Pollution
- Discuss the sources, effects and control of Air pollution
- Discuss the sources, effects and control of water pollution
- Discuss the sources, effects and control of Noise pollution
- Discuss the sources, effects and control of soil pollution
- Explain the Biodegradable and Non-biodegradable pollutants
- What is Biomagnifications?
- What is Bioremediation?

8.2. INTRODUCTION

The word Environment has been taken from French word "environ" which means "surrounding". Fundamentally, our environment is composed of atmosphere, earth, water space, plants, animals and microbes. In the absence of pollution, it remains clean and habitable for millions of species. Environmental pollution is one of the biggest issue of the globe and many components of environment being polluted due to different types of anthropogenic or manmade activities. These activities include industrialization, urbanization, construction, transportation, poor agricultural practices, navigation etc. Such activities, although important for human development and welfare, lead to generation and release of objectionable materials into the environment thus become polluted.

However, in order to keep pace with the rapid industrialization world over, a developing country like India cannot afford to prevent its industrial growth. But, it is necessary to undertake pollution control measures, so as to enable us to keep our environment as clean as possible. In this unit you will learn about sources, effects and control of different forms of environmental pollution, biodegradable and non-biodegradable pollutants, biomagnifications and bioremediation.

8.3. ENVIRONMENTAL POLLUTION AND MANAGEMENT

THE WORD "POLLUTION" HAS BEEN TAKEN FROM the Latin word *Pollutionem* which means "defile" or "make dirty".

Definitions of Environmental Pollution

- According to National Academy of Science, USA (1966) "An undesirable change in physical, chemical and biological characteristics of water, air and soil that may harmfully affect human, animal and plant life, industrial progress, living conditions and cultural assets."
- According to Odum (1971) "Pollution is an undesirable change in physical, chemical and biological characteristics of air, water and soil that may harmfully affect the life or create a potential health hazard for living organisms".
- According to Edward (1972) "Pollution is the release of harmful substances into the environment by man in quantities that damage health and resources".
- According to Tiasmann (1975) "Pollution is the accumulation of substances in the environment which exceed the capacity of the eco-system to either neutralise or disperse them to harmful levels".

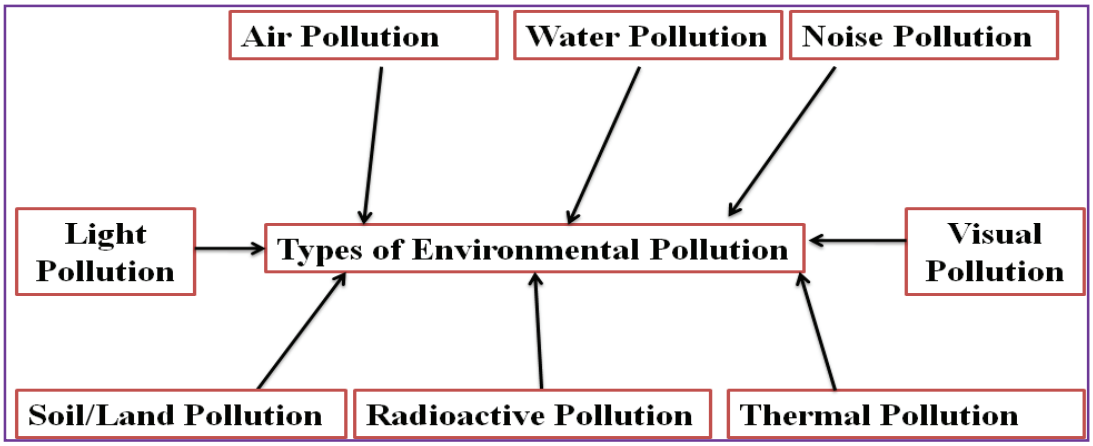

Fig.8.1 showing different forms of Environmental Pollution

8.3.1. AIR POLLUTION

A physical, biological or chemical alteration to the air in the atmosphere can be termed as **air pollution**. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive.

Physical Parameters of Air:

a. Visibility
b. Temperature
c. Humidity
d. Suspended Particulate Matter (SPM)
e. Respirable Suspended Particulate Matter (RSPM)
f. Wind Velocity

Chemical parameters of Air:

a. Carbon Mono Oxide (CO)

b. Ozone (O_3)
c. Oxides of nitrate
d. Oxides of sulphur
e. Heavy metals
f. Ammonia
g. Hydrocarbons

Biological Properties of Air

a. Bacteria and other microbes

SOURCES OF AIR POLLUTION: There are mainly two types of sources of air pollution and these are described below:

1. **NATURAL SOURCES:** These sources produce naturally and these are responsible for air pollution. However, these sources are comparably less harmful as compared to anthropogenic sources. Some of the important natural sources of air pollution are given below:

I. **Volcanic eruption:** Volcanic eruption is responsible for release harmful gases such as CO_2, SO_2, H_2S etc. in atmosphere. These gases are responsible for global warming and formation of acid rain. Acid rain not only damages property like cars and buildings but also pollutes the water. These harmful gases may travel 10 kilometres into the air and then blow hundreds of kilometres away from the site of the volcano to affect air quality. This cloud of volcanic gases settles over the land like smog, and called **"volcanic smog."** These gases are responsible for irritation in eyes, skin or lungs diseases in people.

II. **Forest Fire:** Forest fire is another natural cause of air pollution which releases certain amount of pollutants in the atmosphere. RSPM and SPM generally increase due to the forest or wildfires.

III. **Natural organic decay:** It is another form of natural source of air pollution. Organic decay is responsible for release many harmful gases such as **methane (Marsh gas)** and **ammonia** in atmosphere which cause air pollution. These gases make unpleasant environment in surrounding area.

IV. **Biological agents:** Pollens are important for reproduction in plants but some noxious species of certain plants cause air pollution. These toxic species cause eye irritation, skin diseases, and respiratory problems in human being. Some fungal spores are also cause air pollution.

2. **ANTHROPOGENIC OR MANMADE SOURCES:** These sources produce by human activities and cause air pollution. Some of the important anthropogenic sources of air pollution are given below:

I. **Transportation/Vehicular Emission:** Vehicular emission is major contributor of air pollution. This type of emission release many harmful air pollutants such as carbon mono oxide, sulphur di oxides, benzene, acetaldehyde etc in to the atmosphere. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of air pollution. As we know that we depend on fuel to fulfill our daily basic needs of transportation. But, there overuse is major source of air pollution. Carbon Monooxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant.

II. **Fuel combustion:** Toxic gases such as **s**ulfur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution.

III. **Industrialization:** Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the air quality. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by industrial emission. Petroleum refineries also release hydrocarbons and various other chemicals that cause air pollution.

IV. **Deforestation:** As you know that plants are absorbers of many pollutants from atmosphere, hydrosphere and lithosphere. Carbon dioxide is one of the greenhouse gases that help to hold heat in the atmosphere and trees remove some of this carbon dioxide from the air through photosynthesis and store that carbon in their tissues and in the soil. This process is known as **carbon sequestration**.

V. **Agriculture activities:** Agricultural practices release the various harmful gases such as ammonia in atmosphere which is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Excessive use of insecticides, pesticides and fertilizers in agricultural activities has grown at tremendous rate, these are also responsible for air pollution.

VI. **Mining operations:** Mining is a process in which minerals below the earth are extracted by using large equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is also important reason which is responsible for the deteriorating air quality.

Effects Of Air Pollution:

1. Respiratory and heart problems: The effects of Air pollution are very dangerous. Air pollution is responsible for respiratory disorder & heart problems. Several millions are known to have died due to direct or indirect effects of Air pollution. Air pollution may leads to asthma, pulmonary diseases, cardiovascular disease, neurological disease, skin problems, lung diseases, muscles fatigue. Various air pollutants and their effects on human being also given in table-1.

2. Global warming: Air pollution is directly responsible for global warming. Air pollution introduces many harmful gases such as CO_2, Nitrous Oxide, methane etc in atmosphere which ultimately leads in to global warming. As you know that Global warming is increase average temperature of earth, which leads in to certain problems such as sea level rise, melting of glaciers, droughts, change in weather etc.

3. Acid Rain: During burning of fossil fuels various harmful gases such as **nitrous oxides** and **sulphur oxides** released in to the atmosphere. The droplets of water react with these gases and forms **sulphuric acid** and **nitric acid** and lead in to acid rain. Acid rain can cause great damage to aquatic life, human beings, buildings as well as crops.

SO_2 (Sulphur Di Oxides) $+H_2O \longrightarrow H_2SO_4$ (Sulphuric Acid)

NO_2 (Nitrous Oxide) $+H_2O \longrightarrow HNO_3$ (Nitric Acid)

4. Effect on Wildlife: Toxic chemicals present in the atmosphere can force wildlife species to move a new place and change their habitat.

5. Ozone layer depletion: Ozone layer also depleting by different air pollutants. Ozone layer exists in stratosphere of atmosphere and protects life from harmful Ultra violet rays. This layer is depleting due to release of chloroflorocarbons and hydro-chlorofluorocarbons in atmosphere which ultimately leads in to different types of skin cancer in human being and other animals.

Table-1 Important Air pollutants, their sources and effects on human health

Name of Pollutants	Main Source	Effects	Types
Carbon mono oxide (CO)	Fuel combustion from vehicles and engine	Oxygen deficiency in body, aggravates heart diseases, chest pain	Primary Pollutant
Lead (Pb)	Metal refineries, metal	Damage in Nervous system,	Primary Pollutants

	industries, waste incineration (combustion), battery manufacturing industries	IQ loss, memory loss, renal effects, cardiovascular diseases.	
Nitrogen Dioxide (NO_2)	Fuel combustion, wood burning, Industrial emission	worsen lung diseases leading to respiratory problems	Primary Pollutants
Sulphur Di Oxide (SO_2)	Fuel combustion and Volcanoes, Industrial emission	Ashtma	Primary Pollutants
Volatile organic compounds VOCs)	incomplete combustion and industrial sources	Lung Problems	Primary Pollutants
Particulate matter	Dust, ash, salt particles, Sand storm	Lung Problems	Primary Pollutants
Ground level Ozone (O_3) (Harmful only in troposphere)	Formed by chemical reaction of volatile organic compounds and NOx in the presence of sunlight	Decrease lung function, coughing, shortness of breath, asthma.	Secondary Pollutants
Per Oxy Acyl Nitrates (PAN)	By the reaction of Nitrate, hydrocarbons with oxygen in presence of light	Powerful respiratory and eye irritant	Secondary Pollutants

in india worst effect of air pollution has been notice in 1984.a leakage of the killer gas, methyl isocynate, affect bhopal (m.p) in the early morning hours of december 3, 1984 & caused over 2500 death besides affecting 100000 peoples.

types of pollutants: on the basis of emission, pollutants may be categorized as two types which are described below:

Primary Pollutants: These pollutants directly emitted from the sources. classic examples of primary pollutants are sulphur-dioxide, nitrous oxide, co. co_2 because they are directly emitted from the industries.

secondary pollutants: these pollutants are formed by the inter mingling and reactions of primary pollutants. some examples of secondary pollutants are: peroxy acylnitrates (pan) ozone (o_3), sulphuric acid, nitric acid.

CONTROL OF AIR POLLUTION :-

1. **Use Public Mode of Transportation:** As you know that vehicular emission is major source of air pollution. In many cities millions of vehicles running on the roads and emitted harmful gases. If we use public transport instead of personal vehicles we can minimize the air pollution significantly.
2. **Regular services of Vehicles:** Automobile engines should be redesigned in such a way that their emissions cause minimum pollution. Old automobile engines should be replaced by new ones. People should be encouraged to share the vehicle, and to avoid vehicles for short distances.
3. Set up the industrial area away from residential area
4. Stack of the industries should set up as high as possible
5. Follow the concept of reduce, reuse and recycle: As you know that burning of solid waste release various harmful gases in atmosphere. If we can follow the 3R concept which is Reduce, Reuse and Recycle then we can minimize the air pollution.

5. Plantation: As you know that forests are great absorbers of air pollutants therefore, forest cover should be protected. Sufficient forest cover is essential for maintaining the quality of air. Green belts should be created specially near the roads and industries. There should be strict restriction for establishment of large buildings and industries along the Green belt areas.

6. Follow the rules and regulations prescribed by government for air quality.

7. Advanced research should be done on air quality at regular basis.

8. Public awareness

8.3.2. WATER POLLUTION

Water is one of the most important constituents of life support system. It is an essential ingredient of animal and plant life. Different human activities, like **industrial, domestic, agricultural activities etc.** are responsible for water pollution. The major sources of water pollution are domestic waste from urban and rural areas, and industrial wastes which are discharged into natural water bodies. According to the report of World Health Organization (WHO) about Five million people die annually from water-borne diseases**.**

Physical Properties of water

1. Temperature
2. Turbidity
3. Transparency
4. Total solids
5. Total dissolved solids

6. Total suspended solids
7. Conductivity

Chemical Properties of water

1. Dissolved oxygen
2. pH
3. Bio-chemical oxygen demand
4. Chlorides
5. Total Hardness
6. Calcium
7. Magnesium
8. Heavy metals

Biological properties of water

1. Bacteria
2. Microorganisms

Water pollution is any undesirable changes in, physical, chemical or biological properties in the quality of water that has a harmful effect on any living thing that consume or lives in it. When humans drink polluted water it often has serious effects on their health.

SOURCES OF WATER POLLUTION

There are different source of water pollution in which some of the pollutant may expose human beings and other lives to series problem. Some of the important sources of water pollution are given below:

1. **Domestic sewage:** Domestic sewage is one of the major causes of water pollution special in the riverine ecosystems of earth. Sewage cause low DO contents and high BOD in aquatic ecosystem. Sewage contaminates water with pathogens causing degradation of sewage take up most of the oxygen present dissolved in water. Detergents present in sewage degrade very slowly and therefore, these accumulate and render the water unfit for human and animal use. The phosphates present in detergents further stimulate algal growth that adds to the organic loading of water, which ultimately cause eutrophication like condition in lake or ponds.
2. **Industrial effluents:** Industrial effluent content high concentration of heavy metals such as Arsenic (As), cadmium (Cd), mercury (Hg), chromium (Cr) and lead (Pb) which ultimately leads in to different types of diseases such as minamata disease (Hg) and itai itai (Cd) etc. These heavy metals generally present in industrial effluent are describe below:

i) Mercury (Hg): It is released by combustion of coal, smelting of metallic ores, chloralkali, paper and paint industries. Mercury is persistent. Methyl mercury was responsible for famous **Minamata disease** in which mercury was accumulated in the tissue of shellfishes and fishes

in Minamata Bay (Japan) and when these fishes eaten by local population, resulted in mercury poisoning. Mercury poison is responsible for kidney disorder (damage).

(ii) Lead (Pb): The sources of lead are smelters, battery, industry, paint, chemical and pesticide industries, automobiles etc. It is mutagenic and causes anaemia, headache, and bluish lines round the gums.

(iii) Cadmium: It shows biological amplification and accumulates inside kidneys, liver, pancreas and spleen. It causes renal damage, emphysema, hypertension, testicular necrosis and damage to placenta. **Itai itai** disease was happened due to exposure of cadmium.

3. **Poor agricultural practices:** It includes use of pesticides, harmful chemicals, fertilizers etc. These chemicals are certainly harmful to the human beings and other biota of aquatic reservoirs. Agricultural practices also responsible for releasing high quantity of nitrates and phosphates in aquatic ecosystem which cause eutrophication.
4. **Release of Solid waste:** Million tons of solid waste either dumped in the peripheral zone of aquatic bodies or directly in the aquatic bodies which cause high bio-chemical oxygen demand, low dissolved oxygen high turbidity, high total solids and high total dissolved solids.
5. **Improper fishing methods:** Many fishermen use toxic chemicals such as bleaching powder to harvest the fishes. These toxic chemicals not only harmful to aquatic plants and animals but also responsible for water pollution.
6. **Oil Spills:** Oil spill is the release of a liquid petroleum hydrocarbon into the aquatic ecosystem especially in marine ecosystem where navigation takes place. It is also decrease the dissolved oxygen and reduce water quality in aquatic environment.

Effect Of Water Pollution:

- Polluted water from pesticides, insecticides causes reproductive damage within animals especially in wild animals.
- Sewage, fertilizer, and agricultural run-off contain organic materials that when discharged into waters increase the growth of algae, which causes the depletion of oxygen and cause eutrophication. Various valuable species of fishes cannot survive in low oxygen content.
- Water pollution causes skin rashes, cancer, reproductive problems, typhoid fever and stomach sickness in humans.

- Oil spills in the water causes animal to die when they ingest it. Oil does not dissolve in water so it causes suffocation in aquatic ecosystem. Many species of birds and fishes going threatened due to oil spills.

Table-2: Important water pollutants and their effect on human health

Name of Chemical	Formula /Symbol	Atomic Number	Health Impacts on Human	Environmental Impacts
Arsenic	As	33	Headach, confusion, diarrhea, changing the function of about 200 enzymes in body, Cancer (in Skin, lung, liver, kidneys), arsenicosis	
Cadmium	Cd	48	Improper functioning of liver and kidneys, Osteomalacia (softening of bones), Osteoporosis (loss of mineral density in bones), Itai Itai disease	
Mercury	Hg	80	Muscles weakness, Falconi syndrome (improper function of Kideny), Minamata Disease. Neurological and gastrointestinal disorders.	
Chromium	Cr	24	Renal effect, liver effect, Mutagenic effects	
Nitrates	NO_3		Difficulty breathing, Nausea, diarrhea, vomiting,	Eutrophication
Phosphates	PO43		Nausea, vomiting, diarrhea	Eutrophication

Eutrophication: The word “Eutrophication” has been taken from Greek word, Eutrophia in which Eu=well and Traphein = Nourish. It is also called hyper-trophication. Eutrophication means enrichment of nutrient in aquatic bodies such as streams and lakes. The enrichment is often increased by human activities such as agriculture, sewage discharge. Eutrophication is mainly caused by addition of nitrates and phosphates in aquatic bodies.

Eutrophication may lead in to following situations in aquatic body.

1. High level of nitrates and phosphates in aquatic body.
2. Formation of algal bloom and increased biomass of phytoplankton
3. High turbidity (Haziness of water)
4. Low transparency (Sun light cannot penetrate)
5. Loss of biodiversity
6. Low Dissolved oxygen contents
7. High Bio-chemical oxygen demand
8. Low process of Photosynthesis
9. Toxic or inedible phytoplankton species
10. Loss of desirable fish species

CONTROL OF WATER POLLUTION:-

The various methods for the control of water pollution are discussed below:

1. The sewage and industrial effluents should be treated before release in to aquatic bodies. Generally, sewage or industrial waste treat by the three general processes in first step which is called primary treatment or mechanical treatment (In this treatment large size of solid waste separated from the polluted water through sieve), in secondary treatment which is also called biological treatment certain bacteria or microbes used to degrade the remaining organic matter. In tertiary treatment which is also called chemical treatment, certain chemicals such as chlorine, NaOH, CO_2, are used to improve water quality.

2. Use of biofertilizers and biopesticides instead of chemical fertilizers and chemical pesticides.

3. Thermal pollution can be prevented by techniques like cooling, cooling ponds, evaporative or wet cooling towers and dry cooling towers.

4. Promote techniques like phytoremediation, myco-remediation, bacterial remediation and compost bioremediation to reduce water pollution. We will discuss these points in chapter i.e. bioremediation

5. Plants are also important to reduce water pollution. Plants like Water hyacinth popularly known as Kaloli and Jalkumbhi can purify water polluted by biological and chemical wastes.

6. Plants should be developed in the peripheral region of river, streams and other aquatic bodies.

7. Minimize the generation of solid waste in and around the water bodies.

8. General awareness among one and all.

9. Follow the rules and regulations prescribed by Government.

8.3.3. NOISE POLLUTION

As we know that we cannot communicate without sound. Sound is vibrations that travel through the air and can be heard when they reach ear of individual. Noise is unwanted Sound. The word "noise" is derived from the Latin word "nausea," which means feeling sickness at the stomach with an urge to vomit. Literally Noise means “Unwanted or unpleasant sound”. The noise of sound measurement is called decibels (dB). The frequency or amount of air pressure change vibration is measured in Hertz therefore; unit of sound frequency is hertz (Hz). Generally Sound level meter is used to analyze the sound or noise pollution. The normal range of human hearing is from 0 to 100 dB (A), before sound becomes uncomfortably loud. Human ear is able to hear sounds with frequencies from 20 Hz to 20,000 Hz.

SOURCES OF NOISE POLLUTION:-

(i) **Industrial Sources:** It is primary source of noise pollution in industrial area. Various industries such as: textile mills, printing presses, engineering establishments etc. contribute heavily in the noise pollution.

(ii) **Transportation/ Vehicles:** Automobile revolution in urban centers has proved to be a big source of noise pollution. Increasing traffic has given rise to traffic jams in congested areas where the repeated hooting of horns. Noise from airplanes constitutes an increasing serious problem in big cities. Airport situated in the vicinity of population centers and the air planes pass over residential areas.

(iii) **Domestic noise:** The household is an industry in itself and is a source of many indoor noises such as the, noise of playing children, crying of infants, moving of furniture, loud conversation of the inhabitants, constructional activities etc. Besides these are the entertainment equipment in the house, namely the radio, record-players and television sets. Domestic gadgets like the mixer-grinders,

pressure cookers, desert coolers, air- conditioners, exhaust fans, vacuum cleaners, sewing and washing machines are all indoor sources of noise pollution.

(iv) **Celebration of social/religious functions:** In India people need only the slightest of an excuse for using loud speakers. The reason may be a religious function, birth, marriage, elections, demonstration, or just commercial advertising. Therefore, these contribute towards noise pollution.

(v) **Agricultural Machines:** Tractors, thrashers, harvesters, tube wells, powered tillers etc. have all made agriculture highly mechanical but at the same time highly noisy.

(vi) **Defense Equipment**: A lot of noise pollution is added to the atmosphere by artillery, tanks, launching of rockets, explosions, exercising of military airplanes and shooting practices.

(vii) **Miscellaneous Sources:** The automobile repair shops, construction-works, blasting, bulldozing, stone crushing etc. are other sources of noise pollution.

effects of noise pollution: noise is generally harmful and a serious health hazard. it has far-reaching consequences and has many physical, physiological as well as psychological effects on human beings.

(i) **Physical Effects:** The physical effects of noise pollution are the effect on hearing ability. repeated exposure to noise may result in temporary or permanent shifting of the hearing threshold of a person depending upon the level and duration of exposure. the immediate and acute effect of noise pollution is impairment of hearing. Human ears have sensory cells for hearing. if these cells are subjected to repeated sounds of high intensity before they have an opportunity to recover fully, they can become permanently damaged leading to impairment of hearing. besides the sensory cells, the delicate tympanic membrane or the ear drum can also be permanently damaged by a sudden loud noise such as an explosion.

(ii) **Physiological Effects:** the physiological effects of noise pollution are several as described below:

(a) Headache.
(b) Increase heart rate.
(c) Narrowing of arteries.

(d) Decrease in heart output.

(e) Impairment of night vision.

(f) Decrease in the rate of colour perception.

(g) Lowering of concentration and affect on memory,

(h) Muscular strain and nervous breakdown.

The psychological effects of noise pollution are:

(a) Depression which considerably reduces the efficiency of an individual.

(b) Insomnia (lack of refreshing sleep)

(c) Affecting of psychomotor performance of a person by a sudden loud sound

(d) Emotional disturbance

Besides the above effects noise pollution is also responsible to change the behaviour of many wild animals.

CONTROL OF NOISE POLLUTION:

Noise pollution could be controlled by either reducing the noise at the sources or by preventing its transmission or by protecting the receiver. There are various methods to control noise pollution.

At the sources

1. Reduction in source of noise
2. Proper servicing of machinery and equipments.
3. Tightening the lose nuts
4. Decibel meter should be installed along highways and in factories to check and control the intensity of noise pollution.

In the path

1. A green belt effectively reduce the noise
2. A 20 foot wide plantation inside the compound protects the house from the noise of vehicular traffic
3. Noise making machine should be kept in containers with sound absorbing media.
4. Use of sound absorbing silencers

At the receiver end: If by the above methods we are not able to bring down the noise level up to required level the only alternative is to provide air plugs while working or moving in a noisy area.

General methods to control noise pollution:

1. Sound reducing device should be implemented in each and every industry.

2. Plantation especially around the roads and industries.
3. Minimum use of pressure horns
4. Make the people/communities/societies aware about the effects of noise pollution
5. Follow the rules and regulations for noise pollution prescribed by Government.
6. Regular monitoring or analysis of noise pollution.

8.3.4 SOIL POLLUTION

Soil is top most layer of earth crust and responsible for growth and productivity of crops. Soil pollution has led to a series of issues that we have come to realize in recent times, after decades of neglect. The increasing numbers of barren land plots and the decreasing numbers of forest cover is at an alarming. Moreover the extension of cities and towns due to increasing population is leading to further exploitation of the land. Also due to the lack of green cover, the land gets affected in several ways like soil erosion occurs washing away the fertile portions of the land.

Physical Properties of Soil

1. Temperature
2. Conductivity
3. Moisture content
4. Water holding capacity

Chemical Properties of water

1. pH
2. Nitrates
3. Phosphates
4. Chlorides
5. Calcium
6. Magnesium
7. Heavy metals

Biological properties of water

1. Bacteria
2. Microorganisms

Cause of Soil Pollution:

1.Deforestation and soil erosion: Deforestation is removal of trees from the land and makes the land for non-forest use. As you know that forest holds the soil and prevent soil erosion. Rhizosphere (area of root) keeps the soil moisten, fertile and highly productive. Due to rapid eradication of forest soil becoming infertile.

2.Solid Waste: Each household produces tonnes of garbage each year. Waste like aluminium, plastic, paper, cloth, wood is collected and sent to dumping sites. Items that cannot be recycled become a part of the landfills that cause soil pollution. Industrial wastes also consists variety of chemicals which are extremely toxic to living beings. When these waste dumped in to soil cause soil pollution.

3.Agricultural activities: As you know that human population growing at tremendous rate and demand of food also increases. Therefore, farmers often use highly toxic fertilizers and pesticides to get maximum productivity. However with the overuse of these chemicals, they result in contamination and poisoning of soil. Insecticides, pesticides, molluscides, rodenticides, herbicides, weedicides are being used in modern agriculture which is responsible for soil pollution.

4.Mining Activities: During extraction and mining activities, several land spaces are created beneath the surface.

5.Industrialization: Due to increase in demand for food, shelter and house, more goods are produced. This resulted in creation of more waste that needs to be disposed of. To meet the demand of the growing population, more industries were developed which led to deforestation.

EFFECTS OF SOIL POLLUTION:

1. **Pollution:** Soil Pollution is another form of land pollution in which upper most layers of soil is damaged. This situation is caused by overuse of chemical fertilizers, soil erosion which leads in to soil quality degradation. Many pollutants which are present in soil may reach to higher tropic level through biomagnifications.
2. **Effect on human health:** The soil when contaminated with toxic chemicals and pesticides lead to problem of skin cancer and human respiratory system. The toxic chemicals can reach our body thorough foods and vegetables that we eat as they are grown in polluted soil.

3. **Effects on plants:** Soil pollution my leads to low productivity in agricultural field. Several agricultural crops damaged by the high acidity and alkalinity of the soil coming from chemical industries which reduces the rate of production.
4. **Loss of Biodiversity:** As you know that biodiversity is variety and variability among species. Soil contains millions of microbes which are necessary for the soil composition certain metallic contaminants like Hg, Pb, Zn, As, Cd, Cr, Na, K, Cu etc destroy bacteria and beneficial microorganism in soil and reduced biodiversity of soil.

Controll of soil pollution:

use of biopesticides instead of synthetic pesticides such as insecticides, herbicides, rodenticides, molluscides etc.improve agricultural practices make the people aware about the concept of reduce, reuse and recycle. Promote the use of biofertilizers and biopesticides instead of chemical fertilizers and chemical pesticides and insecticides. Promote the use of biodegradable item instead of non-biodegradable items.

8.4. BIODEGRADABLE AND NON-BIODEGRADABLE POLLUTANTS

Pollutant is any chemical substance which causes pollution. On the basis of degradation pollutants may be of two types:-

8.4.1. BIODEGRADABLE POLLUTANTS

These pollutants can be broken down into simpler, harmless, substances in nature in due course of time by the enzymatic action of micro-organisms like certain bacteria and fungi are called biodegradable pollutants. There are various biodegradable pollutants such as domestic wastes, urine, faecal matter, sewage, agriculture residues, paper, wood, cloth, cattle dung, animal bones, leather, wool, vegetable stuff or plants present in atmosphere.

The degradable pollutants can be further sub-divided into two categories:

(i) Rapidly biodegradable or non-persistent pollutant:

These pollutants degraded at very fast rate. The domestic sewage can be rapidly decomposed by natural processes. However, the problems become complicated when the input into environment get exceeded of the decomposition or dispersal capacity.

(ii) Slowly degradable or persistent pollutant:

These pollutants takes very long time to degrade, for example, degradation of synthetic compounds and radio-active elements like Iodine 137, Strontium 90 or Plutonium 239 takes a longer period of time to degrade.

Table-3: Biodegradable pollutants and their impacts on human health and Environment

Name of Biodegradable pollutant	Effect on human health	Effect on Environment
Domestic waste	Cause Bacterial diseases	Eutrophication in Aquatic body, change the pH of water, increase the biochemical oxygen demand
Faecal matter	Cause Bacterial diseases	Eutrophication in Aquatic body, change the pH of water, increase the biochemical oxygen demand
Papers, animal bones	-	Increase organic matter in aquatic ecosystem

8.4.2. NON-BIODEGRADABLE POLLUTANTS

These pollutants cannot be broken down into simpler, harmless substances in nature by the enzymatic action of bacteria and fungi, are called non-biodegradable pollutants. DDT, plastics,

polythene, insecticides, pesticides, mercury, lead, arsenic etc. metal articles like aluminum cans, synthetic fibres, glass objects, iron products etc. are non-biodegradable pollutants.

Table-4: Non-biodegradable pollutants and their impacts on human health and Environment

Name of Non-Biodegradable pollutant	**Effect on human health**	**Effect on Environment**
DDT	Abnormalities of liver function, skin and the nervous system	Biomagnifications
Insecticides	decreased fertility, breast cancer, diabetes and obesity, neurological disorders	Loss natural productivity of soil, Air and water pollution
Plastic and polythene	-	Loss of Biodiversity, Loss soil productivity, Air, Water pollution

8.4.3. BIOMAGNIFICATION

Bio=life

Magnify=Increase

Biomagnifications is increasing concentration of toxic chemical in each trophic level of food chain. As you know that food chain is linear network in food web in which green plants (producers) use the sun energy and transfer this energy to higher trophic levels (primary consumer, secondary consumer and tertiary consumer). Certain Pollutants such as lead, mercury, arsenic, Dichlorodiphenyl trichloroethene (DDT) that exist in small amounts in the environment (water, soil, air etc.) become concentrated in organisms near the top of the food chain, this process called biomagnifications. These pollutants are produced in several industrial processes and release into streams and rivers. These rivers eventually lead to the ocean where the mercury builds up and is ingested by small organisms.

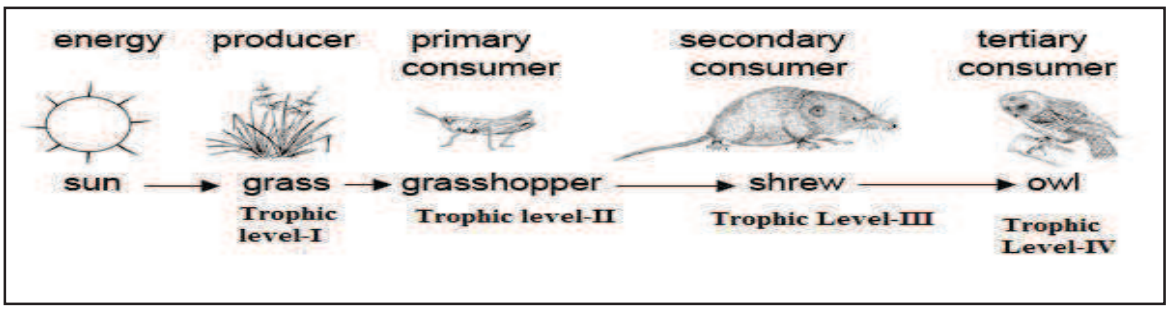

Fig.8.2. Showing simple food chain in an ecosystem

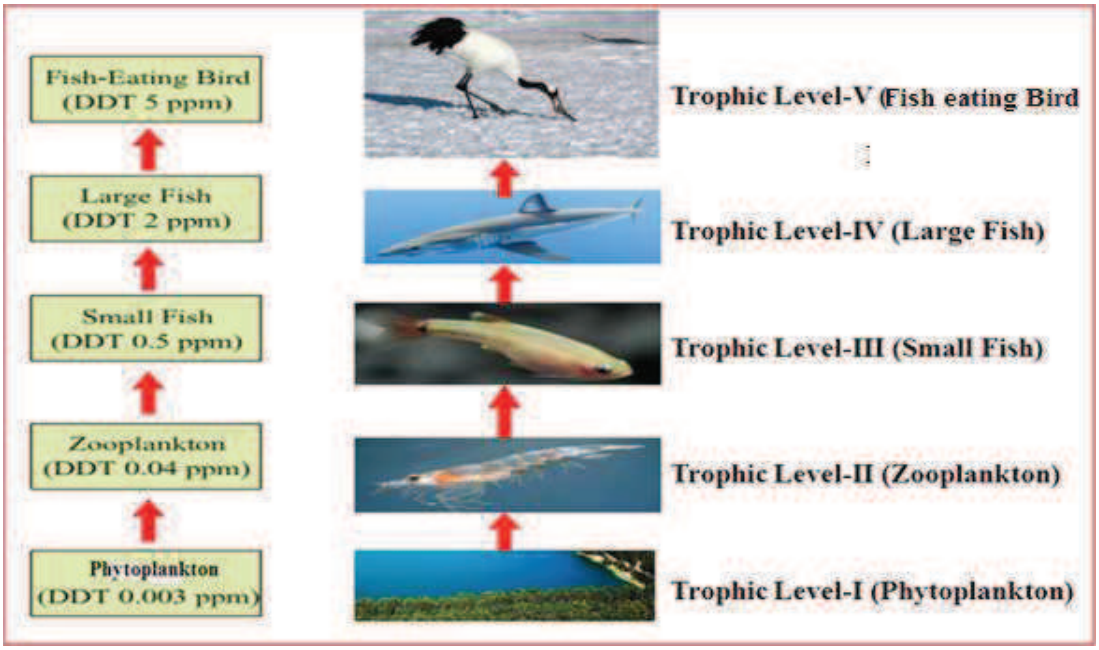

Fig.8.4 Showing magnification of toxic chemical (DDT) in aquatic food chain

8.4.4. BIOREMEDIATION

Bioremediation is technique in which microorganisms are used for the degradation of hazardous substances in soil, sediments, water or other contaminated matters. Certain species of bacteria fungi, algae and plants have used for bioremediation. **Bioaugmentation** is process in which microorganisms are imported to polluted site to enhance degradation of hazardous material.

On the basis of degradation procedure bioremediation may be of following types:

1. **Biotransformation:** It is alteration of contaminants in to less or non-hazardous substances.

2. **Biodegradation:** It is the breakdown of organic substances in smaller organic or inorganic molecules.
3. **Mineralization:** It is the complete biodegradation of organic material in to inorganic substances such as CO_2 or H_2O_4

On the basis of type of organisms used, bioremediation may be of following types:

1. **Bacterial Remediation:** It is the process of using bacteria to breakdown molecular contaminants like hydrocarbons in to simpler and safer components. ***Deinococcus radiodurans*** is genetically modified bacteria which can breakdown the heavy metals as well as toluene. ***Geobacter sufurreducens*** can turn uranium in to non-soluble form. Bacteria namely ***Thermus brockianus*** breaks down hydrogen peroxide 8000 times faster than current chemicals in use. ***Alcaligenes eutrophus*** another type of bacteria can degrade 2-4-D (Herbicide used in United States)
2. **Mycoremediation:** It is the process of using fungi to breakdown molecular contaminants in to simpler and safer components.
3. **Phyto-remediation:** It is the process of using plant species to breakdown molecular contaminants to simpler and safer components.

Table-5: Sowing different phytoremediation techniques

Technique	**Plant mechanism**	**Medium**
Phytoextraction	Uptake and concentration of metal via direct uptake in to plant with subsequent removal of the plants	Soil
Phytotransformation	Plant uptake and degradatyion of organic compounds	Surface water and Ground water
Phytodegradation	Enhance microbial degradation in rhiosphere	Soil, ground water within rhizosphere
Rhizofilteration	Uptake of metals in to plant roots	Surface water and water punped

Many plants are used in bioremediation in which **Transgenic Arabidopsis** can transforms mercury in to gaseous state, **Bamboo** can accumulates silica, Indian mustard (***Brassica juncea***) can accumulates sulphur, lead, selenium, chromium, cadmium, nickel, zinc and copper, Chinese ladder fern (***Pteris vittata***) can accumulates arsenic, **cottonwood** can accumulates mercury, tomato and alpine can accumulate lead, zinc and cadmium.

4. **Compost bioremediation:** In this process large number of beneficial bacteria can be introduced in to soil by brewing something called compost tea. Compost tea is water based, oxygen rich culture containing large population of beneficial aerobic bacteria, nematodes, fungi and protozoa which can be used to bioremediate toxins. This brew is applied to contaminated sites where microbial population breakdown the toxic substances.

In Situ Bioremediation: In situ bioremediation techniques are those technique in which "Bioremediation applied to soil or water at the site with minimum disturbances. It is technologies that are used "in place" without removal contaminated matrix. These techniques are the most desirable options due to lower cost and lesser disturbance since they provide the treatment in place avoiding excavation and transport of contaminants.

Ex Situ Bioremediation: These are the bioremediation technologies that require removal of contaminated matrix by excavation so it can be manipulated in some way through the use of slurry reactors, compositing, biopiles etc. in this technique the contaminants degraded our site of the contaminated place.

Advantages of Bioremediation:

Bioremediation is natural process and has no harmful impacts on local communities or population. Various advantages of bioremediation are given below:

1. Bioremediation is useful for the complete destruction of a wide variety of toxic substances. By using this technique many substances that are legally regarded as hazardous can be transferred in to harmless compounds.
2. Bioremediation can be used on site (in situ) or off site (ex situ).

3. Bioremdiation is less expensive than other technologies that are used for cleanup of hazardous waste.
4. Bioremediation is fully based on natural microbes therefore it has no side effect on plants, animals and human being.

Disadvantages of Bioremediation:

1. Bioremediation generally takes longer time as compare to other technologies.
2. It may be possible that product of bioremediation may high toxic as compared to parental product.
3. Bioremediation is limited to biodegradable compounds.

8.5. SUMMARY

Environmental pollution is any undesirable changes in physical, chemical and biological changes in environmental components. Environmental pollution may be air pollution, water pollution, soil pollution, noise pollution, radioactive pollution; light pollution etc. Various sources of air pollution such as vehicular emission, industrial emission, agricultural practices etc. effects of air pollution are very dangerous and can leads in to respiratory problems, lung disorders, skin cancer, cardiovascular diseases etc. Besides this air pollution may leads in to acid rain, ozone layer depletion, global warming and climate change. Main sources of water pollution are domestic sewage, industrial effluent, agricultural practices etc. Water pollution may leads in to various disorders in kidneys, liver, bones, nervous system, reproductive system etc. excessive amount of nutrients in lakes or ponds is referred as eutrophication. We can control water pollution by treat the domestic sewage and industrial sewage, thorough bioremediation technologies etc. Noise is unwanted sound and there are various forms of noise pollution such as industrial noise, vehicular noise, domestic noise etc. noise may responsible for physical, physiological and psychological effect. Soil is upper most layer of earth surface and polluting by dumping of solid waste, excessive use of chemical fertilizers, deforestation etc. Different pollutants can reach the higher trophic level by soil. If we use various methods such as afforestation, use of biofertilizers and biopesticides, proper management of solid waste, then we can control soil pollution. Biodegradable pollutants are pollutants which can degrade by the action of bacteria in

natural environment. Examples of biodegradable pollutants are sewage, papers, cow dung etc. Non-biodegradable pollutants mean pollutants which do not degrade by the action of bacteria and fungi in natural environment. Examples of non-biodegradable pollutants are DDT, Mercury, plastic and polythene. Biomagnifications is process in which concentration of toxic chemicals increase in trophic level of food chain. On the view of above account you surely aware about the impacts of different pollution and we should promote technique like bioremediation which is technique in which various organisms are use to degrade the pollutants in environment.

8.6. GLOSSARY

Environmental pollution: Undesirable changes in physical chemical and biological properties of air, water and soil which cause harmful effect on organisms.

Eutrophication: Eutrophication means enrichment of nutrient (especially nitrates and phosphates) in aquatic bodies such as streams and lakes.

Primary Pollutants: These pollutants directly emitted from the sources. Classic examples of a primary pollutant would be the sulfur-dioxide, Nitrous Oxide, CO. CO_2 emitted from the industries.

Secondary Pollutants: These pollutants are formed by the inter mingling and reactions of primary pollutants. Some examples of secondary pollutants are: Peroxy Acylnitrates (PAN) Ozone (O_3), Sulphuric Acid, Nitric Acid.

Biodegradable pollutants: Those pollutants which can be broken down into simpler, harmless, substances in nature in due course of time (by the action of micro-organisms like certain bacteria) are called biodegradable pollutants. Domestic wastes (garbage), urine, faecal matter, sewage, agriculture residues, paper, wood, cloth, cattle dung, animal bones, leather, wool, vegetable stuff or plants are biodegradable pollutants.

Non-Biodegradable pollutants: Those pollutants which cannot be broken down into simpler, harmless substances in nature are called non-biodegradable pollutants. DDT, plastics, polythene, bags, insecticides, pesticides, mercury, lead, arsenic etc. metal articles

like aluminum cans, synthetic fibres, glass objects, iron products and silver foils are non-biodegradable pollutants.

Minamata disease: This disease was happened due to the exposure of methyl mercury.

Itai Itai disease: This disease was happened due to the exposure of cadmium.

Bioaccumulation: Accumulation of toxic chemicals in the tissues of organisms.

Biomagnification: Increase toxic chemicals at higher trophic levels.

Bioremediation: Cleaning of environmental by organisms it may be phytoremediation, bacterial remediation, mycoremediation and compost bioremediation.

RSPM: Respirable Suspended Particulates (RSP) with diameter less than or equal to 10 micrometers, thus also named as PM_{10}.

SPM: Total Suspended Particles is the fraction sampled with high-volume samplers, approximately particle diameters <50-100 μm.

Bio-chemical oxygen Demand (BOD): It is amount of oxygen required by microorganisms to decompose organic matter in aquatic ecosystem.

Dissolved Oxygen (DO): It is amount of dissolved oxygen present in water bodies.

Turbidity: It is haziness of water and may be due to TS, phytoplankton and zooplankton. It is negatively correlated with transparency.

Industrial Effluent: Industrial waste is the waste produced by industrial activity which contains certain heavy metals such as mercury, arsenic, chromium, nickel cadmium etc.

Domestic Sewage: It is raw material of house hold which contain organic waste, nitrates and phosphates and primary source of water pollution.

Insecticides: Insecticides are chemical substances used to kill harmful insect, these include larvicides ovicides used against larvae and egg, respectively.

8.7. SELF ASSESSMENT QUESTIONS AND POSSIBLE ANSWERS

8.7.1. MULTIPLE CHOICE QUESTIONS

1. TDS is:
   (a) Physical Property of water (b) Biological Property of water
   (c) Chemical Property of water (d) None of above
2. Minamata disease was happened due to:
   (a) Mercury (b) Arsenic
   (c) Cadmium (d) Chromium
3. Itai itai disease was happened due to:
   (a) Arsenic (b) Cadmium
   (c) Iron (d) Phosphorus
4. Main cause of Eutrophication in lake is:
   (a) Calcium (b) Carbon
   (c) Phosphorus (d) Iron
5. The word noise has been taken from which language:
   (a) Latin (b) Greek
   (c) French (d) Sanskrit
6. Which is biological property of water?
   (a) DO (b) pH
   (c) BOD (d) Bacteria
7. PAN is:
   (a) Primary Pollutant (b) Secondary Pollutant
   (c) Both (a) and (b) (d) Non of above
8. Cleaning of Environment by organisms is called:
   (a) Biomagnification (b) Bioagumentation
   (c) Bioremediation (d) Biopreservation

9. Ozone is harmful in:

(a) Stratosphere (b) Ionosphere

(c) Troposphere (d) Exosphere

10. Increasing toxic chemicals in each trophic level is called:

(a) Bioremediation (b) Toxicity

(c) Biomagnification (d) Bioaccumulation

11. Which one of the following is heavy metal:

(a) Calcium

(b) Cadmium

(c) Chlorides

(d) Nitrates

12. Ex Sit Bioremediation means:

(a) Degrade pollutants at contaminated site (b) Both (a) and (b)

(c) Degrade pollutants at outside contaminated site (d) None

13. Which of the following will have maximum concentration of toxic chemical in food chain:

(a) Zooplankton (b) Fish

(c) Phytoplankton (d) Fish eating bird

14. Atomic number of arsenic is:

(a) 33 (b) 80

(c) 38 (d) 83

15. Which of the following is not pollutant?

(a) As (b) Cd

(c) Hg (d) DO

8.7.2. VERY SHORT QUESTIONS

1. Word Environmental has been taken from which language?
2. Pollution word has been taken from which word?
3. Acid rain forms by
4. Eutrophication means

5. RSPM means
6. The use of living microorganism to degrade environmental pollutants is called
7. The increasing of toxic chemicals in higher trophic level is called.
8. The pollutants which are directly emits from the source are called?
9. Environmental impacts of Air pollution are.
10. Eutrophication also known as?
11. Decibel is unit of.
12. Give the name of some plants which used in bioremediation?
13. Which is commonly known as marsh gas?
14. PAN is which type of pollutant?

ANSWERS

8.7.1. 1.(a); 2.(a); 3.(b); 4.(c); 5.(a); 6.(d); 7.(b); 8.(c); 9.(c); 10.(c); 11.(b); 12.(c); 13.(d); 14.(a); 15.(d)

8.7.2. 1. French; 2. Pollutionem; 3. SO_2 and NO_2; 4. Nutrient enrichment in water bodies; 5. Respirable Suspended Particulate matter; 6. Bioremediation; 7. Biomagnification; 8. Primary pollutants; 9. Golbal warming, Acid Rain and Ozone depletion 10. Hypertrophication; 11. Sound/Noise; 12. Bamboo, Indian Mustard, Cottonwood, Chinese ladder fern; 13. Methane; 14. Secondary pollutant.

8.8 TERMINAL AND MODEL QUESTIONS

1. Define pollution. Describe the sources, effects and control of Air pollution
2. Describe the sources, effects and control of water pollution.
3. What is Noise? Describe the sources, effects and control of noise pollution.
4. Describe the sources, effects and control of soil pollution.
5. Differentiate between biodegradable and non-biodegradable pollutants.
6. What do you understand by biomagnifications? Explain biomagnifications with suitable example.
7. Define bioremediation. Describe the types and in-situ and ex-situ methods of bioremediation.

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UNIT 9: NATURAL DISASTER

CONTENTS

9.1. OBJECTIVES

After reading this unit the readers will be able to:

- Define Disaster
- Discuss the Types of disaster
- Causes, impacts and mitigation measures of Flood
- Causes, impacts and mitigation measures of Earthquake
- Causes, impacts and mitigation measures of Cyclone
- Causes, impacts and mitigation measures of Landslides
- Steps in disaster management

9.2. INTRODUCTION

our environment is fully blessed with variety of natural resources such as land, water, minerals, bioresources (plants and animals), forests, energy etc. Therefore, this earth is home to millions of species. But on the other hand nature also becomes destructive to humankind and other species of earth in the form of Natural disasters. As you well aware about the Earthquake, flood, volcanic eruption, cyclone etc. these are natural form of disaster. Disaster is a sudden, calamitous event bringing great damage, loss, and destruction and devastation to life and property. The damage caused by disasters is immeasurable and varies with the geographical location, climate and the type of the earth surface/degree of vulnerability. This influences the mental, socioeconomic, political and cultural properties of the affected area. Generally, disaster has the following effects in the concerned areas:

1. It completely disrupts the normal day to day life.
2. It negatively influences the emergency systems.
3. Normal needs and processes like food, shelter, health, etc. are affected and deteriorated depending on the intensity of the disaster.

In this unit you will learn about types, causes, impacts and mitigation measures of different forms of Natural disaster and concept of Disaster management.

9.3. CONCEPT OF DISASTER MANAGEMENT

The word "Disaster" has been taken from Latin Astrum. Meaning of disaster also comes from two Greek words "Dus" which means "Bad" and aster means Star.

Definitions of Disaster

Disasters produce a range of impacts; these include direct, secondary and indirect effects. Direct effects include deaths, injuries and physical damage. However, secondary disaster impacts such as releasing fire or hazardous material that is stimulated by disasters. Finally, impacts include the ripple effect resulting from the flow of goods, services, unemployment, etc. Various agencies defined the disaster; some of the important definitions of disaster are given below:

- According to the United Nations "disaster is the occurrence of sudden or major misfortune which disrupts the normal functioning of the society or community".
- According to Disaster Management Act 2005 "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man-made cause, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property or degradation of environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area"
- Disaster is natural or man -made event that leads to sudden disruption of normal life of a society, causing damage to life and property.
- Disaster is a catastrophic situation in which the normal patterns of life have been disrupted and extraordinary emergency interventions are required to save and preserve human lives and the environment".
- According to United Nations International Strategy for Disaster Reduction (UNISDR) "disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses".

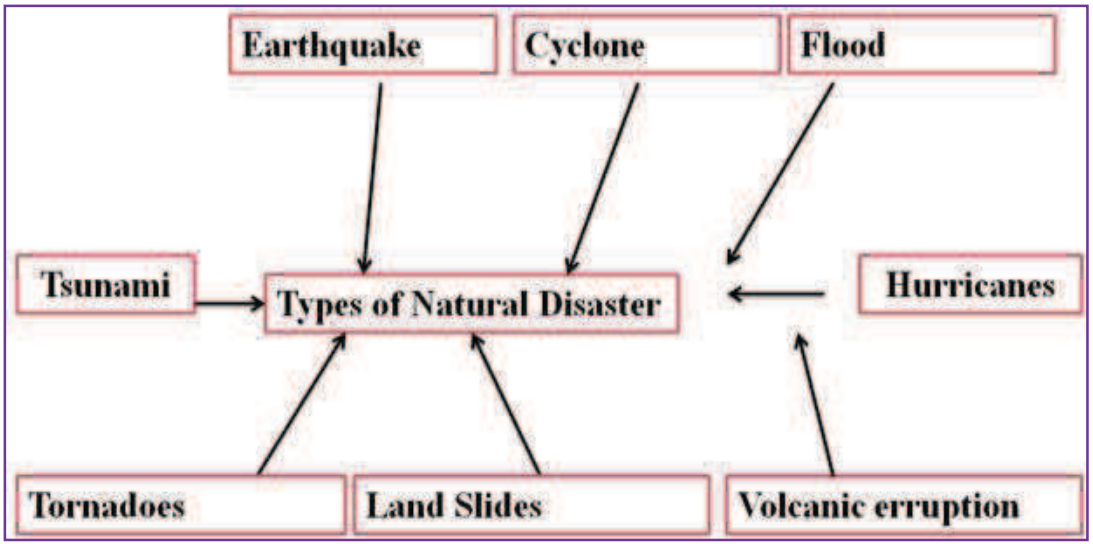

Fig.1. Showing different forms of Natural Disasters

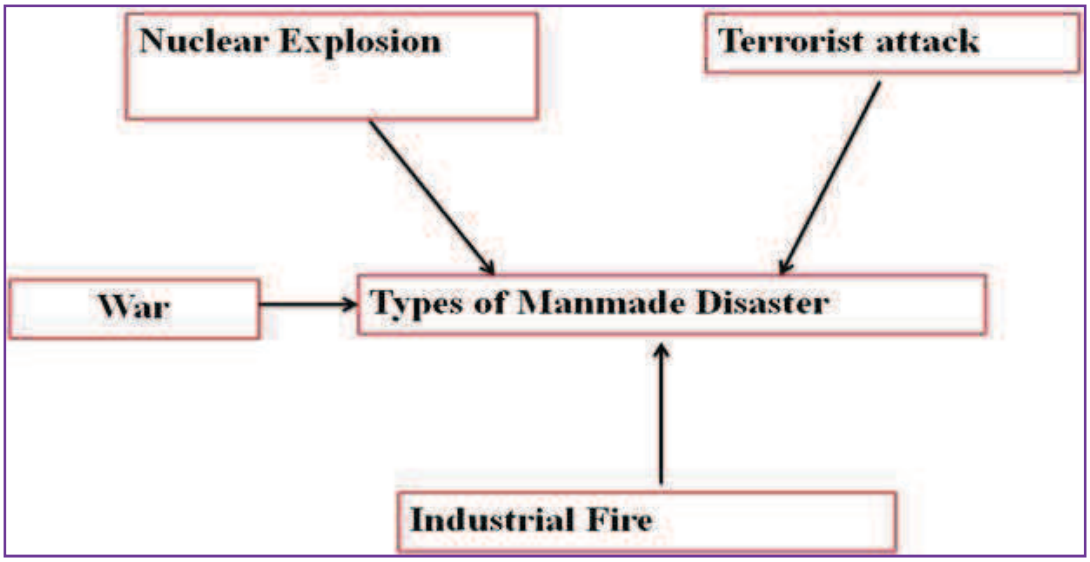

Fig.9.1 Showing different forms of manmade Disasters

Disaster has certain characteristics such as Unpredictability, Speed, Urgency, Uncertainty and threats. Although, natural disaster is natural phenomena which may occur anywhere in anytime. However, certain regions of earth are more prone to particular type of disaster. For example volcanic eruption do not occur in Indian subcontinent frequently, forest fire are also uncommon in country like India. India is more prone to flood, earthquake, cyclone and landslides. The area of our country which are more prone to these (flood, earthquake, cyclone and landslides) commonly occurring disaster are described below:

9.3.1. FLOOD

A flood is an overflow of water that submerges land that is generally dry. According to European Union Floods Directives *"flood is covering of land by water of land not normally covered by water"*.

Floods can also occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at curves or bends. Floods often cause damage to property and businesses if they are in the natural flood plains of rivers. While riverine flood damage can be eliminated by moving away from rivers and other bodies of water, people have traditionally lived and worked by rivers because the land is usually flat and fertile and because rivers provide easy travel and access to business.

Some floods develop gradually, while others, such as catastrophic flood can develop in just a few minutes and without noticeable signs of rain. In addition to that floods can be local, impacting a neighorhood or community, or very large, affecting entire river basins.

Among all the natural disasters occurring in the country, flood is most frequently occurrs phenomena. In India, the most intense and devastating floods are caused by Ganga-Bhrahmuptra Meghna river basin. Out of the total geographical region of India, which is 329 million hectares, about 40 million hectares has been assessed to be prone to flood.

Types of Flood: On the basis of geography flood may be categorized as follows:

1. Riverine flood: This is also called fluvial flood. This type of flood occurs when excessive rainfall over an extended period of time causes a river to exceed its capacity. This type of flood may be due to snowfall which ultimately leads in to exceed river capacity of water. Floods in various major rivers (Ganga, Kosi, Yamuna, Brahmputra etc) of India are examples of riverine or fluvial flood.
2. Estuarine flood: Estuary is an area where fresh water and sea water meets. Increasing in water level of the estuary may lead to estuarine flood. This type of flood generally caused by sea tidal surges and low barometric pressure.
3. Coastal flood: Sea water is responsible for this type of flood.

4. Catastrophic flood: This may be due to the collapse of the dam or hydropower projects, collapse of drainage channel from landslide, earthquake or other natural disasters. This type of flood is generally very dangerous as compared to other forms of flood.
5. Muddy flood: This type of flood generally occurs in agricultural land in which huge amount of soils or sediments runoff with rain water. This type of flood can damage infrastructure and roads.

Causes of Flood: There are various causes of the flood such as heavy rain, deforestation, encroachment etc. some of the important causes of flood are given below:

Flooding in rivers is mainly caused by

1. Inadequate capacity within the banks of the rivers to contain high flows.
2. River bank erosion and silting of riverbeds
3. Deforestation or destruction of riparian vegetation.
4. Landslides leading to obstruction of flow and change in the river path.
5. Synchronization of flood in the main tributary rivers.
6. Flow retardation due to tidal and backwater effects
7. Poor natural drainage
8. Cyclone and heavy rain fall.
9. Destruction of dams and other water storage body by Earthquake

Effects of flood:

The effects of flood are mentioned below:

- floods are responsible for loss of human life.
- it causes damage to buildings and other structures including bridges, sewage systems, roads, and canals.
- floods also damage power supply and sometimes hydropower. you can imagine the life without electricity. without electricity we may face different problems such as

loss of drinking water, treatment of water and water supply, which may result in severe water contamination.

- It may also cause the loss of sewage disposal facilities.
- Floods are also responsible for water borne diseases like typhoid; giardia, cholera etc. make it difficult to mobilize aid to those affected or to provide emergency health treatment.

1. Flood are responsible for destruction of transportation systems therefore, it prevent supply of crops, food and other necessary items.
2. Non-tolerant species can die from suffocation.
3. It also affects economy of area due to temporary decline in tourism, rebuilding costs, and food shortage leading to price increase.
4. Flood destroys millions of species therefore it is responsible for biodiversity degradation of area.
5. Flood also responsible for soil erosion and landslides

Table-1: Effect of Flood in India

S.N.	Items	Loss
1.	Area Affected	7.351 million hectare
2.	Population affected	40.96 million
3.	Human live lost	1800 number
4.	Cattle Lost	85599 number
5.	House damaged	14 Lakh
6.	Houses damaged	370.6 crore
7.	Crop area damaged	3.7 million hectare
8.	Crop damaged	1095.13 crore
9.	Public utility damaged	1186.45 crore
10.	Total losses	2706.24 crore

(Central Water Commission, Ministry of water resources, Government of India)

Preventive measures against Flood: There are various mitigation measures of flood and some important measures which are certainly helpful to minimize the impacts of flood are summarized below:

Before Flood/Disaster:

1. More and more trees should be planted in flood sensitive zones, especially in the riparian zone of river.
2. Flood controlling walls should be built up.
3. Encroachment should strictly prohibit in the peripheral zone of river.
4. Identify the area where flood generally occurs.
5. All the member of community/area should know the safe route to safe buildings.
6. Mud walls are more likely to be damaged during flood. We may consider making houses where the wall are made of local bricks up to the highest known flood level with cement pointing.
7. Every family should have an emergency kit on hand which include: portable radio, torch and spare batteries, stock of fresh water, dry food items, kerosene, candle and matchboxes.
8. Waterproof or polythene bags for clothing and valuable items (purse, mobile etc.), an umbrella and bamboo stick (to protect from poisonous animals such as snake), salts and sugar.
9. A first aid kits, manual and strong ropes for tying things.

Just before flood: When you hear a flood warning or if flood appears likely:

1. Tune to your local radio TV for warning and advice. You should keep vigil on flood warning given by local authorities. Do not follow the rumors. Keep dry food, unpolluted drinking water and clothes ready.
2. Prepare to take bullock cart, other agricultural equipments, and domestic animals to safer place.
3. Plan which indoor items you will raise or empty if water threatens to enter your house.
4. Check your emergency kit.

During Flood:

1. Drink boiled and unpolluted water.
2. Keep your food covered and take lighter meal during flood.
3. Use raw tea, rice water, coconut water etc. during diarrhea contact your ANM for ORS and treatment.
4. Do not let children remain on empty stomach.
5. Use bleaching powder and lime to disinfect the surrounding.
6. Help the volunteer distributing relief materials.

If you have to evaluate:

1. Pack warm clothing, essential medicines, personal papers etc. in water proof bags, to be taken with your emergency kit.
2. Keep your emergency kit with you.
3. Inform the local volunteers about the address of place you are evacuating to.
4. Raise furniture on to beds, tables and to top of the roofs, electrical items should place at highest.
5. Turn off all the power switches with main switch.
6. Whether you leave or stay, put sandbags in the toilet bowl and over all laundry/bathroom drain holes to prevent sewage back flow.
7. Lock your home.
8. Do not enter in to water of unknown depth and current/velocity.

If you stay or on your return:

1. Keep watch or listen to local radio/TV for updated information and advices.
2. Keep the children away from flood.
3. Avoid entering flood waters, if you must wear proper protection for your feet and check depth and current with a stick. Stay away from drains, culverts and water over knee deep.
4. Do not use electric appliances, which have been in flood water until checked for safety.
5. Do not feed on food which has been in flood waters.
6. Drink boiled water until supplies have been declared safe.
7. Be careful of snakes, snakebites are common during floods.

After flood/Disaster:

1. Keep eyes on weather forecast.
2. Generally flood occurs in monsoon seasons; therefore, you should take care of your health which may get affected by contaminated food and water.
3. Clean your home and keep the hygienic environment in surroundings.
4. Be careful about mosquitoes and snakes.
5. Do not go near the sloppy mountainous areas.

9.3.2. EARTHQUAKE

Earthquake also called tremor or temblor. earthquake is “shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave”. earthquakes are most dangerous and devastating form of natural disaster it can destroy millions of life, building, infrastructure within few minutes. therefore, earthquake is the most fearful natural phenomena in the human life. it is more so because it is unpredictable and occurs with any presumptive signs. when the earth shakes due to the movements of tectonic plates below the earth’s crust it is known as earthquake. the maximum destruction generally occurs near the epicenter, the place where the vibrations arise and spread. seismology is the study of earthquakes and seismic waves that move through and around the earth. a seismologist is a scientist who studies earthquakes and seismic waves.

about 50-60% of india is vulnerable to seismic activity of varying intensity and most of the vulnerable areas are located in the himalayan and sub-himalayan regions. the states whose area do fall in the most risky seismic zones are north east states (arunachal pradesh, meghalaya, nagaland, sikkim, tripura, manipur and mizoram), andaman and nicobar of islands, western part of gujarat, himalayan foot hills of uttrakhand, himachal pradesh, uttar pradesh and bihar. the deccan peninsula and rajasthan are least vulnerable areas.

Table-2: Showing different seismic zone in India

S.N	Zone	Area of India	Probability of Risk
1.	Zone-1 (II)	No Area of India is classified as Zone-1	Least damage risk
2.	Zone-2 (II)	Karnataka	Low damage risk
3.	Zone-3 (III)	Some part of some part of Uttar Pradesh	Moderate damage risk
4.	Zone-4(IV)	J&K, Uttrakhand, Himachal Pradesh, Sikkim, Punjab and some part of Uttar Pradesh	High Damage risk Zone
5.	Zone-5(V)	Kashmir, Himalayas, North and Middle Bihar, North East India, Rann of Kutch, Andaman & Nicobar group of Island	Highest Risk

Causes of Earthquake: Earthquake happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called **fault** or **fault plane**. The location below the surface of the earth where, an earthquake starts called **hypocenter** and the location directly above it, on the surface called **epicenter**. Earthquakes often occur in volcanic regions and are caused there, both by tectonic faults and the movement of magma in volcanoes.

Earthquakes are caused mostly by rupture of geological faults, but also by volcanic activity, landslides, mine blasts and nuclear experiments.

Earthquake fault types: There are three main types of fault that may cause earthquake.

1. **Strike slip fault:** In this type the fault is vertical and the tectonic plates slide past one another horizontally. This occurs in areas where the crustal blocks are sliding past another.
2. **Normal fault:** In this type the fault is at an angle and the tectonic plate above the fault (the hanging wall) moves down relative to the block below the fault (the foot wall). This occurs in area where there is extension or pulling of the crustal blocks or in the area such as divergent boundary.

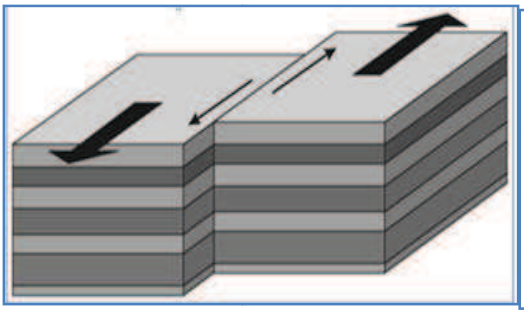

Fig.9.3- Showing Strike slip fault

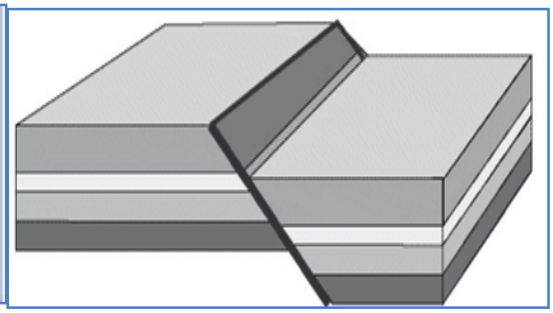

Fig 9..4- Showing Normal fault

3. **Thrust (reverse) fault:** In this type the fault is at an angle, and the hanging wall moves up relative to the foot wall. This occurs in area where the crustal blocks are being pushed together. Reverse fault occur in area where the crust is being shortened such as at a convergent boundary.

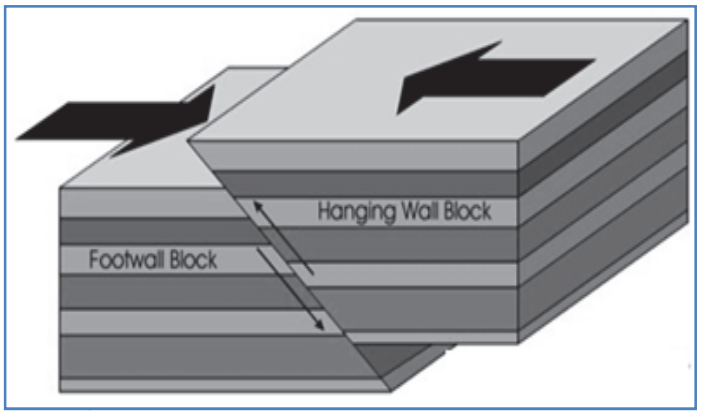

Fig.9.5- Showing Reverse fault

AFTERSHOCKS: an aftershock is an earthquake that occurs after a previous main earthquake. an aftershock is in the same region of the main shock but always of a smaller magnitude. if an aftershock is larger than the main shock, the aftershock is re-designated as the main shock and the original main shock is re-designated as aftershock.

FREQUENCY OF OCCURRENCE OF EARTHQUAKE: it is estimated that around 500,000 earthquakes occur each year. about 100,000 of these can be felt. minor earthquakes occur nearly constantly around the world in places like california and alaska in the u.s. gutenberg-richter law stated that an earthquake of 3.7–4.6 every year, an earthquake of 4.7–

5.5 every 10 years, and an earthquake of 5.6 magnitudes or larger every 100 years. this gutenberg-richter law described the relationship between magnitudes and total number of earthquake in any given region and time period. this law was developed by beno gutenberg and charles francis richter in 1956.

SEISMIC WAVES: Every earthquake produces different types of seismic waves, which travel through rock and liquids with different velocities:

P Waves or Primary waves or Pressure waves:

The first kind of body wave is the P wave or primary wave. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. Sometimes animals can hear the P waves of an earthquake. Dogs commonly begin barking hysterically just before an earthquake. Typical values for P-wave velocity in earthquakes are in the range 5 to 8 km/s.

S Waves secondary waves, or shear waves

The second type of body wave is the S wave or secondary wave, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock, not through any liquid medium. It is this property of S waves that led seismologists to conclude that the Earth's outer core is a liquid. P and S waves are collectively called body waves.

Surface Waves

Travelling only through the crust and are of a lower frequency than body waves, and are easily distinguished on a seismogram as a result. Though they arrive after body waves, it is surface waves that are almost entirely responsible for the damage and destruction associated with earthquakes. This damage and the strength of the surface waves are reduced in deeper earthquakes.

Love Waves

The first kind of surface wave is called a **Love wave**, named after A.E.H. Love, a British mathematician who worked out the mathematical model for this kind of wave in 1911. Love waves produce entirely horizontal motion.

Richter scale: The Richter scale was developed in **1935** by American seismologist **Charles Richter (1891-1989)** as a way of quantifying the magnitude or strength of earthquakes. It is mathematically based.

Seismograph: It measures the motion of ground including above mentioned seismic waves generated by earthquake. effects of earthquakes: the effects of earthquakes include, but are not limited to, the following:

- It destroys the life of human.
- It destroys infrastructure of school, educational institutions, hospitals, industries and other personal/private properties.
- It destroys the hydropower projects or dams.
- It may leads in to landslides, flood cyclones etc.
- It may leads to catastrophic flood.
- It is responsible for great social and economical losses.
- It may cause epidemic diseases by destruction of sewage line systems.
- It completely destroys the electrical system and communication system.
- It destroys agricultural land.

Sometimes earthquake causes complete separation of family members, community and society.

Preventive measures against Earthquake: As you know that earthquake is fastest, quickest and sudden disaster and during the disaster we cannot do so effective methods. Therefore, it is necessary to follow the rules and regulation before the disaster by which we can minimize the impacts of earthquake. There are various mitigation measures of earthquake and some important measures which are certainly helpful to minimize the

impacts of earthquake are summarized below:

Before earthquake/disaster: as you know that earthquakes occurs very fast without giving any signal and if we wait until the earth is start to shake it may be too late. following point should be kept in mind before earthquake specially in earthquake prone areas.

Identify the zone and frequency of earthquake in area where you live.

Follow the rules and regulations prescribed by governments. government of india prescribed various rules for construction of buildings in different seismic zones.

Disaster management training for people/communities must be organized at regular basis.

Keep the phone numbers of media and official of national disasters response force (ndrf) etc.

Always keep the following in a designated place: drinking water bottles, dry food. first aid kits, torchlight and battery operated radio.

Identify place in the house that can provide cover during earthquake.

It may be easier to make log distance calls during an earthquake. identify an out of town relative or friend as a family's emergency contact. if the family members get separated after the disaster and are not able to contact each other, they should contact the designated relative/friend. the address and phone number of the contact person should be with all the family members.

During emergency/earthquake:

earthquakes give no warning at all. sometimes, a loud rumbling sound might signals its arrival a few sounds ahead of time. those few seconds could give us a chance to move to a safer location. here are some important tips for keeping safe during a earthquake.

Take cover, go under a table or other solid furniture, kneel, sit or stay close to the floor. hold on to furniture legs for balance. be prepared to move if your cover moves.

Do not stand in doorways. violent motion cause serious injury.

move away from windows, mirrors, bookcases and other unsecured heavy objects.

Do not run outside the buildings if you are deep inside in room

never use the lift.

If you are living in a house which is not far from the open area, the best thing to do is to move an open area where there are no trees, electric or telephone wires.

If you then move outside into open, away from buildings, streetlights and utility wires. once in the open, stay there until the shaking stops. avoid place where there are loose wires and do not touch metal objects that are in touch with the loose wire. stay away from badly damaged structures.

If you are in vehicle, then move to clear area from buildings, trees, overpasses. avoid bridges or ramp that might have been damaged by the earthquake.

Post emergency or after earthquake:

Here are a few things to keep in mind after an earthquake. the cautions you display in the aftermath can be essential for your personal safety. Wear shoes to protect feed from debris and other hazardous substances.After the earthquake, be prepared for aftershocks. aftershock cause additional damages and may bring down weakened structures. aftershocks can occur in the first hours, day, weeks or even months after the earthquakes.Check for fire hazards and use torch lights instead of candles or lanterns. If the building you live in is in a good shape after the earthquake, stay inside and listen for radio advices. if you are not certain about the damage to your building, evacuate carefully. Help injured or trapped persons and give first aid. do not move seriously injured persons unless they are in immediate danger of further injury. Remember to help your neighbours who may require special assistance infant, the elderly, and people with disabilities. Listen to a radio for the latest emergency information. Stay out of damaged buildings.

Return home only when authentic agencies say it is safe. clear up spilled medicines, bleaches or gasoline or other flammable liquids immediately. leave the area if you smell gas or fumes from other chemicals.

If you smell gas open windows and quickly leave the building. turn off the switch on the top of the gas cylinder.

Look for electrical system damages if you see sparks, broken wires, or if you smell burning of amber, turn off the electricity at the main fuse box. check for sewage and water lines damage. if you suspect sewage lines are damaged, avoid using the toilets. if water pipes are damaged, avoid using water from the tap. Use the telephone only for emergency calls.

In case family members are separated from one another during an earthquake develop a plan for reuniting after the disaster. as an out of state/district relative to serve as the "family contact". make sure everyone in the family know the name, address, and phone numbers of the contact person.

9.3.3 CYCLONE

The term **"Cyclone"** was coined by **Henry Piddington (1848)** which means coil of snake and move in circle. **Henry Piddington** published his thesis on **"Law of storms".** A cyclone is a storm accompanied by high speed howling winds which brings torrential rains. Its strong winds blow at great speed, which can be more than 118 km/hr. when a cyclonic storm approaches, the skies begin to darken accompanied by lightning and thunder. In meteorology, cyclone is an area of closed, circular fluid motion rotating in the same direction as the earth. This is usually characterized by inward spiraling winds that rotate counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere of the earth. It is often difficult to predict where a cyclone will strike. When it start moving from oceans towards the land area, a cyclone can damage track and the hit area other than those anticipated earlier.

Large scale cyclonic circulations are almost always centered on area of low atmospheric pressure. The largest low pressure systems are cold core polar cyclones and extra-tropical cyclones which lies on the synoptic scale. Warm core cyclones such as tropical cyclones, mesocyclones and polar lows lie within the smaller mesoscale. Cyclones have also been seen on the other planets (Marsh and Neptune) outside of earth. **Cyclogenesis** describes the **process of cyclone formation** and intensification. Extratropical cyclones form as wave in large region of enhanced midlatitude temperate contrasts called baroclinic zones. These

zones contract to form weather fronts as the cyclonic circulation closes and intensifies. Later in their cycle cyclones occlude as cold core system.

Tropical cyclogenesis describes the process of development of tropical cyclones. Tropical cyclones form due to latent heat driven by significant thunderstorm activity, and are warm core. Cyclone can transition between extratropical, subtropical and tropical phases under the right conditions. Mesocyclones form as warm core cyclones over land, and can lead to tornado formation. Waterspouts can also form from mesocyclones but more often develop from environment of high instability and low vertical wind shear.

India has a lone coastline about 7500 Km which is exposed to tropical cyclones occurring in the Bay of Bengal and the Arabian Sea. The Indian Ocean is one of the six major cyclone prone regions of the world. In India cyclones occur during April-May and Oct-Dec. Annually, about 5-6 tropical cyclones form in Bay of Bengal and in Arabian Sea out of which 2-3 may be severe. About, 80% of cyclones form in Bay of Bengal. The effects and mitigation measures of cyclone are given below:

Effects of Cyclone:

1. A cyclone causes heavy flood in an area.
2. It uprooted electricity supply and communication system.
3. Transportation come to halt because flood damage rail tracks and roads. Rail movements are also disrupted because of communication failure.
4. The inclement weather conditions also disrupt air services. Seaport stop work due to high wind velocity, heavy rains and poor visibility. Sometimes ships overturn or are washed ashore. The speed wind bends and plucks out trees and plants.
5. A cyclone tear away wall siding, and blow off roofs of houses.
6. House collapse and people are rendered homeless. The floodwater can take time to recede.
7. The flood waters can turn the agriculture land salty.
8. It destroys bridges, dams and embankments.
9. Floods wash away human beings and animals and make water unfit for drinking. There can be outbreak of diseases like cholera, jaundice, viral fever due to intake of polluted water. Contamination of water because of floating corpses of animal and human beings and mixing of sewage stored food supplies get damaged.

Preventive measures against Cyclone: There are various mitigation measures of cyclone and some important measures which are certainly helpful to minimize the impacts of cyclone are summarized below:

Before cyclone / disaster:

1. Identify the area where you live and keep the record of frequencies of cyclone in your area.
2. Keep watch on weather and listen to radio, TV. Keep alert about the community warning systems though loud speakers, bells, conches, drums and any other traditional warning systems.
3. Get to know the nearest cyclone shelter buildings and the safest route to reach these shelters.
4. Do not listen to rumors.
5. Prepare an emergency kit which should have: A portable radio, torch and spare batteries, dry food, matches, fuel lamp, portable stove, cooking utensils, waterproof bags, a first aid kit, manuals etc.
6. Check the roof and cover it with net or bamboo. Check the walls, pillars, doors and windows to see if they are secure. If not, repair those at the earliest. In case of tin roofs, check the condition of the tin and repair the loose points. Cover the mud walls with polythene or coconut leaves mats on a bamboo frame.
7. Trim dry tree branches, cut off the dead trees and clear the place of debris, including coconut and tree branches.
8. Clear your property of loose materials that could blow about and cause injury or damage during extreme winds.
9. If your area is prone to cyclone identify safe high ground or shelter.
10. Keep your important documents (Educational certificates, passport, pass books etc) with your emergency kits if you are evacuating.
11. Identify the area where you can dig holes to store food grains, seeds etc. in polythene bags.
12. Prepare and keep the list of emergency addresses, phone number. Know the contact telephone number of government offices/agencies which are responsible for rescue during cyclone.

Upon a cyclone warning

1. Fill plastic jars with drinking water.
2. Store loose items inside, put extra agricultural products/stock like paddy in plastic bags and store it by digging up a whole in the ground, preferably at a higher elvation and then cover it properly.
3. Give information to volunteer and other authorities about your relatives.
4. Fill fuel in your vehicles and park it under solid cover.
5. Close doors and windows properly and stay inside with your pets.
6. Pack essential medicines, valuable gadget, papers, and dry food to be taken along with your emergency kit.
7. Listen to local radio/TV for further information.
8. In case of warning of serious storm, move with your family to a strong building. In case of strong cyclones of severe intensity, evacuate the area with your family members, precious items, documents and emergency kit. Take special care for children, elder, sick, pregnant women and lactating mothers in your family. Do not forget your emergency food stock, water and other emergency items. **Go to the nearest cyclone shelter.**
9. Do not go into the sea for fishing.
10. On the warning of evacuation wear strong shoes s and clothing for better protection.
11. Lock your home properly, switch off power, gas, and water and take your emergency kit.
12. If evacuating to a distance place take valuable belonging, domestic animals and leave early to avoid heavy traffic, flooding and wind hazards.

During the Cyclone/when cyclone strikes

1. Switch off and unplugged all electrical appliances and turn off gas.
2. If the building starts crumbling, protect yourself with strong table or bench or hold on solid fixture.
3. Listen to your transistor radio for updates and advices.
4. If driving vehicle then stop but well away from the sea and clear of trees, power lines and water courses. Stay in vehicle.

After the disaster/cyclone:

1. Do not go outside until officially advised it is safe.
2. Make sure for gas leak, don't use electrical appliances, if wet.
3. Listen to local radio for official warning and advice.
4. Be careful of snakebites.

9.3.4. LANDSLIDES

Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity. Some landslides are rapid, occurring in seconds, whereas other may take hour, weeks or even longer time. Debris flows are fluid mass of rock, earth and other debris saturated with water. Mudflows or debris flows are characters of steep, scanty vegetated slopes on which heavy rainfall initiates movement in thick layer of weathered material. They develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or slurry. Slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds.

The landslides occur in mountainous hilly regions of Himalaya or at the western ghat. However, landslides occur more frequently in Himalayan region due to their fragile nature.

Types of landslides:

According to **Varnes (1978)** landslides may be of following types:

1. **Falls:** It is abrupt movement of materials that become detached from steep slopes or cliffs, moving by free fall, bouncing and rolling.
2. **Flows:** In this type many types of mass movement takes place such as creep, debris flow, debris avalanches and mudflow.
3. **Creep:** In this types slow steady down slope movement of soil or rocks.
4. **Debris flow:** In this type of landslide rapid mass movement, in which loose soils, rocks and organic matters combine with entrained air and water to form slurry that then flows down slope, usually associated with steep gullies.
5. **Debris avalanches:** A variety of very rapid to extremely rapid debris flow.

6. **Lahar:** Mudflow or debris flow that originates on the slope of a volcano, usually triggered by heavy rainfall eroding volcanic deposits, sudden melting of snow and ice due to heat from volcano vents or the breakout of water from glaciers, crater lakes or lakes dammed by volcanic eruption.
7. **Mudflow:** Rapidly flowing mass of wet material that contains at least 50% sand, silt and clay sized particles.
8. **Lateral Spreads:** Often occur on very gentle slopes and result in nearly horizontal movement of earth materials. Lateral spreads usually are caused by liquefaction, where saturated sediments (usually sand and silts) are transformed from a solid into a liquefied state, usually triggered by an earthquake.
9. **Slides:** Many types of mass movement are included in the general term "landslide". The two major types of landslides are rotational slides and translational landslides.
    a. **Rotational landslides:** The surface of rupture is curved concavely upward or the slide movement is more or less rotational. A slump is an example of small rotational landslide.
    b. **Translational landslide:** The mass of soil and rock moves out or down and outward with little rotational movement or backward titling.
    c. **Topple:** A block of rock that tilts or rotates forward and falls, bounces or roll down the slope.

Causes of Landslides:

Many factors such as geography, gravity, weather, ground water, wave action, type of soil, wave action and human activities are responsible for landslides. Although landslides usually occur on steep slopes, they also can occur in areas of low relief. Landslides can occur as ground failure of river bluffs, cut and fill failures that may accompany highway and building excavation, collapse of mine waste piles and slope failures associated with quarries and open pit mines. Underwater landslide usually involves areas of low relief and small slope gradients in lakes and reservoirs or in offshore marine settings.

Natural factors which cause landslides:

1. **Gravity:** Gravity works more effectively on steeper slopes, but more gradual slopes may also be vulnerable.
2. **Geological factors:** many slides occur in geological setting that places permeable sands and gravel above impermeable layer of silt and clay or bedrock. Water seeps downward through the upper materials and accumulates on the top of the underlying units, forming a zone of weakness.
3. **Heavy and Prolonged rainfall:** Water is commonly the primary factor triggering a landslide. Slides often occur following intense rainfall, when storm water runoff saturates soils on steep slopes or when infiltration causes a rapid rise in ground water levels. Ground water may rise as a result of heavy rains or a prolonged we spell. As water tables rise, some slopes become unstable.
4. **Earthquake:** Seismic activities have always been a main cause of landslides throughout the world. Any time tectonic plates move the soil that covers moves with it. When earthquakes occur on areas with steep slopes, many times the soil slips causing landslides. Furthermore, ashen debris flows caused by earthquakes can also trigger mass movement of soil.
5. **Forest fires:** Forest fires cause soil erosion and induce floods and landslides due to the destruction of natural vegetation.
6. **Volcanoes:** Strato volcanoes are prone to sudden collapse, especially during wet conditions. The conditions commonly prevail after volcanic eruption that kill vegetation over extensive areas and spread loose volcanic rocks over the landscape. During subsequent rainy seasons, swollen rivers will erode the new deposits and sometimes generates lahars that are dangerous to people downstream.
7. **Waves:** Wave action can erode the beach or the toe of a bluff, cutting into the slope and setting the stage for future slide.

Anthropogenic or manmade factors which cause landslides:

Human actions most notably those that affect drainage or groundwater can trigger landslides. Some of the important manmade actions which are responsible for landslides are described below:

1. **Inappropriate drainage system:** Natural drainage lines on slopes are blocked by

terracing/contour bounding adopted to prevent soil erosion and enhance percolation during dry season for cultivation, without adequate provision for surface drainage of excess storm water during high intensity rains increase the landslide vulnerability.

2. **Deep Excavation on slopes for buildings roads, canals and mining:** Developmental activities like construction of buildings, roads, embankment, cut and fill structures cause modification of natural slopes. These types of activities are highly responsible for landslides.
3. **Change in slope/land use pattern, deforestation, agricultural practices on steep slopes:** Deforestation and cultivation of seasonal crops and increase in settlement. Improper land use practices such as heavy tilling, agricultural practices and settlement patterns have contributed to creep and withdrawal of toe support in many cases.

Preventive measures against landslide:

A landslide is caused by combination of various factors (topography, geology, geological structure, ground water etc). Accordingly, measures to be taken for landslide prevention come in a variety of types. Landslides can be controlled by following preventive measures.

Before Landslide/Disaster:

1. Identify the area here you live and note the frequencies of landslide in your area.
2. Plantation should be done over slope therefore roots can stabilize the soil.
3. Cover slope with concrete, while putting pipes in it to let the water from the top out.
4. Don't live in landslide hazard area.
5. Don't construct anything in an area where landslide has occurred previously.
6. Make sure that all water pipes do not leak.
7. Make a strong wall in front of the bottom of the slope to prevent any lahars or flow to run rapidly, which also change the direction of flow.
8. Make sure to stay indoors when the landslide warning is given
9. Stay away from mountainous area where there is heavy rain.
10. Water pipes could also be put in to slope so the water can be taken out, preventing it from flowing too high which provides a slimmer chance of a landslide.

During landslide/Disaster:

1. Stay alert and awake, many debris flows occur when people are sleeping. Listen to a

weather radio or portable radio or television for warnings of intense rain fall. Be aware that intense, short burst of rain may be particularly dangerous, specially after long period of heavy rainfall and damp weather.

2. If you are in area at risk to landslides and debris flows, consider leaving if it is safe to do so. Remember that driving during heavy rain can be hazardous. If you remain at home, move to a second story if possible.
3. Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together. A trickle of flowing or falling mud or debris may precede larger landslides. Moving debris can flow quickly and sometimes without warning.
4. If you are near a stream or river, be alert for any sudden increase or decrease in water flow and for a change from **clear to muddy water**. Such changes may indicate landslides in upstream.
5. Be especially alert when driving. Embankments along roadsides are particularly susceptible to landslides. Watch the road for collapsed pavement, mud, fallen rocks and other indication of possible debris flow.

After the landslide:

1. Keep yourself and family members away from the landslide area. There may be danger of further landslide.
2. Check for injured and trapped person near the landslide, without entering the direct slide area.
3. Help a neighbor who may require special assistance-infants, elderly people, and people with disabilities.
4. Listen or watch to local radio or television stations for the latest emergency information.
5. Watch for flooding and heavy rain, which may occur after a landslide or debris flow. Flood and heavy rain sometimes follow landslides and debris flows because they may both be started by the same event.
6. Check the foundations of building, chimney and surrounding land for damage. Damage to foundations, chimney or surrounding land may help to assess the safety of the area.

9.4. DISASTER MANAGEMENT

According to Disaster Management Act, 2005, disaster management defined as "a continuous and integrated process of planning, organizing and implementing measures which are necessary for:

- Prevention of harmful impacts of any natural and manmade disaster.
- Mitigation or minimize of risk of any disaster or its severity.
- Capacity building.
- Preparedness to handle with any disaster.
- Response to any threatening disaster situation or disaster.
- Assessing the severity of any disaster; evacuation, rescue and relief
- Rehabilitation and reconstruction or development after disaster.

Disaster Management can be defined as "the organization and management of resources and responsibilities for dealing with all humanitarian aspects of disaster, in particular preparedness, response and recovery in order to lessen the impact of disasters".

Key Phases of Disaster Management: A successful disaster management planning must include the situation that occurs before, during and after disaster. All the phases/stage of disaster management and their sub-categories are described below:

Pre –Disaster Phase: As you know that this is first phase of disaster management and in this phase we prepare ourselves for disaster. This phase is about before a disaster to reduce the potential for human, economical or environmental losses caused by disaster. This phase ensure that these losses are minimized when the disaster actually strikes. This is most important phase of disaster management. Important points of pre-disaster phase are given here:

i. **Prevention and Mitigation:** This step includes minimizing the risk of disasters involves activities, which reduce or modify the scale and intensity of the threat The term "prevention" is used to embrace the wide diversity of measures to protect persons and property its use is not recommended since it is misleading in its implicit suggestion that natural disasters are preventable. In mitigation all

measures taken to reduce both the effects of the hazard itself and the vulnerable conditions to it in order to reduce the scale of a future disaster. Mitigation should also be aimed at **reducing the physical, economic and social vulnerability** to threats. Therefore, mitigation may incorporate addressing issues such as land ownership, wealth distribution, implementation of earthquake resistant building codes, etc.

ii. **Preparedness:** This step brings us to the all issues of disaster preparedness. The process is about involvement of governments, communities and individuals to respond rapidly to disaster situations. Preparedness includes the formulation of viable emergency plans, the development of warning systems, the maintenance of inventories, public awareness and education and the training of personnel. These steps can be done with the help of research, training, mass awareness etc.

iii. **Early Warning:** This is the process of analyzing the situation in communities to slow onset disaster, and passing the knowledge of the pending disaster to people or communities. To be effective, warnings must be related to mass education and training of the population who know what actions they must take when warned.

During disaster Phase: This phase is also called **Emergency phase.** It is to make sure that the needs and necessities of victims are met to ease and minimize sufferings. As you know that disaster is sudden and occur very fast therefore this phase also regarded as shortest phase of disaster management.

i. **Response:** This refers to the first stage response to any disaster, which include setting up control rooms, issue warning, evacuation, taking people to safer areas, rendering medical aid to the needy etc., simultaneously relief to the homeless, food, drinking water, clothing etc. reinstallation of communication, expenditure of assistance. The emergency relief activities carried out during and immediately following a disaster, which includes immediate relief, rescue, and the damage, needs assessment and debris clearance.

The Post-disaster Phase: This phase is about mitigation measures after the disaster. This phase is applied to achieve rapid and durable recovery. Following points should consider during this phase.

i. **Recovery:** Recovery is used to describe the activities that encompass the three overlapping phases of emergency relief, rehabilitation and reconstruction.

ii. **Rehabilitation:** In this step injured/affected people located in safer place. Rehabilitation includes the provision of temporary public utilities and housing as interim measures to assist long-term recovery.

iii. **Reconstruction:** Reconstruction attempts to return communities to improved pre- disaster functioning. It includes such as the replacement of buildings; infrastructure and lifeline facilities.

iv. **Development:** It includes construction of embankments against flooding, irrigation facilities as drought proofing measures, increasing plant cover to reduce the occurrences of landslides, land use planning, construction of houses capable of withstanding the onslaught of heavy rain/wind speed and shocks of earthquakes are some of the activities that can be taken up as part of the development plan.

Government bodies/ Agencies Working for Disaster Management: There are various agencies in India which are working for disaster management some of the important agencies are described below:

National disaster response force (ndrf): the disaster management act, 2005 made the legal provisions for the constitution of the **NATIONAL DISASTER RESPONSE FORCE** with the objective of response to disasters. it is a specialist force, the force is gradually emerging as the most visible and vibrant multi-disciplinary, multi-skilled, high-tech force capable of dealing with all types disasters. presently, ndrf is about comprised of battalions from the **BSF, CRPF, CISF AND ITBP.**

National disaster management authority (ndma): the national disaster management authority **HEADED BY THE PRIME MINISTER OF INDIA** and most important body for disaster management in india. the setting up of the ndma and the creation of an enabling environment for institutional mechanisms at the state and district levels is mandated by the **DISASTER MANAGEMENT ACT, 2005. HEADED BY RESPECTIVE CHIEF MINISTERS OF THE STATES** national disaster management authority has been

constituted with the prime minister of india as its chairman, a vice chairman with the status of cabinet minister, and eight members with the status of ministers of state.

National institute of disaster management (nidm): the national institute of disaster management (nidm) was constituted under an ACT OF PARLIAMENT with a vision to play the role of a premier institute for capacity development in india and the region. under the disaster management act 2005, nidm has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management. nidm provides technical support to the state governments.

International strategy for disaster reduction (isdr): it was established in december 1999**.** its main areas of work includes ensuring disaster risk reduction (drr) is applied to climate change adaptation, increasing investments for drr, building disaster-resilient cities, schools and hospitals, and strengthening the international system.

9.5 SUMMARY

Disaster is any calamitous event which causes, human, economical and environmental losses. There are various forms of disaster and these may be of two types i.e. natural and manmade. Examples of natural disasters are flood; earthquake, landslides, volcanoes, cyclones and example of manmade disaster are war, nuclear explosion, terrorist attack, industrial fires/hazards. India has been traditionally vulnerable to natural disasters and flood, earthquake, cyclones; landslides have been recurrent phenomena. In India, about 60% of total landmass is prone to earthquake, 40 million hectares of total land is prone to flood, 8% of total land is prone to cyclones. Flood may be different types such as riverine flood, estuarine flood, catastrophic flood, coastal flood and muddy flood. There are various causes of flood such as heavy rain fall, deforestation, soil erosion etc. effects of flood are very dangerous and can leads in to loss of human life, soil erosion, water borne diseases, socio-economical losses etc. Besides these impacts, flood may lead in to landslides.

The main cause of earthquake is movement in tectonic plate of earth. This is most dangerous form of natural disaster. On the basis of movement in tectonic plates fault may be strike slip fault, normal fault and reverse fault. Richter scale measures the magnitude of earthquake

and it was developed by Richter in 1935. There are various types of seismic waves produced during earthquake in which P waves are fastest waves. Study of earthquake and seismic waves is known as Seismology. Andaman & Nicobar groups of Island, North east states; Uttrakhand, Himachal Pradesh, J&K and Rann of Kutch are more prone to earthquake. Effects of earthquake may include loss of human life, damage to infrastructure and agriculture. Earthquake may lead in to catastrophic flood, landslides and cyclones. We can minimize the impacts of earthquake through proper training and by following pre-disaster, emergency stage and post disaster phases. Meaning of cyclone is move in circle, in this disaster air moves in circle at very high speed and cause great damage to community. Bay of Bengal and Arabian seas are more prone to cyclone. Cyclone can cause great damage to human life, electrical system, communication system and other infrastructure. Landslide is upward or downward movement of debris or soil. Landslide may be different types such as falls, flows, creep, debris, lahar, mudflow, lateral spreads and slides. There are various natural and anthropogenic causes of landslides. Landslides generally occur in hilly regions of Himalaya. Landslides may cause great damage to infrastructure, livestock and sometime lead in to human losses. Disaster management is management of disaster in which we minimize the impacts of disaster in any area. Disaster management includes three stages viz. pre-disaster, emergency phase and post disaster stage. In India, various government bodies such as NDRF, NDMA, NIDM, ISDR etc. are working for disaster management.

9.6. GLOSSARY

Disaster: Occurrence of sudden or major misfortune which disrupts the normal functioning of the society or community.

Natural Disasters: These occur naturally and not introduced by man. Earthquake, flood, volcanic eruption, cyclone etc. these are natural form of disasters.

Manmade Disaster: These disasters are introduced by man. Industrial fires, war, nuclear explosion, terrorist attack etc. these are manmade or anthropogenic disasters.

Flood: flood is covering of land by water of land not normally covered by water

Earthquake: Shaking of the surface of the earth, resulting from the sudden release of energy in the lithosphere that create seismic wave. Earthquake also called tremor or temblor

Hypocenter: The location below the surface of the earth where, an earthquake starts.

Epicenter: the location directly above hypocenter, on the surface.

Richter scale: It was developed Charles Richter as a way of quantifying the magnitude or strength of earthquakes. It is mathematically based.

Seismology: The study of earthquakes and seismic waves that move through and around the earth.

Seismograph: It measures the motion of ground including above mentioned seismic waves generated by earthquake.

P-Waves: The first kind of body wave is the **P wave** or **primary wave**. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station.

S Waves secondary waves, or shear waves: The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake.

Cyclone: A cyclone is a storm accompanied by high speed howling winds which brings torrential rains.

Cyclogenesis: The process of development of cyclone.

Landslides Landslide is a general term for a wide variety of down slope movements of earth materials that results in downward and outward movement of soil, rock and vegetation under the influence of gravity.

Disaster management: disaster management defined as "a continuous and integrated process of planning, organizing and implementing measures.

Pre-disaster/emergency phase: This phase is about before a disaster to reduce the potential for human, economical or environmental losses caused by disaster.

Disaster Phase: In this phase mitigation measures applied during the disaster phase. This phase is also called **Emergency phase.** It is to make sure that the needs and necessities of victims are met to ease and minimize sufferings.

Post disaster/emergency phase: Phase is about mitigation measures after the disaster.

9.7. SELF ASSESSMENT QUESTIONS AND POSSIBLE ANSWERS

9.7.1. MULTIPLE CHOICE QUESTIONS

1. Meaning of Disaster word is:

   (a) Sudden change (b) Evil

   (c) Bad star (d) Ghost

2. Which of the following is/are natural disaster?

   (a) Earthquake (b) Flood

   (c) Cyclone (d) all of the above

3. Temblor is another name of:

   (a) Earthquake (b) Flood

   (c) Landslide (d) Cyclone

4. Richter Scale was developed in the year:

   (a) 1960 (b) 1935

   (c) 1878 (d) 1945

5. The **"Law of Storms"** was written by:

   (a) T. Ramachandran (b) G. Thomson

   (c) Henry Piddington (d) De Candolle

6. NDRF stands for?

   (a) National Diseases Fund Relief Force (b) National Disaster Response Force

   (c) National Damage Response Force (d) National Disaster Relief Fund

7. Which of the following region is prone to cyclone?

(a) Bay of Bengal (b) Karnataka

(c) Deccan Peninsula (d) J & K

8. Rehabilitation belongs to which stage?

(a) Pre-Disaster (b) Emergency

(c) Post Disaster (d) Non of the above

9. Fluvial flood is another name of:

(a) Coastal flood (b) Riverine flood

(c) Estuarine flood (d) Muddy flood

10. Which is the anthropogenic cause of landslide?

(a) Inappropriate drainage system (b) Earthquake

(c) Gravity (d) Waves

11. How many areas of India is prone to flood?

(a) 300 million hectares

(b) 200 million hectares

(c) 40 million hectares

(d) 10 million hectares

12. National Disaster Management Authority (NDMA) headed by:

(a) Prime Minister of India (b) President of India

(c) Speaker of Lok Sabha (d) None of above

13. Which of the following region in India is more prone to earthquakes?

(a) Aravali ranges (b) Himalayan Ranges

(c) Deccan plateau (d) Malwa plateau

14. Landslides often occur in:

(a) Desert region (b) Forest region

(c) Tundra region **(d)** Hilly region

15. Which of the following are fastest waves?

(a) P-waves (b) S-waves

(c) L-waves (d) T-waves

9.7.2. VERY SHORT QUESTIONS

1. Write the names of natural disasters.
2. The law which described the relationship between magnitude and total number of earthquakes in any region in a specific time period?
3. Overflow of water in land which is generally dry is called
4. P and S waves are collectively called
5. In India, Bay of Bengal and Arabian Sea are more prone to
6. Centre where earthquake generated is called
7. The study of earthquake and seismic waves is known as.
8. The process of development of tropical cyclone in known as
9. The key phases or stages of disaster management are.
10. The fault in which tectonic plates are past one another horizontally called
11. Andaman and Nicobar groups of island fall under this seismic zone.
12. In India the most intense and devastating floods are caused by this basin
13. Natural causes of landslides are
14. Give the names of two agencies which are working for disaster management in India.

ANSWERS

9.7.1. 1.(c); 2.(d); 3.(a); 4.(b); 5.(c); 6.(b); 7.(a); 8.(c); 9.(b); 10.(a); 11.(c); 12.(a); 13.(b); 14.(d); 15.(a)

9.7.2. 1. Earthquake, flood, cyclone, volcanoes, landslide 2. Gutenberg-Richter law; 3. Flood; 4. Body waves; 5. cyclones; 6. Hypocenter; 7. Seismology; 8. Tropical cyclogenesis; 9. Pre-disaster stage, emergency stage and post-disaster stage 10. Strike Slip fault; 11. Zone-5; 12. Ganga-Brahmaputra-Meghna Besin ; 13. Gravity, Geological factors,

Earthquake, Forest fire, Volcanoes, waves; 14. National Disaster Response Force (NDRF), National Disaster Management Authority (NDMA), National Institute of Disaster Management (NIDM), and International Strategy for Disaster Reduction (ISDR).

9.8. TERMINAL AND MODEL QUESTIONS

1. Define Disaster. Describe the causes, effects and mitigation measures of flood.
2. Describe the causes, effects and mitigation measures of Earthquake.
3. Describe the causes, effects and mitigation measures of cyclone.
4. Describe the causes, effects and mitigation measures of landslides.
5. Write about types of landslides.
6. What do you understand by following terms?

(a) Richter scale

(b) Hypocenter & epicenter

(c) Seismic waves

7. Define disaster management. Describe the three stages of disaster management.

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UNIT 10: CONCEPTS AND PATTERNS OF BEHAVIOUR

CONTENTS

10.1- OBJECTIVES

Study of Animal Behaviour has made significant contribution and play important role to the basic biological system and has considerably increases rapidly during the past few years. The importance of Animal Behavior is generally not recognized, as the ideas, concept and revelation have not adequately presented. The content of this chapter introduces various aspect of animal behavior like different kind of Behaviour, homing behavior, patterns of Animal Behaviour and parental care in Animal etc.

10.2-INTRODUCTION

The scientific study of the characteristic behaviour patterns and the study of Animal behaviour and social organization from a biological perspective are known as the Ethology, i.e. Ethology (ethos = habit, and logos = study, deals with the study of animal behaviour) is the branch of biology that analyzes the reaction of an animal to its environment, trying to determine specific cause and effect relationship between the animal action and events and condition experienced by the Animals. Thus behaviour is the study of what animals do as they react to their environment with particular patterns of muscular and glandular activity. A scientific study of animal behavior involves a variety of approaches. It can be explained in term of its evolutionary history, in term of the benefits it brings to the animal and in term of physiological mechanism. The consideration of any one of the approaches depends upon aspect of animal behaviour which one wants to know about.

The Scientific study of animal behaviour has its origin in the work of **Gilbert White (**1720-1793) and **Charles Leroy** (1723-1789). The most significant starting point in understanding animal behaviour came from the work of **Charles Darwin (**1809-1832), "Father of scientific study of Animal behaviour". Darwin wrote two books: i.e. **descent of Man and selection in relation to sex** (1871) and **The expression of emotions in Man and Animals** (1873).His theory of natural selection set the stage for consideration of animal behaviour and he believed the the theory of evolutionary continuity of man and other animal.

The modern approaches to animal behavior includes many feature derived from both the behaviorist and the early ethological views. In addition, modern ethology draws upon the physiological tradition, with its emphasis on the explanation of behaviour in term of the activity of the nervous system.Konrad Lorenz & Niko Tinbergen formulated a number of concept on which the study of animal behavior has been based.

10.3 TYPES OF BEHAVIOUR

In all the multicellular animals except sponges (devoid of nervous system), the nervous system is always involved in their behavior. Complex behaviour requires a complex nervous system. Thus changes in the evolution of the nervous system go side by side with the changes in the kind and complexities of behaviour. But the animals identical in the complexity may differ in their kinds of behaviour. Based on two commonly accepted modes of behaviour shown by organisms it may be grouped under two heads:

1. Innate behaviour
2. Learning behaviour

INNATE BEHAVIOUR:-

A behavior that an organism is born with is called an innate behavior. These types of behaviors are inherited.They don'thave to be learned. Innate behavior is commonly called Inborn or Inherited behavior. Innate behaviour is stereotyped behaviour; therefore it is termed as stereo typed innate behaviour. Some behaviour is probably completely innate (built in) e.g. tropism in plants. In birds not only the ability to sing but also a particular song is innate. A simplest form of behavior consists of a given response to a given type of stimulus. Since such response is always associated with a specific given stimulus, this type of behavior is known as stereotyped. Furthermore, such behaviour is innate, in that it is not learned but is present prior to any teaching or experience. In other words, the simplest type of behaviour is that where the responses to stimulus is governed by the hereditary properties.

Fig.10.1 Birds building nest (Innate behavior)

In other words, the behaviour that develops without obvious environmental influence is known as stereotyped or unchanging or innate behaviour. The animal in this category responds to a stimulus in a definite manner which is independent of all other factors except the nature of the stimulus. Thus stereotyped behaviour is that simple behaviour which is essentially stimulus dependent. Therefore, in this type of behaviour the nature of the stimulus determines the nature of the response. Reflex, Taxis, Kinesis, instincts etc. are the examples of this behaviour. Some ethologists have directly interpreted that stereotyped behaviour is a taxis (plural=taxes), if the whole organism changes its position in relation to some environmental stimulus. Taxes are usually named in terms of the guiding stimulus. Protozoan's react to light (Photo taxis); touch (Thigmotaxis); chemicals (Chemo taxis); gravity (Geotaxis); weak electrical currents (Galvanotaxis), and temperature (Thermotaxis). In general taxis refer to an idea about orientation. However, not all orientations are taxis. In general orientation may be defined as the reactions which guide the locomotors responses of the animals. The normal position of the animal which is the basic position, from which other reactions start, is known as primary Orientation. The locomotory behaviour of animals in response to various stimuli like temperature, light, humidity etc. is called secondary Orientation.

DIFFERENT TYPE OF INNATE BEHAVIOR

Secondary Orientation is basically of three main types which are regarded as kinds of innate behavior:-

1. Taxis

2. Kinesis

3. Transverse Orientation.

Besides the aforestated type of orientation, there three more types of innate behaviors' which are as follows:-

1. Instinctive
2. Reflexes and
3. Motivation.

1. Taxis

When the animals either move towards or away from the stimuli and their general course of movement is the straight line joining them with the source of stimulus, such orientation is called as 'taxis'. If the movement of Animal towards the source of stimulus than this is called as positive taxis and if it is opposite to this direction than it is known as negative taxis.

Types of Taxis: -

Taxis are of three types.

1. Klinotaxis 2. Tropotaxis 3. Telotaxis

1. Klinotaxis:-

This is the simplest form of orientation & undirected. Orientation by successive comparison of stimulus intensity requires turning movements. Usually it is called klinotaxis. Many animals show Klinotaxis in response to gradients of chemical stimulation.

2. Tropotaxis:

Tropotaxis is shown by those animals which possess receptors. With the help of receptors, they can compare the intensity of stimulus in all sites simultaneously. Tropotaxis enables the animal to steer a course directly towards or away from the source of stimulation. Usually the receptors are arranged in a bilaterally symmetrical fashion.

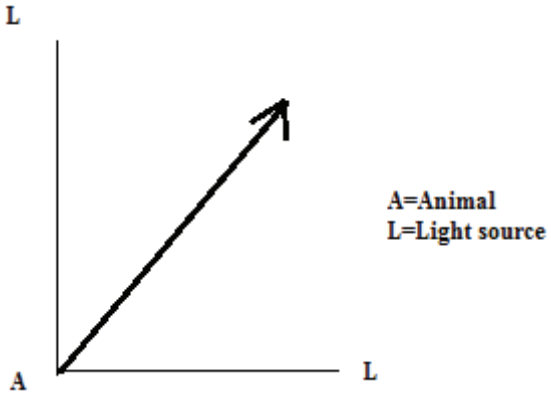

Fig.10.2 Topotaxis

It has been observed that if the receptors of one side are put out of action then the animals are unable to decide the course and move almost aimlessly. Such type of movement of the animal is called as “Circus movement”.

3. Telotaxis:

In this type of axis the balance does not exist and orientation of animal to light is not altered. The animal at one time may orientate to one light source and at the other time to the other light source. Thus it is capable of ignoring one or more light sources at a particular time. It shows that the bilateral arrangement of the stimulus is not a necessary factor for orientation

of this type. In other words, eyes that are capable of providing information about the direction of light by virtue of their structure are capable of Telotaxis.

Kinesis:-

The orientation of the whole animal in space may be based on very simple principles but may also involve very complex mechanism. The simple principles can be seen most easily in certain invertebrate species. The simplest form of spatial orientation in kinesis, in which the animal's response is proportional to the intensity of stimulation but is independent of the spatial properties of the stimulus. For example, common woodlice (porcellion scaber) tend to aggregate in damp places beneath rocks and fallen logs. They move about actively at low humidity levels but are less active when the humidity is high. They consequently spend more time in damp conditions but their enhanced activity in dry conditions increases the chance of discoveries of a damp place. It may be inferred that when the speed of movement and the frequency of turning of animals are affected by the stimulus then such orientation is called kinesis. Kinesis is directed movement of animals in relation to the sense of stimulus and is of two types:

A. Orthokinesis

B. Klinokinesis

A. Orthogenesis:-

When a relationship exists between the speed of locomotion and the intensity of stimulation then it is called Orthokinesis. Such kinesis may be seen in Porcellion scaber (Woodlice), in which the linear velocity of its movement is affected by the intensity of stimulus. As referred above, the woodlice move faster in dry condition than the humid condition. The result is that when the woodlice are kept in a chamber with graded humidity, then they aggregate in the humid zone. Actually this is not because they prefer humidity but because of the fact that they move quickly through the non-humid areas (i.e. dry areas) to humid ones.

A. Klinokinesis:-

In this type of kinesis the rate of change of direction increases with the increased light intensity (According to Fraenkel and Gunn, 1940, Hinde, 1970.) The flatworm *Dendrocoelum lacteum* does not move in a linear fashion but shows a twisted course of movement which includes turning in various direction of linear movement are random and take place even in uniform environmental condition. The rate of random turning or angular velocity is called as **'rate of change in direction'** (R.C.D.) and is represented in degress/Unit time.

TRANSVERSE ORIENTATION

When an animal is moving towards the source of stimulus but turns at an angle, the Orientation is called as Transverse Orientation. Transverse Orientation is of two types:

1. Light compass reaction 2. Dorsal ventral light Reaction.

Light compass reaction

Many animals have tremendous homing ability. The best example of light compass reaction or response is shown by homing ants. These animals are guided, in part, by the direction of the sun. If the apparent direction of the sun is changed slowly by means of a mirror, then the ants change course accordingly. It was thought by Brun (1914) that if garden ants (Lasius niger) were confined in a dark box for a few hours in the middle of their homeward journey, they would maintain the same angle to the sun when released. However, it later transpired (Jander, 1957) that the ants compensated for the movement of the sun and continued their journey in the same direction upon being released. Such time compensated compass reactions have been known to occur also in the bettle Geotrypyes sylvaticus, the pond skate Velia currens and the honey bee Apis mellifera (Saunders, 1976). It is now known that in light compass reaction the animal maintains a constant angle between the path of movement and line joining the light source to the photoreceptors. This angle is called as 'Orientation angle".

However due to the presence of compound eye, the Arthropods in general do not face any difficult in maintain a fixed Orientatio angle. If only a few ommatidai are illuminated at a

time, these animals first take up certain angular position in relation to sun and then keep the sun's image on same ommatidia throughout the journey. However, an important condition for orientation by sun is that there must be an inversion of the position of image during the return journey. For example, if during the outward journey the sun's image is kept at the front of the left eye then during return journey it should be at the base of the right eye. The type of Orientation achievable in a given situation depends jointly upon the nature of the external cues and the sensory equipment of the animal.

Doral-Ventral Light reaction:-

This is one of the reactions by which animals deprived of balancing organs; maintain their primary orientation and the normal position. Normally he aquatic swimmers viz. Fish have a tendency to Orientate themselves so that the dorsal surface face the light coming from the top water level. They do it constantly whether they are in motion or in rest. This is called as the Dorsal Light reaction. While in certain other animals the orientation is reversed i.e. the ventral surface faces the light and is called ventral light reaction.

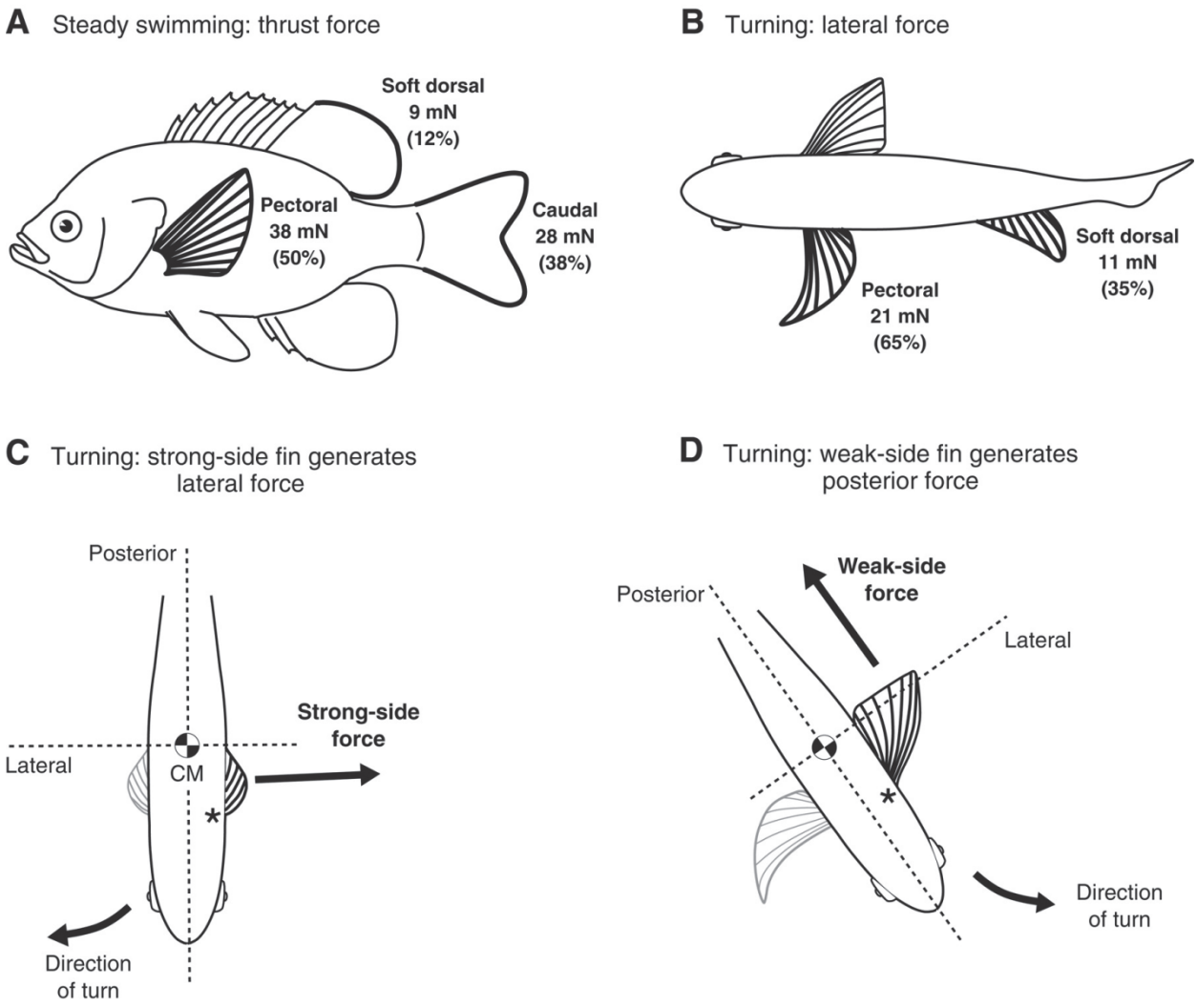

Fig.10.3 Dorsal - ventral light reaction in fish

Experimental demonstration of dorsal and ventral light reaction is rather very easy. The general principle involved in such experiment is the reversal of incidental light beam resulting in a reversal of position of the animal concerned.

Special types of Orientations:-

With reference to the study of orientation in birds, the navigation is a special and complex type of orientation. Besides, another special type of orientation found frequently in Bats in Echolocation.

Navigation:

The ability to find a goal using different cues orienting aids are the apparent movement of sum, moon & stars (used in conjugation with a biological clock) & occasionally also the earth magnetic fields. Navigation is the most complex form of spatial orientation, and is common in birds. Navigation requires not only a compass, or directional sense, but also some king of map.

Three types of orientation are important in navigation:-

1. **Pilotage, or steering: -** a course using familiar landmarks.

2. **Compass Orientation: -** the ability to head in a particular compass direction without any consideration of landmarks.

3**. True navigation: -** the ability to orient towards a goal such as home or breeding ground without the use of landmarks and also regardless of the direction. On their long-distance migrations, birds probably use all three types of orientation. With reference to orientation, pigeons show sensitivity to the following stimuli: -

(a) Ambient Pressure

The pigeon is sensitive to atmospheric pressure changes in the region of 1 to 10 millimeters of water, equivalent to a change of less than f10 meters in altitude (Kreithen and Keeton, 1974; Delius and Emmerton. 1978). Thus a sensory ability may provide the pigeon with an accurate physiological altimeter.

(b) Infrasound

A sound with the frequency of less than 10 hertz is called infrasound. Humans cannot hear it but pigeons can hear sounds as low as 0.06 hertz. Infrasound travels a very long distance, and natural sources of infrasound, are used by pigeons as a navigational aid (Kreithen, 1978.)

(c) Odour

Birds have long been thought to have a poor sense of smell, but experiments using Cardiac-conditioning (Hnton et al., 19666; Shumake. Et al., 1969) confirm the results from physiological methods in showing that the olfactory sense in pigeons is sufficiently good to be used in navigation. Similar results have been obtained from other bird species also (Schmidt Koenig, 1979).

(d) Magnetic compass

Scientists long had thought that the energy involved in geomagnetic effects would be too low to be detected by animals. This is known to be incorrect, and responses to magnetic fields have been shown to occur in many species. Although there were early indications of magnetic sensitivity in birds (Merkel and Wiltschko, 1965), yet the possibility was long doubtd because of successive failures to demonstrate magnetic sensitivity in cardiac-conditioning experiments.

(e) Sun compass

Gustar Kramer (1951) has shown that pigeons can use a compass. He trained starlings in a circular cage to look for food in a certain compass direction. All visual landmarks were excluded, and only the sun and sky wee visible. The birds were able to maintain a particular compass direction throughout the day, showing that they could compensate for the movement of the sun.

The above findings can be reset experimentally by confining the bird in a lightproof room and exposing it to artificial photoperiods (Hoffman, 1954.) Klans Schmidt Koening (1960, 1961), in experiments with homing pigeons, tested the effects of shifting the clock 6 hours forward, or 6 hours backward, or by 12 hours.

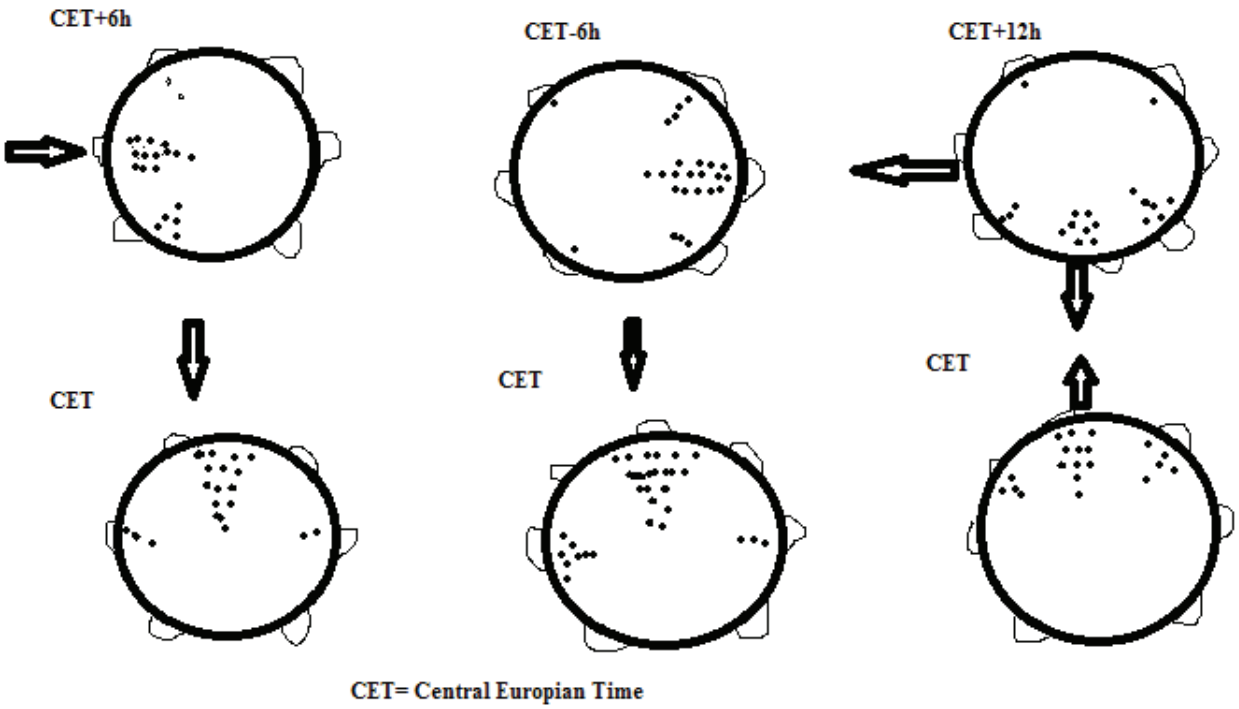

Fig.10.4 Central European Time

F. Star compass

If songbirds are caged during the period when they normally would be migrating, they shown a typical directional migratory restlessness, at night this directionality is related to the stars (Sauer and Sauer, 1955). The birds were oriented under a natural starry sky and under a planetarium sky.

Cardiac-conditioning methods have been applied to investigate the perception of the night sky by birds. There is evidence that mallards (Anas platyrhynchos) learn to recognize particular star patterns (Wallraff, 1969) although stat patterns provide potential maplike information, the evidence so far indicated that the stars are used purely as a compass (Schmidtkoening, 1979.)

Polarized Light

In normal, unpolarized light, the wavelike vibration occurs equally in all the planes whereas in polarized light, the vibrations are greater in one plane only. When unpolarized sunlight is scattered by atmospheric molecules, polarization occurs, greatest for the light scattered at an angle of 90^0 to the rays of sun, which means there is a pattern of polarization in the sky that changes according to the position of the sun.

INSTINCTIVE BEHAVIOR

An instinct is a complex pattern of innate behavior. Spinning a web like the one in -----is complicated, yet spiders spin webs correctly on the first try. Unlike reflexes, instinctive behaviors can take weeks to complete. Instinctive behavior begins when the animal recognizes a stimulus and continues until all parts of the behavior have been performed.
Early ethologists regarded instinct as the natural origin of the biologically important motives. Thus, Thomas Aquinas believed that animal judgments are not free but implanted by nature. Descartes regarded instinct as the source of the forces that govern behaviour, being designed by God in such a way as to make the behaviour adaptable.

The idea of instinct as a prime mover was taken up by Psychologists such as Freud (1915) and McDougall (1908.) Sigmund Freud developed a motivational theory of neurosis and psychosis that emphasized the irrational forces in human nature. He saw, behaviour as the outcome of the two basic energies, a life force underlying life-maintaining and life-continuing human activities and a death force underlying aggressive and destructive human activities. Freud thought of the life and death forces as instincts whose energy required expression or discharge.

Darwin (1859) was the first to propose an objective definition of instincts in terms of animal behavior. He treated instincts as a complex reflexes made up of units compatible with the mechanisms of inheritance, and thus, a product of natural selection that had evolved together with the other aspects of the animal's life. Darwin's concept of instinct is then similar to that of Descartes, with evolution replacing the role of God.

Criteria for instinctive behaviour

There are three criteria for instinctive behaviour:

(1) They are unlearned, (2) They are adaptive and (3) They are the characteristic of the species.

Exceptions are always there and in higher animals learning by individual life experiences cannot be ruled out, For example cats are carnivorous and instinctively kill rates, but not cats kill rats, for it turns out that kittens often must see adult cats killing rats before they do so themselves. Kittens brought up with mice rarely become mouse killers. Illustrations of innate behaviour in Animal kingdom innate behaviour are often stereotyped and occur in all animals but are more significant in lower forms. In higher animals, innate responses occur along with learned ones and are often modified by learning. Few important patterns as an example of innate behaviour are illustrated as under:

1 st example: When a toad sees a long thin object such as a garden snake, it characteristically reacts by filling its lungs to capacity and rising up from the ground while at the same time tilting towards the object. The increased size and changed attitude is effective in preventing it from being swallowed by the snake, but the toad probably does not known that, it is just reacting "instinctively" to the stimulus.

2 nd example: many calm species characteristically react to contact with starfish by flapping their shells in such a manner that they are propelled upwards and away from the predator.

III rd example: Mammals also show complex patterns of innate behaviour. The curiosity of a young kitten, it playful pouncing on its mother's body, its persistent searching for an available nipple are examples of unlearned behaviour patterns that characterize normal young kittens.

IV th example: Mammals also show complex patterns of innate behaviour. The curiosity of a young kitten, its playful pouncing on its mother's body. Its persistent searching for an

available nipple is examples of unlearned behaviour patterns that characterize normal young kittens.

Vth example: In many meat eating mammals(carnovores), it is usual for the mother to be the only parent to protect and provide food for the offspring. The male parent is often likely to eat its own young, if the opportunity arises. Nevertheless, it is innate behaviour of males of many species, such as courgars, wolves and foxes, to provide food and protection by the mother. Especially in mammals, however innate behaviour is modified and improved by learning, so that it is difficult to tell how much of a particular behaviour pattern is innate and how much is learned.

Human's Aggressive Behaviour-Innate or Learned?

A great deal of attention has been directed to the question of whether aggressive behaviour in humans is innate or learning; the results of these studies are also inconclusive. According to one speculation, the rewards of aggressive behaviour are learned as a result of frequent success in play and fighting; the idea being that the more fights an animal wins the more willing it is to be aggressive in order to achieve its goals.

This is a difficult concept to prove, however, because one can argue with equal logic that an animal wins frequently because it is more aggressive in the first place.

Another view is than human aggression is the result of frustration, a reaction to anything that stands in the way of achieving a goal. Thus, a child who wants another child's toy becomes aggressive when the second child refuses to give it up. With practice, the first child, according to this view, learns that it can have its own way at the expense of others simply being the most aggressive.

5. Reflexes

Like taxes, reflexes are stereotyped and fixed responses to stimuli that fit the definition of innate behavior in the sense that they are the outcome of inherited neural mechanism. Actually, definition wise taxes often mix up with reflexes, for e.g. in taxes the orientation of the whole body may involve a number of reflexes. "Reflexes" in the true sense are responses of the part of the body, for instance flexion of the leg in response to painful stimuli, or the

constriction of the pupil in intense light. Reflexes are, therefore, adaptive and relatively invariable.

It is needless to mention at this level of study the constituents of a reflex action and the mechanism involved, however, it may suffice here to remind the readers that a simple reflex action requires the following: a receptor organ; a sensory or afferent neuron, the spinal cord or the brain where the sensory and motor neurons synapse, the motor or efferent neuron, and the effectors organ. In lower animals like Hydra and Jellyfish, the synapses take place in the mesogloea nerve-net.

6. Motivation

Motives are internal stimuli such as hunger, thirst; urge of sex etc. in other words, motivated behaviour is a drive or an urging force that leads to goal-directed behaviour and satiation. Actually motivated behaviour may be unlearned or leaned.

LEARNING BEHAVIOUR

All animals have innate and learned behaviors. Learned behavior develops during an animal's life time. Animals with more complex brains exhibit more behaviors that are the result of learning. However, the behavior of insects, spiders, and other arthropods is mostly instinctive behavior. Fish, reptiles, amphibians, birds, and mammals all learn. Learning is the result of experience or practice. Learning is important for animals because it allows them to respond to changing situations. In changing environments, animals that have the ability to learn a new behavior are more likely to survive. This is especially important for animals with long life spans. The longer an animal lives, the more likely it is that the environment in which it lives will change.

Fig 10.5 grouse and quail chicks

Learning also can modify instincts. For example, grouse and quail chicks, shown in fig 10.4 leave their nests the day they hatch. They can run and find food, but they can't fly. When something moves above them, they instantly crouch and keep perfectly still until the danger has passed. They will crouch without moving even if the falling object is only a leaf. Older birdshave learned that leaves will not harm them, but they freeze when a hawk moves overhead. Learning is the modification of stereotyped behaviour or the acquisition of new behavioural patterns based upon past experiences. Therefore, learnt behaviour is also called Modifiable Behaviour or Acquired behaviour. Two criteria are used to distinguish learning from other modification of stereotyped behaviour.

1. Learning must be permanent and not the result of fatigue or fluctuation in motivation, and
2. Learning must not the simply a permanent change in behaviour resulting from maturation.

It is practically impossible to say that any behaviour is completely learnt in that it depends in no way on inherited mechanism. One might say that nothing is more obviously learned than human language. But the real point about linguistic behaviour is that its mechanism is innate, and is highly modifiable. The ability to talk is innate, but the particular language we talk is not. Simply put, learning is a process that causes changes in behaviour as result of experience. In contrast to innate behaviour patterns that depend on the genetic makeup of the individual, learned behaviour patterns depend on the animal's environment and prior experience. An animal's ability to learn is a function of the complexity of its nervous system.

Kinds of learning behaviour

The various levels of learning found in the animal kingdom have been classified ethologically in several ways which are recognized by animal psychologists.

1. Habituation
2. Imprinting
3. Conditioned Reflexes or Associative learning
4. Trial-and-error learning
5. Latent learning
6. Insight learning
7. Reasoning

1. Habituation

Habituation is actually the simplest kind of learning. It is a form of non-associative learning. Habituation is a process in which an animal learns to inhibit a response and is considered to be the most primitive and widespread from of learning. In other works, it is the general suppression of a stereotyped behaviour pattern as the result of a repeated stimulus that is not followed by an adverse effect. In simple terms, it is a learning to ignore stimuli in the environment and not associated with any reward or punishment. For example, if a garden snail is allowed to crawl across a surface and the surface is trapped sharply, the snail will rapidly withdraw into its shell. After a few moments, it will come out again and continue moving. Tapping the surface again will cause it to stop, withdraw, wait, and then reemerge. This response will continue for while, but gradually the time taken to remerge diminishes, and ultimately the snail will not respond to the tapping at all.

2. Imprinting

Imprinting is actually a specialized form of learning that is seen clearly in many kinds of birds during their early period of life (Hess, 1958.) When the early period overs, the birds are unable to learn. For example, young ducks will normally follow their mother around soon after they hatch. This following behaviour is the result of hatching. Apparently imprinting will occur only for a short time after the bird is hatched. If imprinting is prevented from occurring by hatching the egg in an incubator and not exposing the young bird to an adult bird for some days, it never occurs. Experiments have been performed with ducks and other birds hatched in incubators. In the case of many, the first large moving

object seen by the newly hatched animal (bird) will be the stimulus for imprinting. If the first such object seen is a man, the young birds will follow the man about. In simple form, if the young duckling are hatched artificially and then exoposed early to some moving object other than their true mother, they will behave towards the object as they normally would to their mother duck, following the object wherever it goes. Such a "substitute mother" might be a ball bicycle, an electric train engine, or even a human.

3. Conditioned Reflexes or Associative learning or Learned Reflexes

Do you have an aquarium in your school or home? If you put your hand above the tank, the fish probably will swim to the top of the tank, expecting to be fed. They have learned that a hand shake above them means food. What would happen if you tapped on the glass right before you fed them? Soon the fish probably will swim to the top of the tank if you just tap on the glass. Because they are used to being fed after you tap on the glass, they associate the tap with food.

Actually a conditioned reflex is substituting one stimulus for another in bringing about a type of response. In other words, where nerve impulse travels in a reflex and which involves brain association neurons to decide on what response is to be made to the original stimulus, the response is called a conditioned reflex .Saliva secretion occurs by simple reflex caused by the touch of food inside the mouth affecting the receptors which stimulate the salivary gland effectors, via sensory and motor neurons.

Food touch → receptors → Sensory neuron

↓

Salivary gland secretes saliva ← Effectors ← Motor neurons

The sight and smell of food can cause salivation. Similar a dinner gong sound can produce salivation. Associative learning or learned reflex is of two types: A-classical conditioning and B-Instrumental conditioning.

3. Trial and Error learning

It is also called as "Selective Learning". Trial and error learning results when instrumental conditioning is made more complex by introducing several variables. Various types of mazes i.e. problem apparatus as weel as other multiple choice situations have been developed to measure learning ability in various animals.

Attempts have been made to show that various protozoans, expecially paramaecia, can lern. Even experiments designed to illustrate habitation learning have not been entriley successful. In fact, learning has not yet been successfully demonstrated in the simple multicellular animals or in any of the radially symmetrical animals (Coelenterata, Ctenophora, and Echinodermeta) .

4. Latent learning

Latent learning is acquired even when there is no particular reward or punishment associated with an animal's activity. Many animals appear to be naturally "curious", exploring their surroundings in great detail. When finches are relased into an aviary for example, they will investigate every nook and cranny until they are thoroughly familiar with their new home. When a hive of honeybees is closed up, moved to a new location, and then reopened, many of the emerging bees appear to perform short orientation flights, lasting only a minute or two. They emerge and fly in ever widening circles around the hive, apparently learning to recognize the surroundings sufficiently to find there, way back from a longer flight.

5. Insight learning

The most sophisticated kind of learning is called insight learning, the ability to use knowledge obtained in one context to solve a problem in a different context. The chimpanzee, who pokes a stick into an ant nest, allows the ants to climb on the stick and then licks them off, is using insight learning if it has "reasoned" beforehand that the stick would make a suitable tool for capturing the ants. Insight learning may also be termed as "intelligence."

Insight learning differs from trial-and-error leaning because it involves the sudden production of anew response. In the human species insight learning is most highly developed. However, birds, such as crow also possess this type of learning.

Actually human behaviour contains many learned responses and depends especially on insight learning.

6. Reasoning

With increasing complexity of the nervous system in the higher vertebrates', for instance, mammals and especially the primates, the behavioural pattern many not always be innate or acquired from past experiences but a complex of one more ability of reasoning. Reasoning is of the top of all modes of adaptive behaviour. Reasoning capacity includes the ability to solve complex problems with something more than simple trail-and-error habit or stimulus-response modification. In other words, reasoning is the ability to use past experience and logical deductions to solve some new complex problem.

10.4 INDIVIDUAL BEHAVIOR PATTERNS AND HOMING BEHAVIOR

There are millions of different species of animals, and each species behaves somewhat differently. Nevertheless, there are common patterns of behavior exhibited by many species, and a few behavior patterns that are exhibited by all species. Since all species need to reproduce, eat, and try not to be eaten by someone else, all species exhibit some type of reproductive behavior, foraging (eating) behavior, and defensive behavior. Over time, natural selection has also favored

other behavior patterns that help species, accomplish these basic goals, including communication behavior, territorial behavior, dispersal behavior, and social behavior.

Behavior pattern is a recurrent way of acting by an individual or group toward a given object or in a given situation such as:-

Reproductive Behavior:-

Although some animals are able to reproduce asexually (such as some insects and a few species of lizards), most animals must find a mate in order to reproduce. In many cases, one of the individuals, usually the male, tries to attract a mate by performing a courtship display. This is often a visual display, as is the case with the peacock and many species of coral reef fish. Studies have shown that the females select males partly on the basis of their courtship displays. Scientists believe that vigorous and brightly colored displays might signal to the female that the male is strong and healthy. Thus, mating behaviour plays an important role in determining which genes get passed on to the next generation.

Foraging or eating Behavior:-

Animals exhibit several different types of foraging behaviour. Some animals are quite selective in what they eat. These animals are called foraging specialists. For example, the diet of the lynx consists primarily of snowshoe hares. Some species of insects feed only on a single plant species; they are the ultimate feeding specialists. Other animals are generalists, eating a wide variety of food types. An example of a foraging generalist is the opossum, which eats everything from insects and berries to garbage. It is thought that natural selection has favoured many animals to forage in an efficient manner. This means that the animals make feeding choices that maximize the amount of energy they can obtain in the shortest time possible. This type of foraging, sometimes referred to as "optimal foraging," leaves the animal with more time and energy for other important activities, such as finding a mate or caring for offspring.

Defensive type of Behaviour:-

Virtually all animals are vulnerable to predation (being eaten by another animal) at least some time during their lives. Even wolves and lions can be prey for other animals when they are very young. As a result, animals from worms to whales have evolved ways to reduce the likelihood they are eaten. This behavior often referred to as defensive, or antipredator,

behavior, can take many forms. Some animals, such as many moths and lizards, try to blend in with their surroundings so the predator cannot see them. This is called cryptic behavior. Other species have evolved effective escape behaviors, such as fast-running antelope and fast-swimming fish. Others fight back with stinging or biting behavior. In many cases, prey can deter predators with a threat display. Threat displays are special behaviors that tell the predator that the prey may fight back ferociously. A raccoon that bares its teeth and growls when cornered by a predator is giving such a threat display.

Communication Behaviour:-

As discussed above, effective communication behavior is vital for an animal. Besides communicating with sight and sound, some animals communicate using chemicals. For example, male moths find mates by detecting special chemicals called pheromones that the females release into the air. Ants also use pheromones to determine if another ant is an intruder or a member of the colony.

Territorial Behavior:-

Setting up and maintaining a territory is another common pattern of behavior exhibited by many species of insects, fish, birds, reptiles, and mammals. Territories are used for a variety of purposes, including feeding, mating, and caring for offspring. The territory owner normally tries to keep other individuals of its species out of the territory.

Social Behavior:-

Other patterns of behavior include dispersal behavior, exhibited when individuals move away from the area in which they were born, and many types of social behavior. Social behavior is particularly common in animals that live in groups, such as ants, penguins, and primates. In all cases, scientists believe that these patterns of behavior have evolved over time because they have increased the ability of animals to survive and reproduce.

Homing Behavior:-

Homing is the inherent ability of an animal to navigate towards an original location through unfamiliar areas. This location may be either a home territory, or a breeding spot.

Instinctual patterns of activity related to a specific area including ability of certain animals to return to a given place when displaced from it, often over great distances using navigational clues such as those used in migration. The major navigational clues used by homing animals seem to be the same as those used in migration (Sun angle, star patterns, Earth's magnetic field, etc.), but homing may occur in any compass direction and at any season.

Most of the best-known examples of strong homing ability are among birds, particularly racing, or homing, pigeons. Many other birds, especially sea birds and also swallows, are known to have equal or better homing abilities. Non-avian animals that have homing abilities include some species of reptiles and fishes. When female loggerhead sea turtles (*Caretta caretta*) emerge from their shells, they imprint on the unique magnetic field signature of the beach on which they hatched and can navigate back to it as adults to lay eggs of their own. In addition, experimental studies have shown that several species of salmon can navigate back to their spawning streams by using their olfactory senses to find the unique chemical signature of the waterway, and juvenile sockeye salmon (*Oncorhynchus nerka*), like loggerhead sea turtles, also appear to navigate using magnetic fields, from the ocean back to their spawning streams.

10.5 PARENTAL CARE IN AMPHIBIAN

In amphibians there are many devices for the protection of the eggs during the early stages of development and the young's. In this way nature has practised economy in the number of eggs, which varies in direct proportion to the chances of destruction. Parental care is the care of the eggs or the youngs until they become able to protect themselves from the predators.

(1) Protection by the parents by means of nests, nurseries, or shelters and

(2) Direct caring or nursing by parents.

The different modes of protection are given below in the three important orders of class Amphibia.

1. Protection by means of nests, nurseries and shelters:

A number of different species of frogs and toads construct nests or shelters of leaves or other materials in which the eggs are deposited and the Youngs are developed.

A. In Enclosures in the Water (Mud Nests):

A large tree frog (Hyla faber) known in Brazil as the "Ferreiro". It protects its progeny by building a basin-shaped nest or nursery in shallow water on the border of the pond. The female scoops mud to a depth of 7.5 or 10 cm and with the mud, thus, removed a circular wall is built around the nest, which emerges above the surface of the water.

The inside wall is smoothened by the flattened webbed hands and the bottom is also levelled by belly and hands. The eggs and early larvae are, thus, protected from predators (insects and fishes, etc.) until they are able to defend themselves. Heavy rains later on destroy the wall and larvae go to the water.

B. In Holes near Water (Foam Nests):

A still better mode of protecting the offspring during the early stages of development has been adopted by a Japanese tree frog Rhacophonis schlegelii. The male and female in embrace bury themselves in the damp earth on the edge of ditch or flooded rice field, and make a hole or chamber, a few centimetres above water level. The walls of this chamber are polished and during this process the gallery by which they enter into that chamber gets obliterated and then oviposition begins.

C. In Nests on Trees (Tree Nests):

Some tree frogs like Phyllomedusa in South America, Rhacophorus malabaricus in India, and Chiromantis in tropical Africa glues the eggs to foliage hanging over water, and after hatching, the tadpoles drop straight into the water. Hyla resinfictrix (tree frog) lines a shallow cavity of the tree by bees wax brought from the hives of stingless bees. Eggs are laid there when it is filled with rain water. Tadpoles develop here safely.

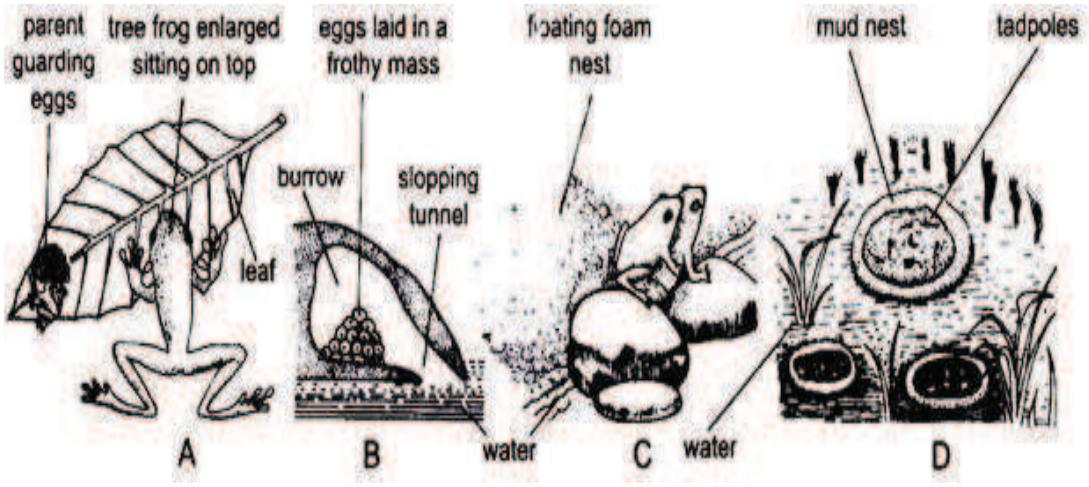

Fig. 10.5 Parental care in Amphibia (A) a tree frog guarding egg glued to a leaf overhanging water (B) Foam nest of rachophorus schlegelii (C) Foam nest floating on water (D) Mud nest of Hyla faber

D. In Transparent Gelatinous Bags:

The eggs of Phtynixalus biroi are large which are enclosed in sausage-shaped transparent common membranous bag secreted by the female and is left in the mountain streams. The whole development takes place within the eggs and little frogs go out in perfect condition. No gills have been observed and the large tail serves as a breathing organ of young ones. Salamandrella key serlingi (urodele) deposits its small eggs in a gelatinous bag which is attached to an aquatic plant below the water level.

E. On Trees or in Moss away from Water:

Several species of tropical American genus Hylodes lay their large eggs in damp places under stones or moss or plant leaves. The metamorphosis is hurried up within the egg. Due to plenty of yolk in the egg the entire development takes place within the egg and young frogs hop out as an air breather with a vestige of tail.

10.6 SUMMARY

In all the multicellular animals except sponges (devoid of nervous system), the nervous system is always involved in their behavior. Complex behaviour requires a complex nervous system. Thus changes in the evolution of the nervous system go side by side with the changes in the kind and complexities of behaviour. All animals have innate and learned behaviors. Learned behavior develops during an animal's life time. Animals with more complex brains exhibit more behaviors that are the result of learning and Imprinting is actually a specialized form of learning that is seen clearly in many kinds of birds during their early period of life, when the early period overs, the birds are unable to learn. Parental care is a behavioural and evolutionary strategy adopted by some animals, making a parental investment into the evolutionary fitness of their offspring. This strategy means that more effort is spent on a relatively small number of offspring to give each of them a high chance of surviving to reproduce; an opposite strategy is to produce a very large number of small offspring, often as eggs, which are left to fend for themselves.

Parental care is seen in many insects, notably the social insects such as ants, bees and wasps; in certain fishes, such as the mouth brooders; widely in birds; and especially widely in mammals, which share two major adaptations for care of the young, namely gestation (development of the embryo inside the mother's body) and production of milk.

10.7 TERMINAL &SELF ASSESSMENT QUESTION

Q.No.1. How is an innate behaviour different from a learned behavior?

Q.No. 2 compares imprinting and conditioning?

Q.No.3 some behavior patterns appear only after a specific developmental stage or time. This stage or time is called:

(a) Imprinting **(b) maturation** . (c) Learning (d) Instinct

Q.No.4 The inherited behavior is called instincts:

(a) Imprinting (b) Learning (c) maturation **(d) Instinct**

Q.No.5 The change of behavior by life experiences is called:

(a) Instinct (b) maturation **(c) Learning** (d) Imprinting

Q.No.6 Explain in detail the parental care in Amphibian?

Q.No.7 Write a short note on Homing behaviour?

Q.No.8 Explain the type of Behaviour?

Q.No.9 Explain in detail the different type of Innate Behaviour?

Q.No.10 Write a short note on Transverse Orientation?

10.8 REFERENCES

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UNIT 11: SOCIAL ORGANIZATION

CONTENTS

11.1 OBJECTIVES

Study of social behavior and social life in termites and the study of Dance language of honey bees. In this topic we will understand the Biological clock and Migration in birds and Fishes.

11.2 INTRODUCTION

Social behavior is defined as interactions among individuals, normally within the same species, that are usually beneficial to one or more of the individuals. It is believed that social behavior evolved because it was beneficial to those who engaged in it, which means that these individuals were more likely to survive and reproduce. Social behavior serves many purposes and is exhibited by an extraordinary wide variety of animals, including invertebrates, fish, birds, and mammals. Thus, social behavior is not only displayed by animals possessing well-developed brains and nervous systems.

11.3 SOCIAL LIFE IN TERMITES

The termite belongs to the order of the roaches called Blattodea. It has been known for decades that termites are closely related to cockroaches, predominately the wood eating species of roach. Until recently, the termites were the order Isoptera, which is now the suborder. This new taxonomical shift is supported by data and research to confirm the new comparison that termites are actually social cockroaches. This suborder of Isoptera has over 2,600 species worldwide and 50 species that call North America their home. The heaviest populated areas are located in the tropic and sub tropic regions. The origin of the name Isoptera is Greek and means two pairs of straight wings. The termite has been called the white ant over the years and commonly confused with the true ant. It wasn't until modern times and the use of microscopes they were able to observe distinguishing features between the two orders. The features were the straight termite antennae, the four equally sized wings, the broad waist of the thorax, and broad abdomen.

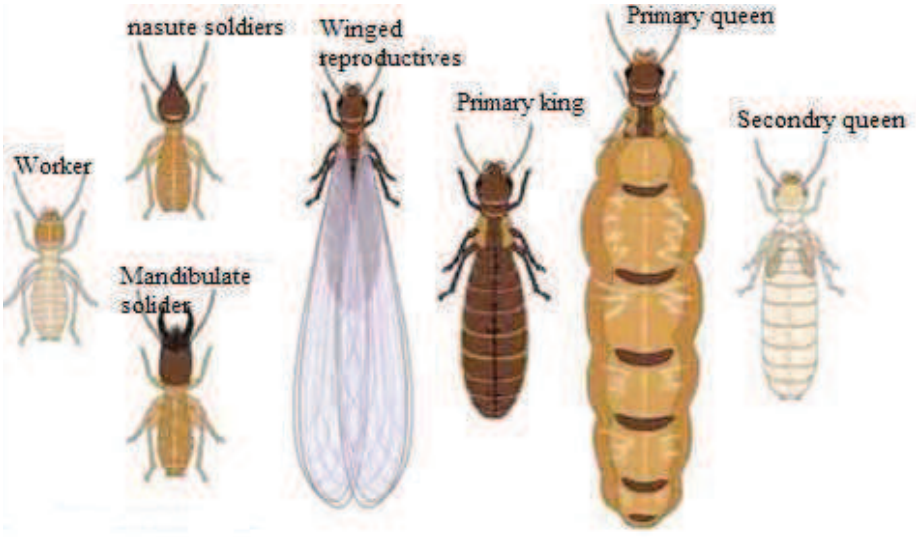

Fig.11.1Termites

Taxonomy of Termites:-

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Infraclass: Neoptera

Order: Blattodea

- Families:
- Mastotermitidae
- Termopsidae
- Hodotermitidae
- Kalotermitidae
- Rhinotermitidae
- Serritermitidae
- Termitidae

- Termites are social insects. This means that they live in colonies. Scientists think that the termite social structure is a big reason they have thrived in almost every part of the world.
- A colony of termites contains three forms of termites. The forms are called castes. Members of each caste look very different from the other castes. Each caste has a different role or job in the colony. The three castes are workers, soldiers, and reproductive.
- Workers are the most common termites. In most colonies, workers are sterile adults. A few types of termites do not have a worker caste. In these colonies, immature termites do the work.
- Workers are the termites that eat the wood. They are the termites that appear when someone breaks open a piece of infested wood.
- If they are eating food that is above ground, subterranean termite workers build mud tubes to cover their trail. The tubes keep the environment humid. The tubes also keep the termites safe from predatory ants.
- Workers have to feed themselves in order to do their jobs. They also have to feed the immature termites and the soldiers. Sometimes the workers also feed the reproductive.
- Workers care for the eggs and the immature termites. They also build and repair the nest. In some colonies, workers also help the solders defend the colony.
- Soldiers have very large heads and enormous jaws. The jaws, called mandibles, are on the front of the head. The mandibles enable the soldiers to fight ants. However, the size of the mandibles makes it impossible for the soldiers to feed themselves.
- When ants attack a termite colony, the soldiers often push their heads into the opening to prevent the ants from entering. The soldiers also rap on the walls of the tunnels with their heads to signal danger.
- In a colony of termites, the soldiers are only a small part of the population. The actual ratio can vary according to the type of termite. The conditions in the colony can also affect the number of soldiers.

- Reproductive's are the termites that produce eggs. The primary reproductive are the original pair of termites that started the colony. They shed their wings and made a small nest where they began producing eggs.
- It usually takes four or five years for a termite colony to develop. By that time, many colonies are so large that the original queen cannot produce enough eggs to replace the termites that die.
- Mature colonies often have secondary reproductive's. These are supplemental queens. They develop within the colony and produce eggs.
- In many colonies, the secondary reproductive travel about with the workers. If groups of termites become isolated from the colony, they can often start new colonies. The secondary reproductive simply begin to produce eggs in the new location.
- An immature termite can develop into any of the three castes. As it develops, the immature termite can even develop backward if the needs of the colony change. A termite that was developing into a soldier can regress and then develop into a worker instead.

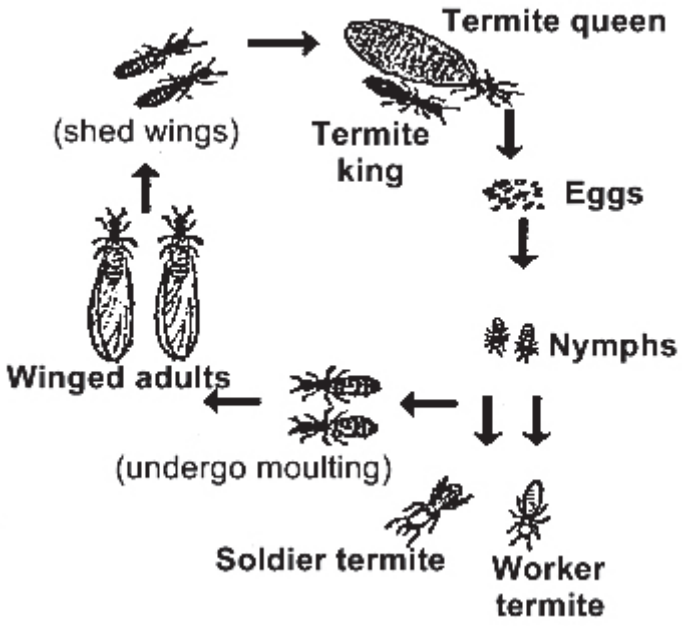

Fig.11.2 Life cycle of Termites

Social Organization of Termites:-

WORKERS:-

Worker is termites are the powerhouse of the termite colony. The worker caste feeds soldiers, tends the queen and eggs from the queen and other reproductive, finds food sources, and builds protective walls around the colony activities.

Worker termites are soft bodied and are blind. They communicate via scent and pheromones. The consume wood and regurgitate it to feed non-workers in the colony.

Formosan termite colonies can have over a million workers and the native subterranean termite colonies can have well over 100,000 workers. The workers will work long “shifts” and then become immobile and rest. After a certain period, they will then start work again. The mechanism which starts and stops the termites is not known. As a colony, it works around the clock.

If a worker termite is exposed to sun or dry air, it can easily dry out and die. This is why a termite colony and all exploratory areas must remain humid and cool. If the colony has agreeable conditions, a termite worker may live for months.

SOLDIERS:-

One caste of termite is the soldier. Typical colonies have reproductive, soldiers, and worker termite castes. Soldiers of most subterranean termites found in North America have the role of protecting the colony. Soldiers of dry wood termites protect the colony as well and block access to the colony by predators or even disagreeable atmosphere. This is also true of powder post termites, related to dry woods. While behaviour of soldiers will depend on the species, soldiers have an important role in any colony.

The solider cannot feed it in that it has large mandibles used for defence or a hardened enlarged head in the case of dry wood termites. In either case, feeding must be done by the worker termites.

If a predator or even a competing insect infiltrates the colony, the soldier will generally be the first line of defence to ensure that the intruder is neutralized. Sometimes, ants will enter a colony and the soldiers will rush in to kill the ant. This is commonly observed when studying termites.

If the worker population is reduced and cannot feed the soldier, the soldier termite will die of starvation. Some types of termites have soldiers which give off a repellent chemical through a gland in the head. This mechanism is used by Formosan termites.

Some species of termites have soldiers which can actually latch onto the investigator's hands. Formosan termites, with their rounded heads and mandibles can do this. This is not painful but is an interesting attribute of Formosan termites.

DIET:-

Some termites in the world are soil consuming termites. Termites in North America, though, are wood or cellulose consuming termites. Those termites which consume cellulose or wood are sometimes called "higher" termites.

The fact that domestic termites consume cellulose-based products such as wood can be a real advantage in the wild. When a tree falls and begins to decay, termites can move into the area and consume the dead wood. This serves a need to break down such trees into soil. The resulting soil is enriched.

Dry wood termites do not have much of a function in nature in that they do not readily break down wood but rather seem to be found mostly in structures.

Subterranean termites are the most common type of termite and they do break down wood by consuming natural wood or by consuming wooden or cellulose-based portions of the structures inhabited by humans. Subterranean termites are native to living in the soil and have a need for moisture. They can bridge their colony to a food source by building termite mud tubes or shelter tubes using mud so that the termites can consume a food source without being exposed to high heat or low humidity, either of which can be fatal.

If there is a moisture source above ground, termites can live in that area without returning to the soil. Sometimes this is called a secondary colony or aerial colony.

REPRODUCTIVES:-

Reproduction in a termite colony is fascinating. Perhaps the most remarkable reproduction occurs in subterranean termite colonies, but dry wood termite reproduction is important as well.

When a termite colony is healthy it will send out reproductive in order to carry on and spread the species. This allows population of the species to expand and also allows for additional colonies if the original colony is decimated due to disease, predators, natural collapse from weather, or control by humans. The reproductive's which leave the colony are winged and leave the colony finding a suitable place to mate and start a new colony. For drywood termites, these can be in the same structure as the original colony. Subterranean termites usually travel further.

Subterranean termites and the relatively few species included will have three types of reproductives. The first is the original queen who can move throughout the colony in the case of native subterranean termites and lay eggs. The second type are the secondary reproductive's, also called neotenics, which are wingless and are fertile and supplement the eggs laid by the queen. The third type is the winged reproductive or alates. These do not reproduce in the colony but fly away to start new colonies. Since most subterranean termites have access to the exterior of structures, they will "swarm" outside where possible. Sometimes these swarm inside, leading to panic by the residents.

Usually native subterranean termites swarm once a year while the Formosan termite can swarm over an extended period in the evening. Eastern subterranean termites usually swarm in the evening.

If a colony is stressed or is declining, reproductive's many also be sent out to carry on the species. The reproductive caste has a vital role in guaranteeing the survival and success of their species.

11.4 DANCE LANGUAGE OF HONEY BEES

Honey bees are sensitive to odors (including pheromones), tastes, and colors, including ultraviolet. They can demonstrate capabilities such as color discrimination through classical and operant conditioning and retain this information for several days at least; they communicate the location and nature of sources of food; they adjust their foraging to the times at which food is available; they may even form cognitive maps of their surroundings.

It has long been known that successfully foraging Western **honey bees** perform a waggle **dance** upon their return to the hive. The laden forager **dances** on the comb in a circular pattern, occasionally crossing the circle in a zigzag or waggle pattern.

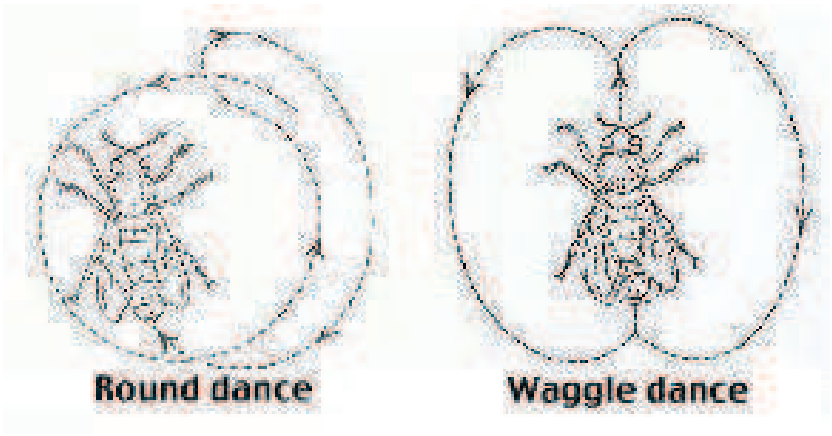

Fig.11.3 Dance of Honeybee

Social behaviour in bees has a number of advantages. One of the most important of these is the ability to quickly mobilize a large number of foragers to gather floral resources that may only be available for a short period of time. The ability to communicate location with such precision is one of the most interesting behaviours of a very interesting insect.

The recruitment of foragers from a hive begins when a scout bee returns to the hive engorged with nectar from a newly found nectar source. She begins by spending 30-45 seconds regurgitating and distributing nectar to bees waiting in the hive. Once her

generosity has garnered an audience, the dancing begins. There are 2 types of bee dances: the round dance and the tail-wagging or waggle dance, with a transitional form known as the sickle dance.

In all cases the quality and quantity of the food source determines the liveliness of the dances. If the nectar source is of excellent quality, nearly all foragers will dance enthusiastically and at length each time they return from foraging. Food sources of lower quality will produce fewer, shorter, and less vigorous dances; recruiting fewer new foragers.

Round Dance:-

The round dance is used for food sources 25-100 meters away from the hive or closer. After distributing some of her new-found nectar to waiting bees the scout will begin running in a small circle, switching direction every so often. After the dance ends food is again distributed at this or some other place on the comb and the dance may be repeated three or (rarely) more times.

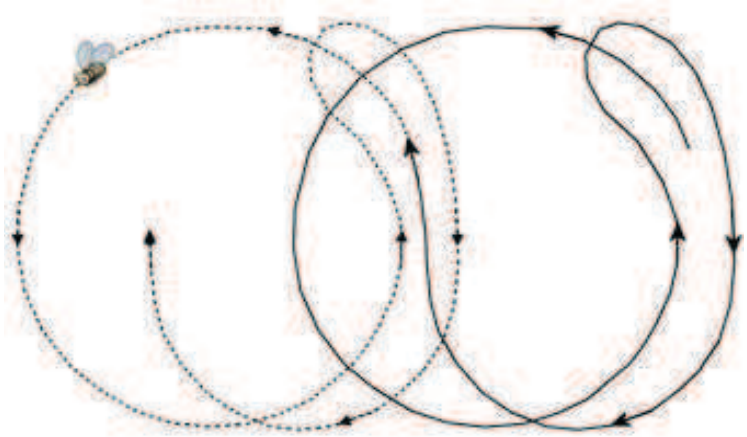

Fig.11.4 Round dance of honey bees

The round dance does not give directional information. Bees elicited into foraging after a round dance fly out of the hive in all directions searching for the food source they know must be there. Odour helps recruited bees find the new flowers in two ways. Bees watching the dance detect fragrance of the flower left on the dancing bee. Additionally, the scout bee leaves odour from its scent gland on the flower that helps guide the recruits.

Waggle Dance:-

As the food source becomes more distant the round dance is replaced by the waggle dance. There is a gradual transition between the round and waggle dance, taking place through either a figure eight or sickle shaped pattern.

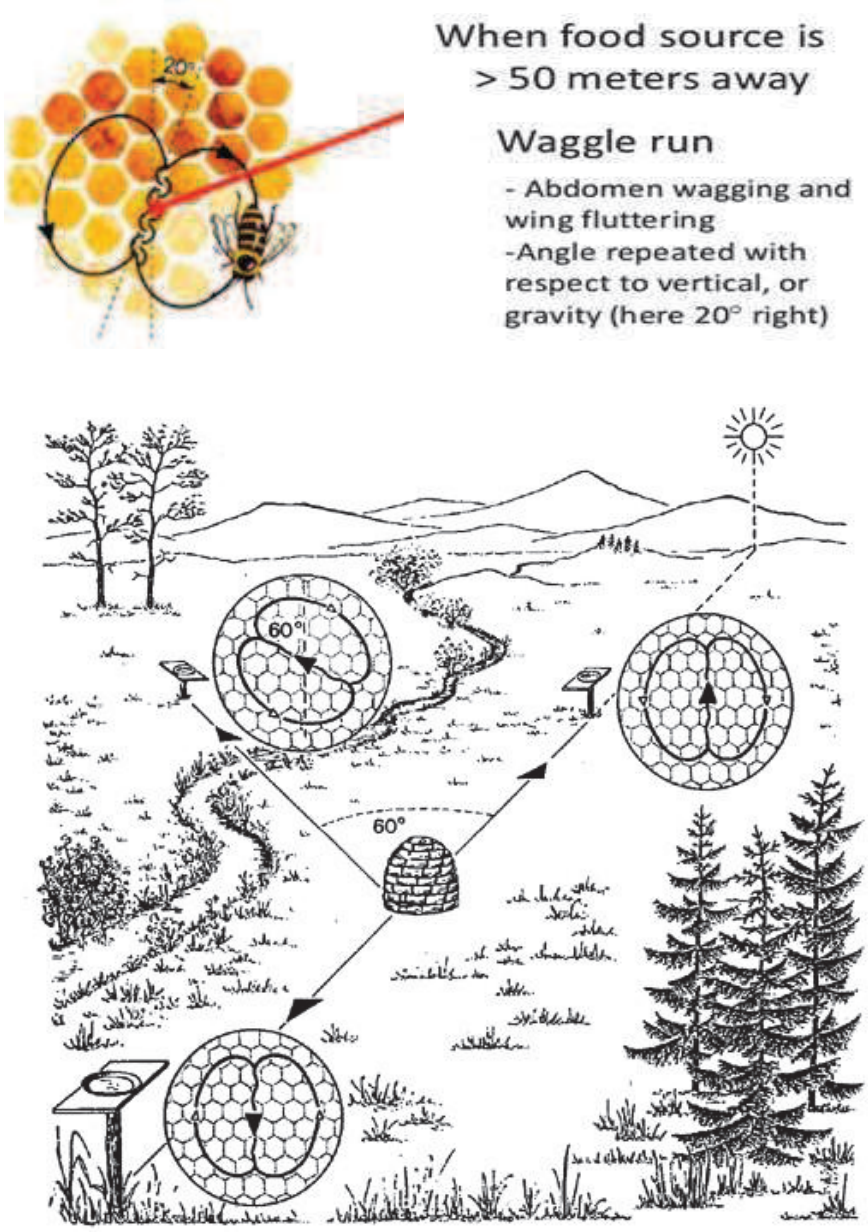

Fig.11.5 Waggle Diagram

The waggle dance includes information about the direction and energy required to fly to the goal. Energy expenditure (or distance) is indicated by the length of time it takes to make one circuit. For example a bee may dance 8-9 circuits in 15 seconds for a food source 200 meters away, 4-5 for a food source 1000 meters away, and 3 circuits in 15 seconds for a food source 2000 meters away.

11.5 BIOLOGICAL CLOCK

An innate mechanism of the body that regulates its rhythmic andperiodic cycles, as that of sleeping and waking. It is also called the Body Clock. An internal system that controls an organism's circadian rhythms, the cycles of behavior that occurs regularly in a day. In mammals, the biological clock is located near the point in the brain where the two optic nerves cross. In many birds, the biological clock is located in the pineal gland. In protests and fungi, the individual cells themselves regulate circadian rhythms.

Many examples of **seasonal** behavior, particularly reproductive behavior, are synchronized to the changing environment by **biological clocks.** Behavioral cycles of shorter duration, for example daily cycles, are also linked to biological clocks.

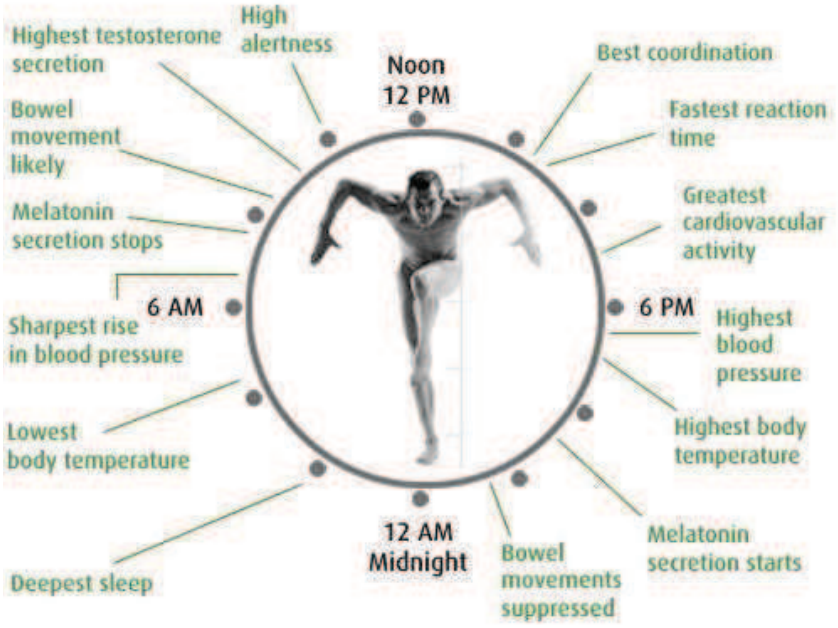

Fig.11.6 Biological clock

Biological clock is the internal physiological system that tracks the environmental rhythms and it is responsible for the biological rhythms. The true biological has the four characteristics i.e.-

1. The clock is endogenous it means it gives the organism an innate ability to maintain periods of a particular length between the biological function.

2. The clock is temperature independent, it means a very unusual situation in biology but an essential characteristic to avoid biological rhythms being governed by the weather.

3. The biological clock has the ability to be reset in order to maintain a relationship with the environmental cause.

4. The biological clocks are an internal continuous monitor of the passage of time allowing the organism to keep track of time biologically.

11.6 MIGRATION IN BIRDS AND FISHES

Migrations in fishes:

The word migration is has been derived from Latin “migrate” meaning to go from one place to other or to travel and is used to represent long journey that are undertaken particularly by animals such as fish & Birds.

Migrations involve the fish moving from one part of a water body to another on a regular basis. Some particular types of migration are anadromous, in which adult fish live in the sea and migrate into fresh water to spawn, and catadromous, in which adult fish live in fresh water and migrate into salt water to spawn.

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and migrate into fresh water to spawn, and catadromous, in which adult fish live in fresh water and migrate into salt water to spawn.

The types of Migratory fishes:

(a) Anadromous Fishes: The anadromous is used for such marine fishes that migrate from sea water to river water for spawning like Sturgeon (Acipenser), Atlantic salmon (Salmo solar).Pacific salmon (Oncorynchus nerka) and Hilsa.

(b) **Catadromous Fishes:** Those types of freshwater fishes that migrate that migrate to sea for the spawning are called catadromous fishes. Like the common European or fresh water eels, Anguilla anguilla and Anguilla vulgaris and some American species Anguilla rostrata.

Migration of Salmon:

The Atlantic Salmon spawn mainly during November and December. They ascend the river as the breeding period's approaches, travelling several thousand kilometres in sea and then are inland. One entering freshwater they stop feeding. The salmon run is the time when salmon, which have migrated from the ocean, swim to the upper reaches of rivers where they spawn on gravel beds. After spawning, all Pacific salmon and most Atlantic salmon die, and the salmon life cycle starts over again. The annual run can be a major event for grizzly bears, bald eagles and sport fishermen. Most salmon species migrate during the fall (September to November).

Salmon spend their early life in rivers, and then swim out to sea where they live their adult lives and gain most of their body mass. When they have matured, they return to the rivers to spawn. Usually they return with uncanny precision to the natal river where they were born, and even to the very spawning ground of their birth. It is thought that, when they are in the ocean, they use magnetoception to locate the general position of their natal river, and once close to the river, that they use their sense of smell to home in on the river entrance and even their natal spawning ground.

After spawning they return their journey to the sea begins but few males survive to breed a second time. However many females are able to reach the sea and start feedings. They soon recover their normal condition and silvery colour. The salmon doesn't usually spawn more than three times in its life span of eight or nine years.

In northwest America, salmon is a keystone species, which means the impact they have on other life is greater than would be expected in relation to their biomass. The death of the salmon has important consequences, since it means significant nutrients in their carcasses, rich in nitrogen, sulphur, carbon and phosphorus, are transferred from the ocean to terrestrial wildlife such as bears and riparian woodlands adjacent to the rivers. This has knock-on effects not only for the next generation of salmon, but to every species living in the riparian zones the salmon reach.[3] The nutrients can also be washed downstream into estuaries where they accumulate and provide much support for estuarine breeding birds.

Migration of Hilsa: The Hilsa of Indian Ocean also migrates to river for spawning .This species has been reported to ascend up the Ganges and going up to Varanasi and Allhabad, during the monsoon month Hilsa also migrate to many large rivers of southern India .However the detail of its migratory behaviour is not known.

Migration of Eel: The migratory behaviour of Eel fishes has been described by *J.Schmidt (1922)*.Eel fishes have two different stages in their whole lifecycle or life history,' Yellow eels' represent the feeding & reproductive phases, while' silvers eel fishes represent the breeding phase. During autumn a number of yellow eels become silvery and prepare to leave spawning grounds. They stop feeding and their colour becomes silvery along the sides. The reproductive organs develop, while the alimentary canal shrinks. The eels migrate down the rivers to reach on the sea. They move about 5 to 6 thousands kilometres in the Atlantic Ocean to reach their breeding grounds in the Western Atlantic, south of Bermuda. it is belived that the eels spawn at the depth of about 500 meters below the surface and the parents die after spawning. The adult larvae that hatch called as leptocephali. They being their homeward journey in the eastern direction.They grow fast during the first few months and when they reach the coast of Western Europe, They are about 8 cm long and 2 year old. Now they undergo metamorphosis during which they stop feeding. Their needle – like teeth

are most the transparent body assumes a cylindrical shape. They are now known as elbers or glass like eels.

Factors affecting the fish Migration: The fish migrations are mostly for spawning and feeding which influence the chemical, Physical & Biological factors. The Physical factors include the bottom materials, water deapth, pressure, Temprature light intensity and photoperiod, currents tides &v turbidity. The chemical factors are the salinity, pH, pollutants, smell and taste of water. The biological factors influencing migration are sexual maturity, blood pressure, food memory, effect of endocrine secretion and related physiological changes in the body system and behaviour.

Fig 11.7Migration cycle in fishes

Many types of fish migrate on a regular basis, on time scales ranging from daily to annually or longer, and over distances ranging from a few metres to thousands of kilometres. Fish usually migrate to feed or to reproduce, but in other cases the reasons are unclear.

Marine forage fish often make large migrations between their spawning, feeding and nursery grounds. Movements are associated with ocean currents and with the availability of

food in different areas at different times of year. The migratory movements may partly be linked to the fact that the fish cannot identify their own offspring and moving in this way prevents cannibalism. Some species have been described by the United Nations Convention on the Law of the Sea as highly migratory species. These are large pelagic fish that move in and out of the exclusive economic zones of different nations, and these are covered differently in the treaty from other fish.

Bird's migration

Birds migration is the regular seasonal movement, often north and south along a flyway, between breeding and wintering grounds. Many species of birds migrate. The Arctic tern holds the long-distance migration record for birds, travelling between Arctic breeding grounds and the Antarctic each year. Migration carries high costs in predation and mortality, including from hunting by humans, and is driven primarily by availability of food. It occurs mainly in the northern hemisphere, where birds are funnelled on to specific routes by natural barriers such as the Mediterranean Sea or the Caribbean Sea.

Migration of species such as storks, turtle doves, and swallows was recorded as many as 3,000 years ago by Ancient Greek authors, including Homer and Aristotle, and in the Book of Job. More recently, Johannes Leche began recording dates of arrivals of spring migrants in Finland in 1749, and modern scientific studies have used techniques including bird ringing and satellite tracking to trace migrants. Threats to migratory birds have grown with habitat destruction especially of stopover and wintering sites, as well as structures such as power lines and wind farms.

Fig. 11.8 Migration in birds

The Arctic tern holds the long-distance migration record for birds, travelling between Arctic breeding grounds and the Antarctic each year. Some species of tubenoses (Procellariiformes) such as albatrosses circle the earth, flying over the southern oceans, while others such as Manx shearwaters migrate 14,000 km (8,700 mi) between their northern breeding grounds and the southern ocean. Shorter migrations are common, including altitudinal migrations on mountains such as the Andes and Himalayas.

The timing of migration seems to be controlled primarily by changes in day length. Migrating birds navigate using celestial cues from the sun and stars, the earth's magnetic field, and mental maps.

Kinds of Migration:

(a) Altitudinal Migration: It is merely a short journey from a mountain to more protected valleys and is practised by many mountain birds, e.g. Willow ptarmigan.

(b) Latitudinal Migration: The most familiar migration are those from north to south and vice-versa.A large number of Eurasian and North American birds cross the

equator to spend the winter in Africa or South America. The golden plover of the arctic tundra passes winter 12,800 kms south in the pampas of Argentina.

(c) Seasonal Migration: Field observers in the temperate countries have grouped migratory birds according to the seasons of the year. some birds like swifts, swallows, nightingales and cuckoos arrive in springs from the south,remain to breed and leave for the sou th in autumn,these are called summer visitors.Other like fieldfare,snowbunting and redwing arrive in autumn chiefly from the north stay throughout the winter,and fly northward again spring.these are called winter visitors.

Range of Migration: The distance travelled by migratory birds depends upon the local condition and the species concerned. The longest distance of about 17600 kms is covered by the arctic tern which migrates from north to the edge of Antarctic. The golden plover is often cited as second; migrate from the arctic tundra's to the pampas of Argentina.The pectoral sandpiper of all migrant in Europe in white stork. Stork spend summer in Europe but the spend the winter in South Africa.

11.9 SELF ASSESSMENT QUESTION

Question No. 1. Explain in detail the social life of Termite?

Question No. 2.What do you understand by the Biological clock?

Question No. 3 Give the difference between waggle and round dance?

Question No.4. Write a short note on the migration in Fishes?

Question No.5.Explain the migration in Birds?

11.10 REFERENCES

- Singh H.R. (Vishal publishing Co) Introduction to Animal Ecology and environmental Biology.
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