Chapter ... 2

ECOSYSTEMS

♦ SYNOPSIS ♦

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INTRODUCTION

The term ecosystem was first coined by A. G. Tansley in 1935. The term is derived from two words namely *eco* and *system*. Eco refers to environment and system refers to an interacting, inter-dependent complex. Tansley defined ecosystem as "*the system resulting from the integration of all the living and non-living factors of the environment*". An ecosystem is a basic functional ecological unit. It consists of living organisms called biotic factors and non-living substances or abiotic factors. Ecosystem is an interacting system where biotic and abiotic factors interact to produce an exchange of materials between the living and non-living factors. Thus, structural and functional system of communities and their environment is called *ecosystem*.

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The central theme of ecosystem concept is that 'at any place where an organism lives, there is continuous interaction between the living and non-living components, i.e. between the plants, animals and their environment'. They continuously produce and exchange materials. This means that, these are mechanisms for continuous absorption of materials by organisms for the purpose of production of organic materials and their conversion back into inorganic form, much of which is then released back into the environment.

2.1 CONCEPT OF AN ECOSYSTEM

An ecosystem is a region with specific and recognizable area such as forest, grassland, desert, wetland or coastal area. The nature of ecosystem is based on its geographical features such as mountains, hills, plains, rivers, lakes or islands. The ecosystem is also controlled by sunlight, the temperature and rainfall in the area. The soil, climate and geographical characteristics are the abiotic or non-living components. These features are useful for plant and animal communities. All the living organisms are called biotic components of the ecosystem.

Basically, there are two types of ecosystems namely terrestrial or land based ecosystems and aquatic ecosystems in water. Thus, these are two major habitats for living organisms on the earth.

In the ecosystem, plants and animals live in communities. They show interactions with their non-living environment. Biosphere is the small portion of earth's land, water and its atmosphere at a global level. At a sub-global level, biosphere is divided into six biogeographical realms. These are (1) Eurasia or palaeartic realm. (2) South and South East Asia (of which India forms a major part) is the oriental realm; (3) North America is the Nearctic realm, (4) South America Forms Neotropical realm, (5) Africa is the epiphiopian realm and (6) Australia is the Australian realm.

At a national or state level, this forms biogeographic regions. The Himalayas, the gangetic plains, the highlands of the Central India, the Western Eastern Ghats, the semi-arid desert in the west, the Deccan plateau, the costal belts and the Andaman and Nicobar islands are the important geographical regions in India. These regions have plants and animals which are adapted to these regions. At local level each area has ecosystems like forests, grasslands, river, mangrove swamps in deltas, sea shores, islands etc. They form habitat for specific plants and animals.

2.1.1 Understanding Ecosystems

There are different ecosystems on land and in water, and man is modifying these ecosystems including agricultural land and urban or urban land use patterns.

If we want to understand, one should be able to describe the specific features of the ecosystem as well as its structure. At the same time one should also know the composition of plant and animal species of ecosystem. The common and uncommon species of plants and animals should be recorded. We must know the functioning of the ecosystem through biogeochemical cycles and energy transfer mechanism. One should observe and document

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the abiotic and biotic components and food chains of the ecosystem. How, all these chains are joined together to form a 'web of life' on which human life depends.

2.1.2 Ecosystem Degradation

Ecosystems are basic of life itself. Each and every ecosystem provides variety of products. Without their presence existence of human civilization was impossible. Man is continuously disrupting natural ecosystems by his encroachment and actions on them. This act is responsible for extinction of many species of plants and animals. Elimination of some species affects the ecosystem. These species are called 'keystone' species. Extinction of a particular species occurs due to changes in land use. Deforestation, use of wetland semi-arid land for agriculture leads extinction of species. Several species became extinct due to pollution from industry and waste from urban areas.

Our natural resources are rapidly depleting due to increasing population. Affluent societies consume resources and energy in a large proportion and produce waste. These resources are extracted from natural ecosystem which affect the important functions of ecosystem. This is nothing but the degradation of ecosystem. We should use our resources sustainably and apply 3Rs formula in our day to day life. Avoid use of plastic which is not degradable.

2.1.3 Resource Utilization

The people living near forest use their environment sustainably. Whatever is required that much resources they collect from their ecosystems. There is inequality seen in resource utilization in different societies. Poor people use resources in very limited proportion. However, in recent times the rich people in affluent societies use resources in a large scale. Same is the situation regarding building of big dams led to wealth in those areas that had canals and others who depend on the constant supply of river itself, found it difficult to survive. Therefore, there is need of equitable distribution of all kinds of natural resources. A more even sharing of these natural resources within the community can reduce these pressures on the natural ecosystems.

Abiotic Factors

Abiotic or non-living factors are essential for the survival of living organisms. They are:

(1) Water (2) Humidity (3) Temperature (4) Light (5) Gases and (6) Soil.

(1) Water

Water is essential for life and without water life is impossible. The water available to plants and animals is due to rainfall. It occupies 71% of the earth surface in the form of fresh water, marine water and estuarine water. The water circulating between atmosphere and earth surface is called hydrologic cycle. The water is in the form of liquid, solid and vapour state. Water of the earth's surface reaches to atmosphere by evaporation and transpiration.

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Water plays an important role in the ecosystem which affects the distribution, growth and activities of organisms in it. The amount of rainfall and evaporation and their ratio determines the types of vegetation growing in an ecosystem. Depending on the availability of water, plants are called hydrophytes, xerophytes or mesophytes. Xerophytes grow in regions of water scarcity. The animals living in these conditions are called **desert animals**. Hydrophytic plants occur in water and the animals that live in water are called **aquatic animals**. According to the habitat, the plants and animals show certain morphological modifications. For example, xerophytes grow in conditions of very dry air, high temperature, strong winds, high transpiration rate and high rate of evaporation. Hence, xerophytic trees show very deep and long roots to absorb water. Plants may be succulents or with spines, reduced leaves and leaves bearing thick cuticle. The desert animals absorb water by skin spines. e.g. Lizard. Certain animals like camel can store large quantity of water in the stomach. The desert animals are nocturnal and burrow deep into the soil, during the day to escape the excessive heat and dryness. Desert animals move faster than other land animals.

(2) Humidity

The amount of water vapour or moisture in the air is called *humidity*. Humidity is of two types, namely, relative humidity and absolute humidity. The relative humidity is the ratio of the actual amount of water vapour in the air to the amount that can be held in the air, at a particular temperature and pressure. *Absolute humidity* is defined as 'the amount of water vapour or moisture present in the air'.

Humidity plays an important role, as it affects the life of plants and animals indirectly. In warm and humid regions, birds and mammals tend to be darker in colour than those inhabiting in the cold and dry regions. As the air warms up, the relative humidity drops because warm air can hold more moisture than cool air. Generally, relative humidity is low during day time and high at night.

Both excessive and deficient moisture can be harmful to organisms. Low relative humidity increases the loss of water in plants through transpiration. Hence, during winter, they shed leaves. Some plants as orchids, lichens, mosses etc. make direct use of atmospheric moisture. In fungi and other microbes, it plays an important role in germination of spores and subsequent stages in life cycle.

Humidity is greatly influenced by the intensity of solar radiation, temperature, altitude, wind, exposure, cover and water status of soil. Relative humidity is measured by an instrument called the psychrometer or by paper strip hygrometer, or thermo-hydrograph.

(3) Temperature

Temperature is a physicochemical, ecological abiotic factor. Temperature can be defined as '*the intensity aspect of heat*'. It is in the form of energy called thermal energy. Temperature is measured in Fahrenheit (F°) or Centigrade (C°). The biosphere obtains its thermal energy mainly from the sun in the form of solar radiation. Temperature affects all forms of life. It influences the various stages of life activities, such as growth, metabolism, reproduction, movement, distribution, behaviour, death etc. Temperature is a variable factor. It varies from place to place and from time to time. During the day, temperature is high and at night, the temperature is low. Temperature is high at sea-level and low at high altitudes. It is high at the

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equator and low in the polar regions. Temperature is more in terrestrial habitat and low in the aquatic habitat.

Within a limited range of temperature, the rate of biochemical reactions doubles with every 10°C rise in temperature. This is known as Van't Hoff's rule. The temperature exerts profound influence on the physiological activities of organisms. Organisms differ in their tolerance limit to extreme temperatures. Most organisms perform their activities in a temperature range of 4 to 45°C.

Temperature affects plants and animals in various ways, which are as follows:

(a) Effects on metabolism: All metabolic activities are influenced by temperature. All chemical reactions, enzyme mediated chemical processes in organisms are controlled by temperature. It affects the rates of transpiration, photosynthesis in plants and respiration rates and other metabolic processes in plants as well as animals.

(b) Temperature also influences reproduction in animals and flowering in plants. In animals the temperature influences maturation of gonads or sex cells and their liberation.

(c) Temperature influences growth and development of all living organisms. Extremely high and very low temperatures both have adverse effects on the growth of organisms. In animals, temperature affects growth as well as development e.g. In blow fly, incubation period decreases with increase in temperature.

Temperature also influences crossing over in *Drosophila*, sex ratio in rotifers and daphnids.

Temperature also affects the colouration in some insects, birds and mammals. The animals living in warm and humid climate bear darker pigments than animals inhabiting cool and dry climate. Temperature also affects morphology of animals. Birds and mammals attain greater body size in cold regions than in warm areas. Cold blooded animals are smaller in cold regions. The tail, snout, ears and legs of mammals are relatively shorter in colder parts than in warmer areas. Desert and arctic fox show difference in the size of ears. Temperature is also responsible for the distribution of animals.

(4) Light

Light is the most important and indispensible abiotic factor without which life can not exist. All plants depend on light for their energy and all animals depend on plants and hence, without light life is impossible. Sunlight is the ultimate source of energy for the biological world. Light is a narrow band of visible radiant energy comprising wavelengths of 390 to 760 nm. If visible light is passed through a prism, it gives a spectrum of seven different colours. Light is a form of radiant energy. Ultra-violet radiation has damaging properties but most of it is absorbed by the ozone, which forms distinct layers in the stratosphere.

Chlorophyll is the dominant light absorbing pigment found in green plants. By the process of photosynthesis, it converts light or photon energy into chemical energy. Variation in the duration of light exposures also affects plant growth. Photo-period influences stem elongation, flowering, fruit growth and other physiological processes of plants and animals. Depending on the length of day required for the induction of flowering, plants are classified as short day plants, long day plants (more than 14 to 16 hours day length) and day neutral plants, which bloom regardless of the photo-period.

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Light is not only responsible for photosynthesis, but it also plays an important role in transpiration and stomatal functioning. Photo-period also affects the structure of vegetative organs, growth, germination, pigmentation, nutrition requirement and even susceptibility to parasites. Light affects chlorophyll production and distribution of plants.

Light also has far reaching effects on animals, by affecting their activities like pigmentation, reproduction, development, growth, locomotion and migration. Light, particularly UV light induces gene mutations. Protective colourations, colour changes are also influenced by light. Cave dwelling animals lack eyes as no light penetrates these regions. Some animals like owls or loris can see even in dim light at night. Light affects the developmental process in many fish and in silk moth. A strong correlation exists between the reproductive cycles of some marine animals and the lunar cycle.

Light affects locomotion in animals and has an effect on the eye size of marine animals. Marine animals living at a depth of 500-3000 metres have much larger eyes than those inhabiting surface waters.

Biological production of light occurs in some bacteria, fungi and animals. Light production in animals is result of a chemiluminescent reactions.

(5) Atmospheric Gases

Up to a height of about 300 km, above the earth's surface, there is present some sort of a thick gaseous mantle. The gaseous mantle consists of different gases in different proportions. Of these gases nitrogen, oxygen and carbon dioxide are major components. Argon, neon, helium, krypton, xenon, hydrogen, methane, ozone are other gases in very minute proportions.

Table 2.1: Relative Proportions of Various Gases in Atmosphere

Gases	% (By volume)	Gases	% (By volume)
1. Nitrogen	78.08	7. Crypton	0.00011
2. Oxygen	20.94	8. Xenon	0.00009
3. Argon	0.9340	9. Hydrogen	0.00006
4. Carbon dioxide	0.0318	10. Methane	0.0002
5. Neon	0.0018	11. Nitrous oxide	0.00005
6. Helium	0.00052	12. Ozone	0.000004

Oxygen

A supply of free O_2 is necessary for most forms of life. Aerobic organisms require it for obtaining energy through oxidative processes. Air contains about 21% oxygen and water usually contains about 4 to 10 ml oxygen per litre. In air, O_2 is abundantly available except at higher altitudes. Therefore, in high altitudes (mountains), the respiratory activity of animals is increased significantly. Mammals react strongly to this change, when partial pressure of O_2 falls below 50% of its value at sea level. Because of their high O_2 requirement, they cannot remain at high altitudes for long time, if the partial pressure of O_2 is 45% below than present at sea level, it acts like a stress factor at high altitudes. Water contains dissolved oxygen,

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which does not combine chemically with water itself. Animals living in water use this O_2 for aquatic respiration and metabolic activities. The aquatic animals develop different adaptations, such as skin, gills, for respiration. Some have special respiratory pigments which help the animals to get O_2 at very low partial pressure.

Carbon Dioxide

Air contains 0.03% of CO_2 which is essential for photosynthetic activity. CO_2 forms carbonic acid when mixed with water and therefore, the amount of CO_2 present in water determines its pH. The pH of water determines the distribution of organisms. Sea water contains 3.5% salt and usually 47 ml CO_2 per litre. The concentration of CO_2 in water may also influence the orientation, movement and respiratory activity of organisms. At higher concentrations of CO_2, the rate of respiratory movement in some molluscs and arthropods increases. An increase in CO_2 content in the blood of animals usually causes decrease in O_2 carrying capacity of haemoglobin. Fishes are sensitive to CO_2 concentration in water. They usually choose streams containing a lower amount of CO_2.

(6) Soil

Soil is also called edaphic factor in which structure, formation and characteristics of different soils are studied. It acts as a suitable substratum for plants and animals. It is a bridge between inorganic and organic materials. The study of soil is called **pedology** or **soil science**.

Soil is a complex physical biological system providing support, water, nutrient and O_2 for the plants. It is made up of mineral matter (40%), organic matter (humus) (10%), soil water (25%), soil air (25%) and biological system. The soil contains top soil, which may be of different colours depending upon the types of humus and mineral materials. The top soil is followed by subsoil, which contains the roots of most plants, humus and minerals.

Soil is formed from the parent rock material (bed rock) by the process of physical, chemical and biological weathering. Physical weathering is caused by various climatic factors, such as light, temperature, water, wind etc. Chemical weathering involves the breaking down of complex compounds by the carbonic acid in water and by acidic substances derived from the decomposition process of organic matter in soil. Hydrolysis, hydration, oxidation and reduction are chemical processes which bring about the changes. These are irreversible changes occuring in rock constituents. Biological weathering involves the decomposition process by which organic materials are broken down and leads to humification and mineralisation. The organisms produce acid substances which help in the weathering of rock fragments. Humus is formed and it mixes with clay, sand and slit to form soil.

Soil Profile

Soil is formed of many horizontal layers arranged one below the other. This is called *soil profile*. The layers are called horizons. Soil is formed by five main horizons. They are O, A, B, C and R horizons.

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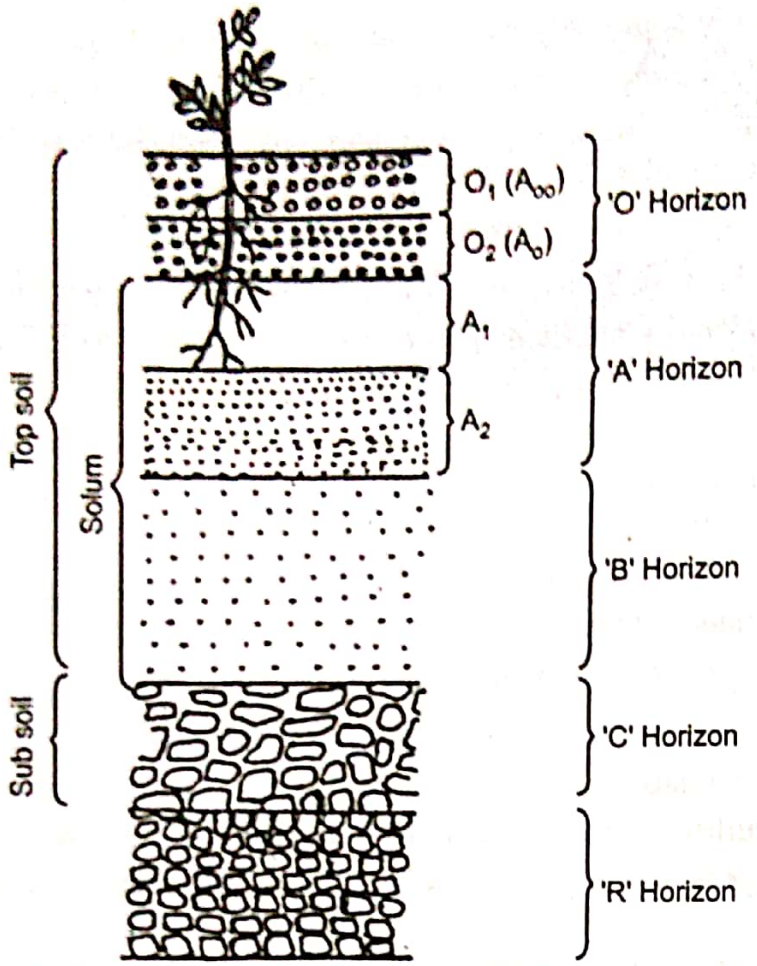

Fig. 2.1: Hypothetical Diagram of the Soil Profile Indicating the Principal Horizons

'O' horizon: It is the top soil, very rich in organic matter content, dark in colour and of light texture marked by intense biological activity. Life is abundant in this horizon. It is again divided into two parts: O_1 and O_2. O_1 horizon is the upper layer formed of fresh fallen dead leaves, twigs, barks, flowers, fruits and animal excreta. O_2 horizon contains humus.

'A' horizon: It is the zone of alluviation or leaching. In this layer, humus mixes with mineral particles. It is divided into A_1, A_2 and A_3.

'B' horizon: This horizon forms the subsoil and contains iron and aluminium compounds with clay and humus. It is again divided into three sub horizons, B_1, B_2, B_3. B_1 is transitional layer between A and B. The B_2 layer shows maximum accumulation of silicate, clay, mineral, iron and organic matter.

'C' horizon: This is mineral horizon containing incompletely weathered large masses of rocks. It consists of $CaCO_3$ and $CaSO_4$. Long roots of big plants reach this horizon.

'R' horizon: This is the parent, unweathered bedrock, upon which there is collected water.

Soil is classified on the basis of mode of formation. Residual and transported soil are of two main types. Transported soil is classified as Colluvial (by gravity), Alluvial (by running waters), Glacial (ice) and Eolian (by wind).

Soil contains various components that show its physical properties such as texture, mineral matter, soil porosity, soil air, soil water, soil organisms etc. Soil contains particles of different sizes that determine the water holding capacity of soil. Aeration and water holding

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capacity determines vegetation that can grow. Soil contains sand, clay and silt in definite proportions. It also contains mineral nutrients important for plant metabolism and growth. Soil also contains micro and macro elements, which play an important role in development, metabolic functions and an enzymatic action.

Plants absorb water containing organic nutrients and minerals from the soil through their roots. The amount of soil water available to plants depend upon the type and properties of the soil. The source of soil water is rain.

Chemical Properties

Soil solutes are partly organic and partly inorganic compounds, usually soluble in water. Sources of these solutes are organic matter, parent rocks and chemical reactions that occur around soil roots. The substances are usually in the form of bicarbonates, nitrates, nitrites, chlorides and sulphates of sodium, potassium, calcium, iron, aluminium and boron. Highly alkaline or saline soils are also devoid of vegetation and are highly unproductive.

Soil Organisms

Soil organisms include microorganisms, such as bacteria, actinomycetes, fungi, algae, and soil animals, such as protozoa, helminth worms, nematodes, annelids, collembola, mites, insects and their larval forms, pupae, archnids, and other arthropoda, gastropods etc. Some mammals and birds use the soil for various purposes. They also play an important role in determining the physical and chemical properties of soil, soil fertility and so on. Earthworms and termites play a significant role in soil formation. Many animals show burrowing or fossorial adaptations which shows certain modifications in their body and organs.

Soil is an important factor for life; hence its conservation is also equally important for survival of animals and plants.

2.2 STRUCTURE AND FUNCTIONS OF AN ECOSYSTEM

Any ecosystem is formed of two components namely abiotic and biotic components.

Abiotic or Non-living Components

These are non-living factors of the environment. Abiotic factors include inorganic substances such as P, S, C, N, H etc. Water, soil, air, light, temperature, minerals, climate, pressure etc. are the important abiotic factors. For the survival of the biotic factors, abiotic factors are essential.

Biotic Components of Environment

Biotic components of environment are plants, animals including human beings and microbes.

Plants: The green plants, certain bacteria and algae can synthesise their own food with the help of chlorophyll in presence of sunlight. They are called *autotrophs* or *producers*.

Animals: Animals cannot produce their food but depend on plants and other organisms to obtain their food. These are called *heterotrophs* or *consumers*. Animals which feed on green plants are called primary consumers or *herbivores* e.g. deer, cow, giraffe. Organisms which consume a herbivore are called *secondary consumers* e.g. lion, frog. The organisms which consume secondary consumers are called *tertiary consumers* e.g. eagle. Organisms which consume both plants and animals are called omnivores e.g. bear.

Microbes: They are also called *decomposers*, because they are responsible for decomposition of dead organic matter. E.g. Fungi and bacteria.

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2.3 PRODUCERS, CONSUMERS AND DECOMPOSERS

The biotic factors include living organisms of the ecosystem.

They are classified into two types:

(i) Autotrophs: Organisms, basically green plants, certain bacteria and algae that can synthesise their own food in the presence of sunlight are called autotrophs or producers. These organisms contains chlorophyll with which they can prepare their own food material. They do not depend on others for food.

(ii) Heterotrophs: All other organisms that do not make their own food but depend on other organisms to obtain their energy for survival are called heterotrophs or consumers.

Among consumers some animals such as insects, cow, rabbit, deer, goat etc. which can eat green plants are called *primary consumers* or *herbivores*. Organisms which eat herbivore, like a frog that eats grasshopper are called *secondary consumers*. Organisms which eat these secondary consumers are called *tertiary consumers*. While the primary consumers are herbivores, the secondary and tertiary consumers are carnivores. Animals like lions and vultures which are not killed or eaten by other animals are *top carnivores*.

Heterotrophs are classified into two types i.e. macro-consumers and micro-consumers or decomposers.

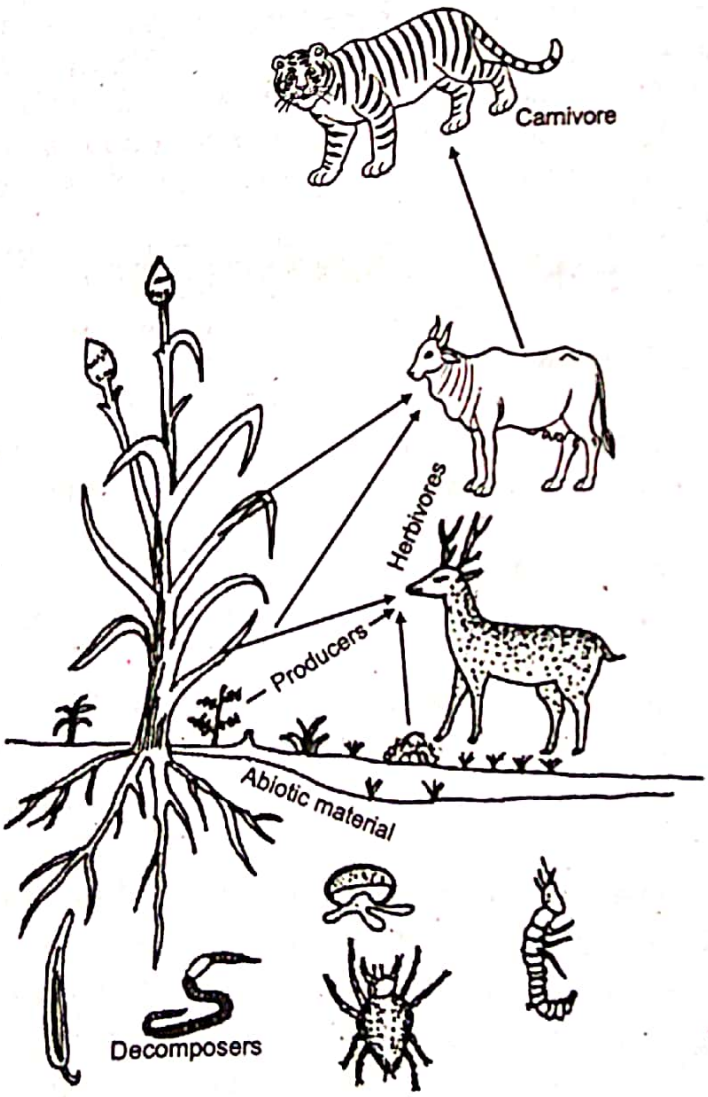

Fig. 2.2: Grassland Ecosystem

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Decomposers

Certain fungi and bacteria which are responsible for the decomposition are called *decomposers* or *reducers*. The role of the decomposers is very special and important. Certain decomposers are also called *scavengers*. They are saprotrophs and they breakdown complex compounds of dead or living protoplasm and release water, CO_2, phosphates and a number of organic compounds which are largely the metabolic by-products and release them in the environment, making them available again to autotrophs.

Consequently, an ecosystem is considered as a basic unit, where complex natural community obtain their food from plants through one, two, three or four steps and accordingly, these steps are known as the first, second, third, and fourth *trophic levels* or food levels such as:

(1) Green plants (producers), Trophic level I

(2) Herbivores (primary consumers), Trophic level II

(3) Carnivores (secondary consumers), Trophic level III

(4) Top carnivores (Tertiary consumers), Trophic level IV.

The amount of living material in different trophic levels or in a component population is known as *standing crop*. This term is applicable to both, plants as well as animals. The standing crop may be expressed in terms of:

(i) Number of organisms per unit area or

(ii) Biomass i.e. organism mass in unit area, which can be measured as living weight, dry weight, ash free dry weight or carbon weights or calories.

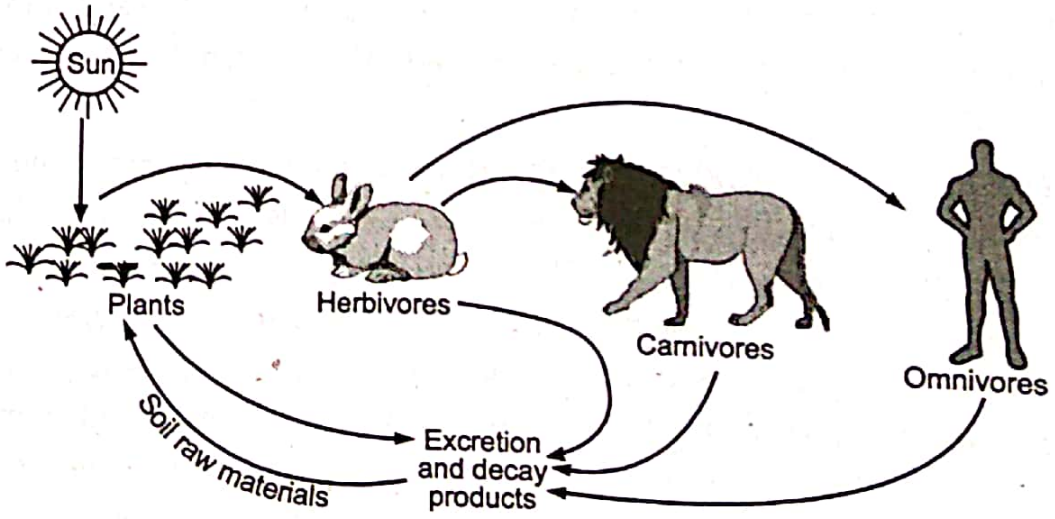

Fig. 2.3: Generated Scheme of Nutritional Relationships among Different Biotic Components of an Ecosystem

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2.4 ENERGY FLOW IN THE ECOSYSTEM

Every ecosystem has several interrelated mechanisms that affect human life. These are the water cycle, the carbon cycle, the oxygen cycle, the nitrogen cycle and the energy cycle. Every ecosystem is controlled by these cycles. In each ecosystem, its abiotic and biotic features are distinct from each other.

All the functions of the ecosystem are related to the growth and regeneration of its plants and animals. These linked processes can be depicted as the various cycles. These processes are depend on solar energy. In the process of photosynthesis, CO_2 is taken up by the plants and O_2 is released. Animals depend on this O_2 for respiration. Water cycle depends on the rainfall, which is essential for the survival of plants and animals. The energy cycle recycles nutrients into the soil on which plant life grows. Our own lives are closely linked to the proper functioning of these cycles of life. If human activities go in altering them, humanity cannot survive on our earth.

The Water Cycle: When it rains, water falls on the ground and it flows into rivers or falls directly on the sea. Some water percolates into the ground and it is stored as a underground water for longer period. Plants absorb underground water along with the nutrients. Plants release water from the leaves by transpiration in the form of water vapour which returned to the atmosphere. Due to sunlight, water from sea surface is converted into vapour. The water vapour is lighter than air which forms clouds. When clouds rise higher the vapour condenses and changes into droplets, which fall on the land as rain. This is an endless cycle on which life depends. Human activities are making drastic changes in the atmosphere through pollution which is changing rainfall patterns. This sometimes results in droughts and floods. El Nino storms have devested many places in the last few years. Africa suffered from drought and U.S suffered from floods.

Carbon Cycle: Carbon is found in both abiotic and biotic components of the ecosystem. Carbon acts as a building block of both plants and animal tissues. In the atmosphere, carbon occurs in the form of carbon dioxide (CO_2). During the process of photosynthesis plant leaves absorb CO_2 in sunlight and it combines with water and form carbohydrates. Plants use photosynthesis for their growth and development. In this process, O_2 is released in the atmosphere for respiration of animals. Thus, plants help in regulating and monitoring the percentage of O_2 and CO_2 in the earth's atmosphere. All mankind depends on the O_2 produced by this cycle. It also keeps CO_2 at acceptable levels. Herbivore animals feed on plants and get energy for their growth. CO_2 is released in the atmosphere by both plants and animals during respiration. They also return fixed carbon to the soil in the waste they excrete. When plants and animals die they return their carbon to the soil. All these processes complete the carbon cycle.

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The Oxygen Cycle: Plants and animals take O_2 from air during respiration. Plants release O_2 to the atmosphere during photosynthesis. Thus, O_2 and carbon cycles are linked. Because of deforestation O_2 level in the atmosphere is gradually reducing. Thus, plants play vital role in our lives which we generally neglect. Therefore, afforestation programmes are very important and everybody should participate in it.

Nitrogen Cycle: Nitrogen forms many essential molecules, like amino acids, the building blocks of proteins and genetic material like DNA and RNA. In the air nitrogen is present 79% but plants and animals can not use nitrogen in this form. For usable form it must be converted into ammonia (NH_3) or nitrate (NO_3). The conversion of atmospheric nitrogen into nitrate and ammonia is called nitrogen fixation and this is done by nitrogen fixing bacteria present in soil and water. Herbivorous animals feed on plants and carnivorous animals feed on herbivorous animals. Thus, animals get nitrogen by feeding on plants. When animals defecate, this waste material is broken down by worms and insects mostly beetles and ants. The soil bacteria and fungi further broken down into nutrients that plants can absorb and use for their growth. The nutrients are recycled back from animals to plants. Similarly dead bodies of animals are also broken down into nutrients that are used by the plants for their growth. Thus, the nitrogen cycle on which life is dependent is completed.

The nitrogen fixing bacteria fix atmospheric nitrogen into nitrates which is important element to plants. The nitrates are a part of the plant's metabolism, which help in forming new plant proteins. This is again used by animals that feed on the plants. The nitrogen is transferred to carnivorous animals when they feed on herbivores. Thus, our own lives are closely interlinked to soil animals, fungi and bacteria. Thus, microorganisms play an important role in ecosystem.

The Energy Cycle: The energy cycle is based on the flow of the energy through the ecosystem. In the process of photosynthesis, plants convert solar energy into chemical energy i.e. carbohydrates and this material is used for growth of leaves, flowers, fruits, branches, trunks and roots of the plants. The plants grow themselves by converting solar energy into their tissues. They produce their own food hence plants are called producers. These plants are eaten by the herbivorous animals as a food and they get energy from plants. Major part of this energy is used for day to day functions of these animals like respiration, digestion of food, growth of tissues, maintaining blood flow and body temperature. Animals also require energy for searching food, finding shelter, breeding and bringing up young ones. Carnivorous animals feed on the herbivorous, animals and they get energy from them. Thus, different plant and animal species are linked to one another through food chains. Each food chain has three or four links. Each plant or animal can be linked to several other plants or animals through many different linkages and these inter-linked chains can be depicted as a complex *food web*. This is thus called the 'web of life', which shows that there are thousands of interrelationships in nature.

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2.5 ECOLOGICAL SUCCESSION

The biotic communities are not stable. They are changing into different communities or forms in a longer time span. The changes which occur in community composition and structure are larger. Thus in a particular geographical area one community may be replaced by another community or by a series of communities. This can be explained with the example of pond or lake community which fills with silt and changes gradually from a deep to a shallow pond or lake then transformed into a marshyland community if it is filled with sand and mud. In the course of time, the marshy land may be converted into grassland or a dry land forest community. If forest is completely burned over, it remains as a plot of bare ground, on which after some period series of plant communities grow up and replace one another first annual weeds, then perennial weeds and grasses, then shrubs and trees and formation of forest community. Thus, 'the process of formation of new communities' is called ecological succession. It is defined as 'an orderly and progressive replacement of one community by another till the development of a stable community in that area'. The stable community is called climax community. Thus, succession is the birth of ecosystem and subsequent aging process of its biotic and abiotic factors.

Characteristics of Ecological Succession

(1) It is an orderly process of community development that involves changes in the species structure and community processes within time.

(2) It is directional and predictable.

(3) Succession results due to the modifications of physical environment by the community.

(4) It is transformed into a stabilized ecosystem with maximum biomass and symbiotic functions between organisms.

(5) Due to increase in biomass new habitat niches are created.

(6) There is continuous change in plants and animals in succession.

(7) The diversity of species tends to increase with succession.

Types of Succession

In the succession, formation of stable or climax community takes place by several communities which replace one another in an orderly sequence. The various development stages of a community are called *sere*, and each stage where change take place is called *seral stage*, which represents community although temporary with its own characteristics and may of short or long life. The final stable community is called climax community.

The ecological succession may be of the following two types in any of the two basic environments such as terrestrial and aquatic environments.

(1) Primary Succession: If the development of the community begins on a sterile area which has been not occupied by any community previously. Then the succession is called *primary succession*. For example, on newly exposed island the first organisms which start the

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ecological succession are called pioneer community. The process starts with base rock or sand dune or river delta or glacial debris and it ends when climax is reached. This is also example of primary succession. Suppose landslide exposes a surface of rock in the mountains, on which first of all lichens, the pioneer community will develop. Then in course of time spreading moss mat appears and moss is followed by grasses, herbs, shrubs and finally by larger trees. The trees become dominant community and forest community is formed.

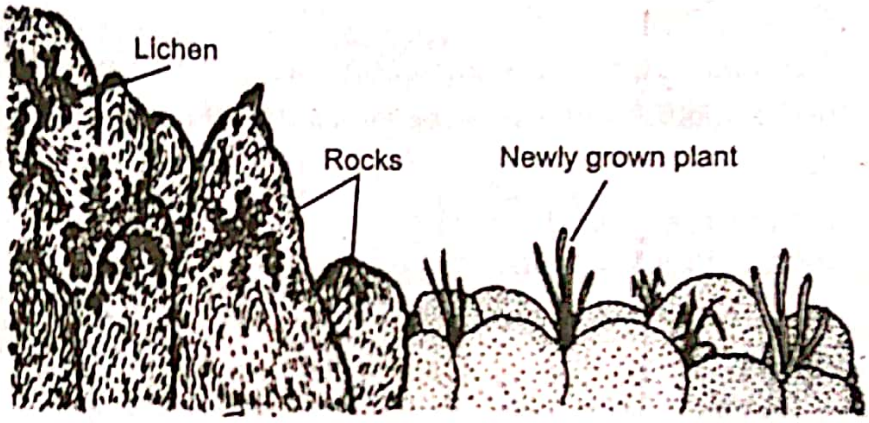

Fig. 2.4: Primary Succession on an Island

(2) Secondary Succession: When community development starts on the areas or sites previously occupied by well developed communities called secondary succession. In this situation, organic matter and some organisms from the original community will remain. For example, areas burned by fire or cut by farmers for cultivation, cut over forests, abondoned crop lands and ploughed fields are the examples of secondary succession.

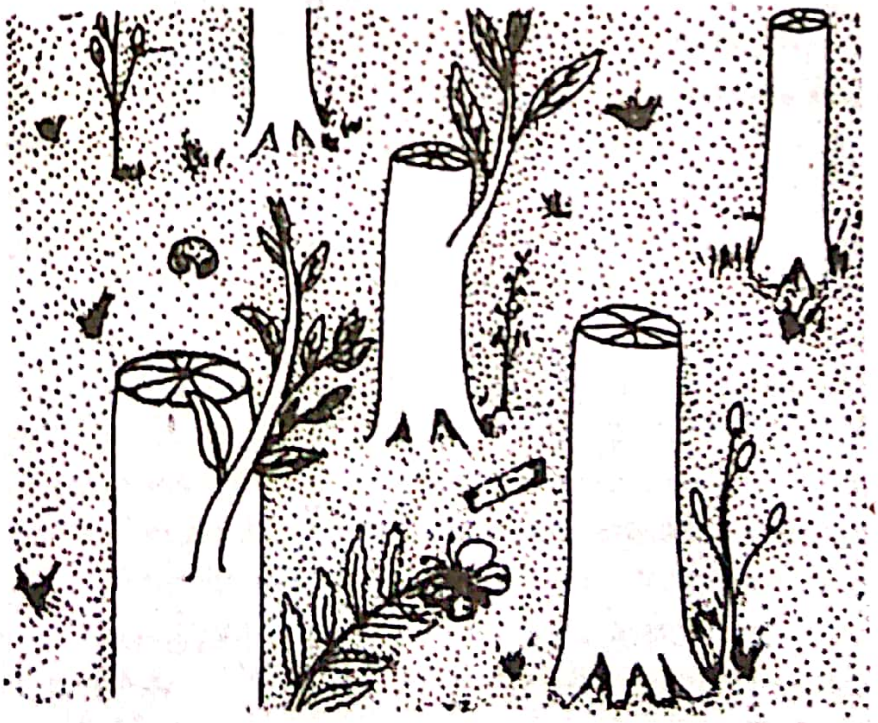

Fig. 2.5: Secondary Succession in a Forest

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Depending on the moisture contents, the succession may be of the following types:

(a) **Hydrach or Hydrosere:** The succession when starts in aquatic environment like ponds, lakes, streams, swamps etc. is called hydrach or hydrosere.

(b) **Mesarch or Mesosere:** The succession which begins in an area where adequate moisture is present is called mesarch.

(c) **Xerach or Xerosere:** The succession when starts in dry habitat like deserts, rock etc. in which moisture is very scanty, it is called xerach.

On the basis of community metabolism succession is of two types, namely *autotrophic succession* (dominance of plants) and *heterotrophic succession* (bacteria, fungi and animals).

Process of Succession

Following sequential steps involve in the process of succession:

(1) **Nudation:** The process starts with formation of a bare area or nudation by several causes, such as flooding, erosion, volcanic eruption, fire etc. There are many new lifeless areas created by man e.g. stone quarrying, walls, burning, digging, flooding large land areas under dams etc.

(2) **Invasion:** It involves the arrival and settlement of various organisms on bare area. The plants are the first invaders hence called pioneers in this area. The seeds, spores reach on base area through air, water or animals. This is called *dispersal* or migration. When new migrated species establish on the new area by germination and start reproducing. This is called ecesis. Very few species can establish in new and hard environment and remaining disappear. The successful immigrants establish, propagate and increase their number forming a large population in the area called aggregation. This is the final stage of invasion.

(3) **Competition and reaction:** In the limited area, the number of species or individuals increase due to reproduction, multiplication which ultimately results into competition for food and space. This competition is of two types namely intraspecific competition in which competition is in between the individuals of same species and interspecific competition i.e. competition between the individuals of other species. The individuals interact with each other as well as with environment. Due to interactions the individuals modify the environment and it becomes unsuitable for the existing community. In the course of time they are replaced by another community members who find this environment more suitable. These new inveders compete with previous occupants and ultimately they are eliminated or brought to subdominant level. The small plants enrich the environment for larger plants or trees by organic matter, moisture and nutrients. The animal community also develops in the area because of availability of food. Again interactions among individuals further modify the environment and allow to invade another species of plants and animals which move the process of succession.

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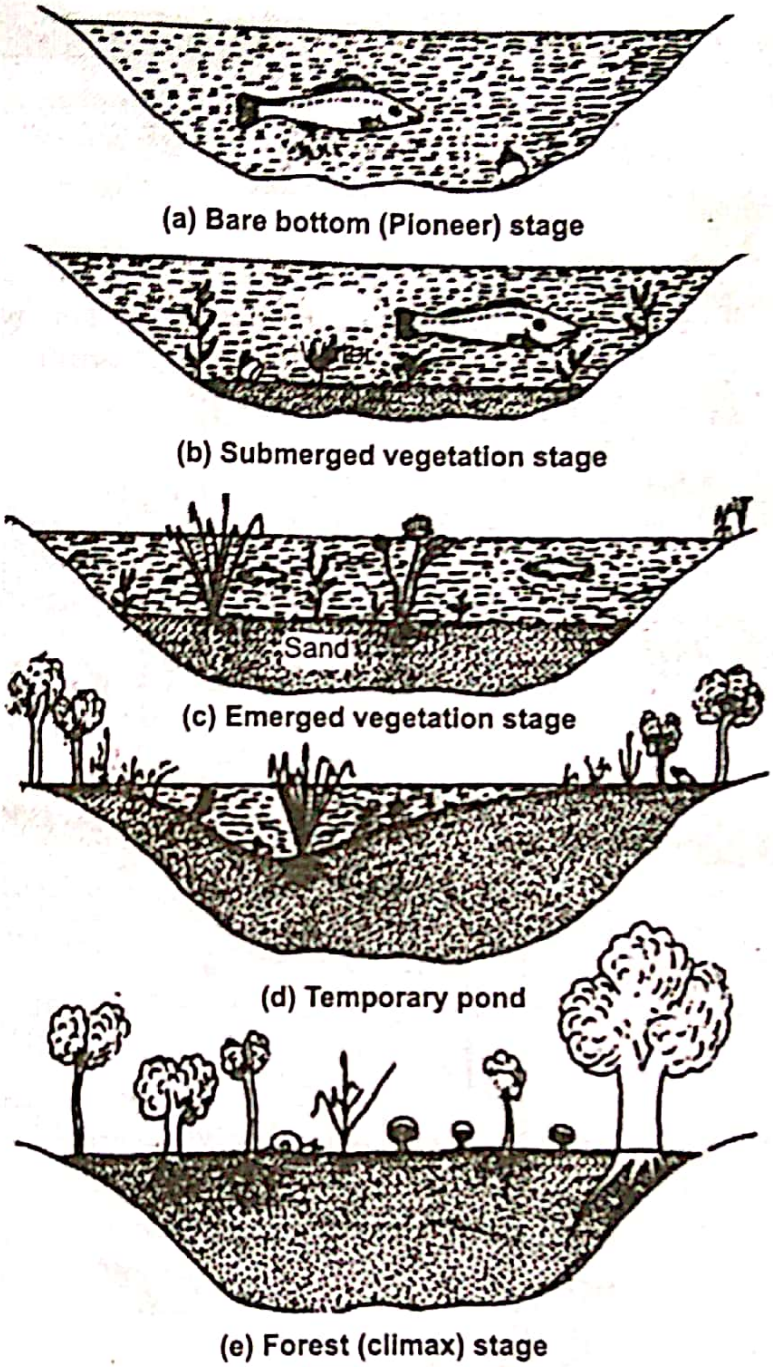

Fig. 2.6: Ecological Succession : A Pond Community is replaced by a Forest Community through Ecological Succession

(4) **Stabilization or climax:** The final terminal community becomes permanently stable in the area which is mature and self maintaining and self reproducing. This community is tolerent to the environmental conditions and it shows equilibrium as well as species diversity. This dominant and stable community is called climax community.

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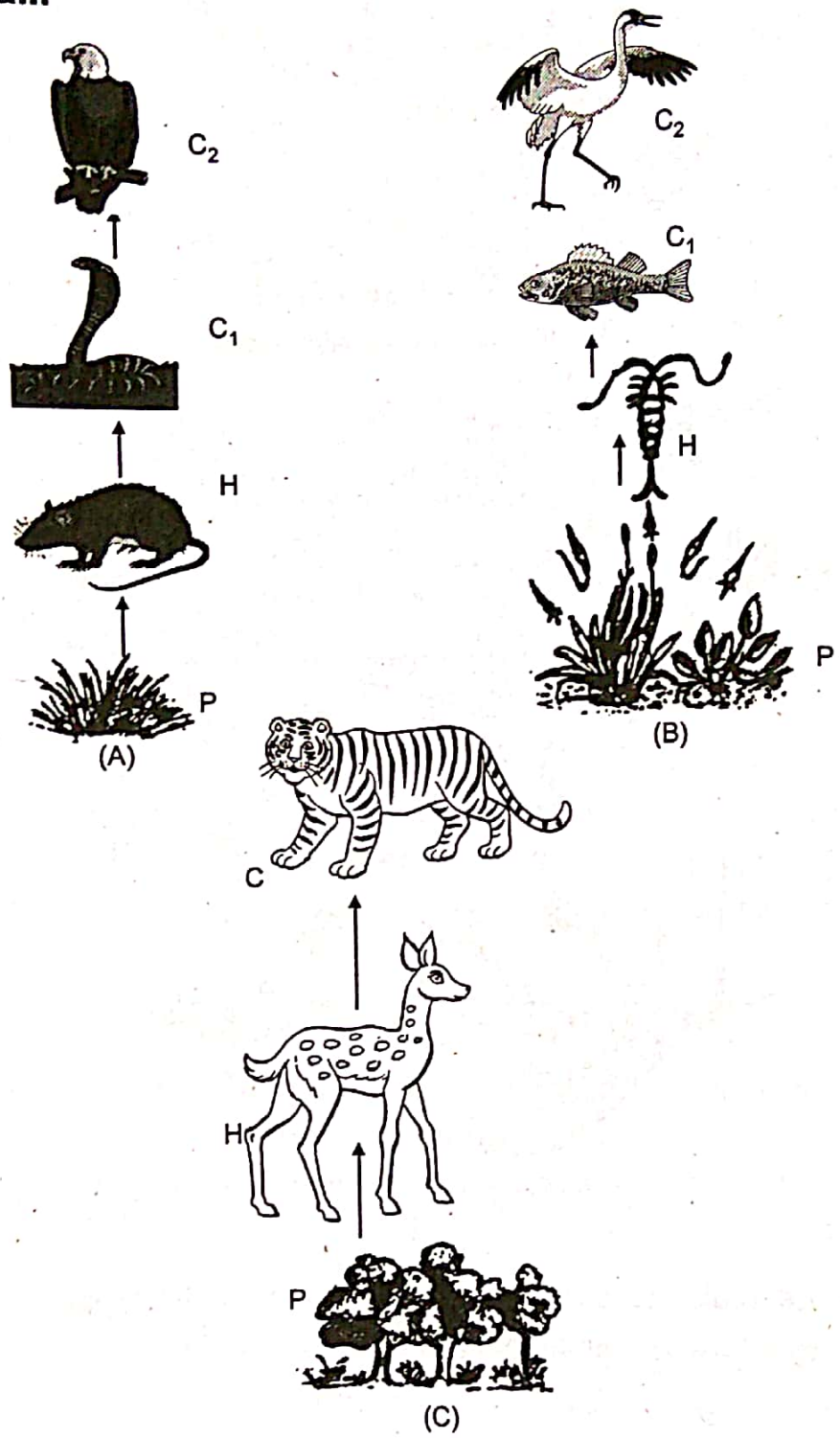
2.6 FOOD CHAIN, FOOD WEBS AND ECOLOGICAL PYRAMIDS

2.6.1 Food Chain



(A) – food chain in a grassland; (B) – food chain in a pond; (C) – food chain in a forest. The base of the food chain is always formed by autotrophs (producers). The links are usually 3 to 5 and the arrangement is mainly, producer → herbivore → carnivore (P = producer, H = herbivore, C_1 = carnivore order - 1, C_2 = carnivore order - 2)

Fig. 2.7: Food Chain in Nature

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In an ecosystem, various living organisms such as plants and animals are arranged in a definite sequence according to their food habits. Plants are producers which are eaten by herbivores. The herbivores in turn are consumed by carnivores. This transfer of food energy from producers (plants) through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten is known as the food chain.

Plants convert solar energy into chemical energy i.e. carbohydrates by the process of photosynthesis. The producers always remain in any ecosystem at the first trophic level or producer level. The food energy stored in the body of plants is utilised by herbivores or plant eaters which form the second trophic level called *primary consumers*. In an ecosystem, the herbivores are eaten by carnivores which constitute the third trophic level or *secondary consumers* level. These carnivores in turn may be eaten by other carnivores at the tertiary consumers level i.e. by *tertiary consumers*. In an ecosystem, there are a number of organisms which eat both plants as well as animals at the lower level in a food chain. Such animals are called as omnivores. Such organisms occupy more than one trophic level in the food chain.

For example, plants are eaten by insects, which are eaten by frogs, which in turn are eaten by fish, which are ultimately eaten by human beings. In this food chain, there are five trophic or feeding levels. Several factors are important in determining an animal's position in a food chain. Each species occupies a specific place and participates in the flow of energy in the ecosystem, from sunlight through photosynthesis into autotrophic producers, to the tissues of herbivores, the primary consumers, to the tissue of carnivores, the secondary consumers. The energy flow determines the number and biomass of organisms at each level in the ecosystem. Flow of energy is greatly reduced at each successive level of nutrition, because of the energy utilisation by the organisms and heat loss at each step in the transformation of energy. This largely accounts for the decrease in biomass at each successive level. Moreover, no predator is completely efficient at capturing its prey; some energy is lost in the hunt.

An animal may be a primary consumer in one chain (animals eating plants) but a secondary or tertiary consumer in other chains (animals eating herbivorous animals or other carnivores).

Food chain in grassland ecosystem starts with

Grasses → Grasshopper → Frogs → Snakes → Hawk.

In a pond ecosystem, the food chain starts with

Phytoplanktons → Water fleas → Smaller fish → Bigger fish → Birds or Man.

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

(1) Grazing Food Chain

The consumers which start the food chain, utilising plants or plant parts as their food, constitute the grazing food chain. The food chain begins from green plants at the base and the primary consumer is herbivore.

For example: Grass → Grasshopper → Birds → Hawk.

(2) Parasitic Food Chain

It also begins from green plant base, and then moves to herbivores which for example may be the host of a huge number of lice which live as ectoparasites. The parasitic food chain begins with a green plant which may support a large number of herbivores. These herbivorous animals support a large number of hyperparasites.

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(3) Detritus Food Chain

This type of food chain goes from dead organic matter into micro-organisms and then to organisms feeding on detritus (detrivores) and their predators. Such ecosystems are thus less dependent on direct solar energy. These mainly depend on the influx of the organic matter produced in another system. For example, such type of food chain operates in the decomposing accumulated litter in a temperate forest. A good example of this food chain is based on mangrove leaves.

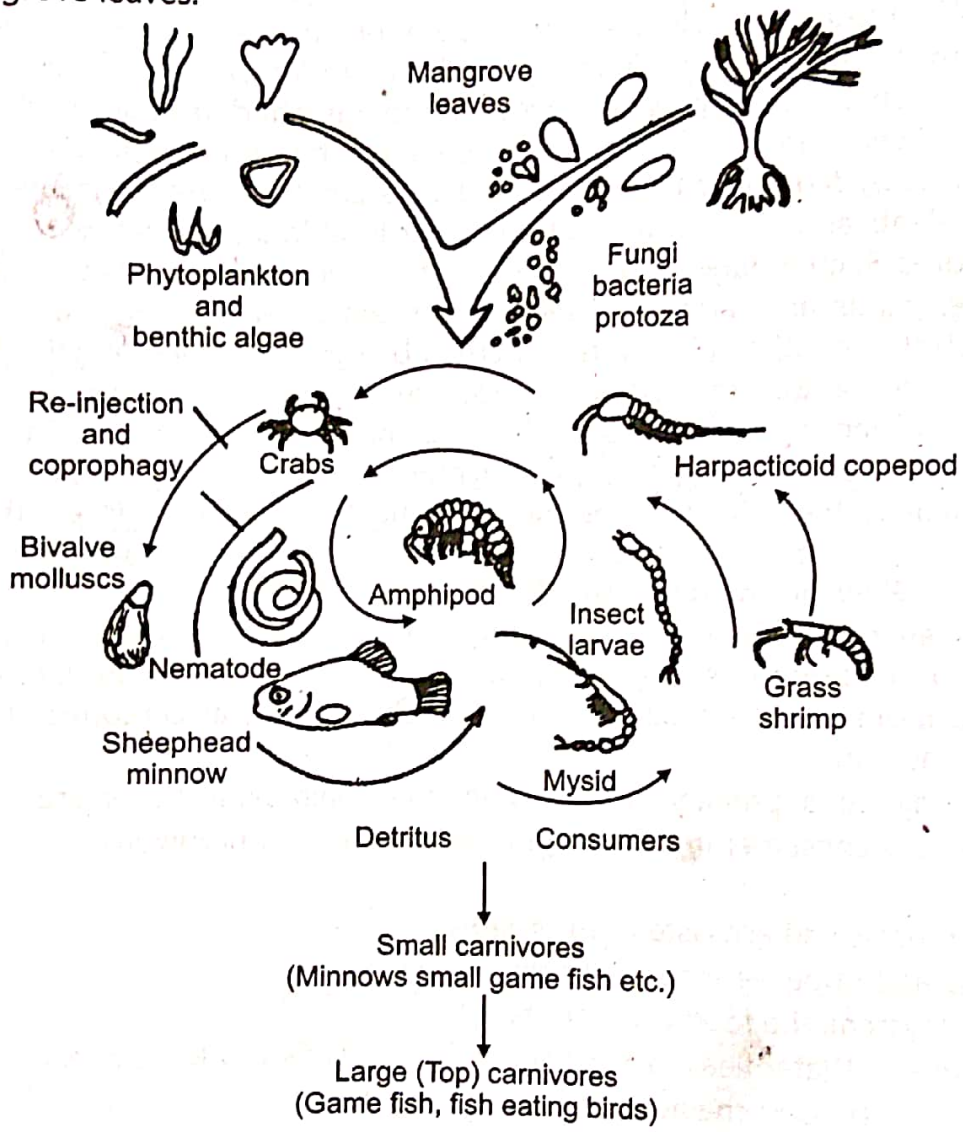

Fig. 2.8: Detritus Food Chain based on Mangrove Leaves Falling into Shallow Estuary Waters. Leaf fragments acted on by the saprotrophs and colonised by algae are eaten and re-eaten (coprophagy) by a key group of small detritivores which in turn, provide the main food for game fish, herons, storks and ibis

Leaves fallen in shallow water → Saprotrophs (fungi, bacteria, protozoa etc.) eaten and re-eaten by small organisms like crabs, copepods, insect larvae, grass shrimp, mysid, nematodes, bivalve molluscs → Small carnivores (fish) → Top carnivores (birds).

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2.6.2 Food Web

Food chains in natural conditions never operate as isolated sequences, but in an ecosystem the various food chains are interconnected with each other forming some sort of interlocking pattern called **food web**. Simple food chains are very rare in nature, this is because each organism may obtain food from more than one trophic level. In other words, one organism forms food for more than one organism of the higher trophic level. For example, in a grazing food chain of grassland, in the absence of rabbit, grass may also be eaten by mouse. The mouse in turn may be eaten directly by hawk or snake first which is then eaten by a hawk.

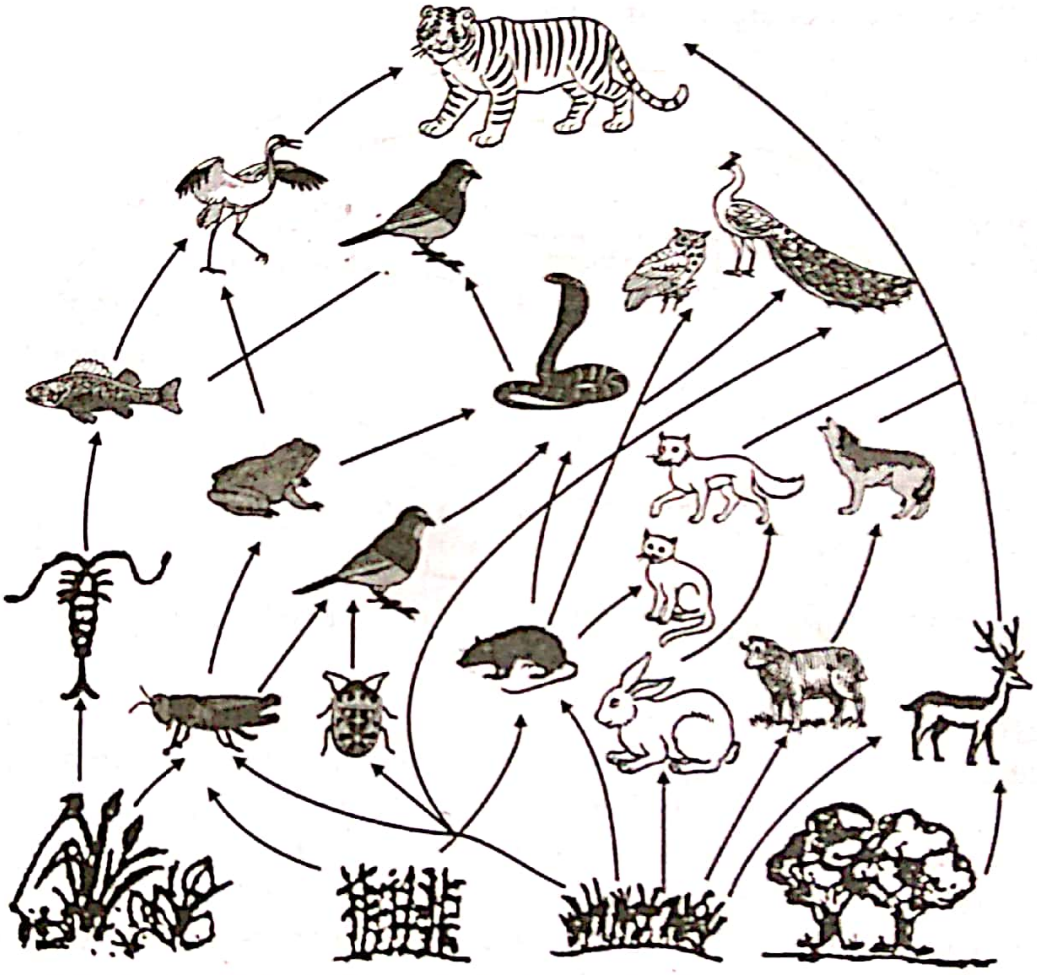

Fig. 2.9: A Food Web shows the Main Food Links and Interconnection of Many Food Chains

An organism may form a food source for many other organisms thus forming a web.

The grass is eaten by grasshopper, rabbit and mouse. Grasshopper is eaten by lizard which is eaten by hawk. Rabbit is eaten by a hawk. Mouse is eaten by a snake which is eaten by hawk. In addition, hawk also directly eats grasshopper and mouse. Thus, there are five linear food chains which are interconnected to form a food web.

(1) Grass → Grasshopper → Hawk
(2) Grass → Grasshopper → Lizard → Hawk
(3) Grass → Rabbit → Hawk
(4) Grass → Mouse → Hawk
(5) Grass → Mouse → Snake → Hawk

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Food webs are very important in maintaining the stability of an ecosystem. For example, decrease in population of rabbit would naturally cause an increase in the population of alternative herbivore, the mouse. This may decrease the population of the consumer (carnivore) that prefers to eat rabbit. The alternatives or substitutes serve for maintenance of stability of the ecosystem. When one type of herbivore becomes extinct, the other types of herbivores increase in number and control vegetation. Similarly, when one type of herbivorous animals becomes extinct, the carnivore predating on this type may eat another type of herbivore. Thus, each species of any ecosystem is indeed kept under some sort of a natural check, so that the system may remain balanced. The complexity of any food web depends upon the diversity of organisms in the system.

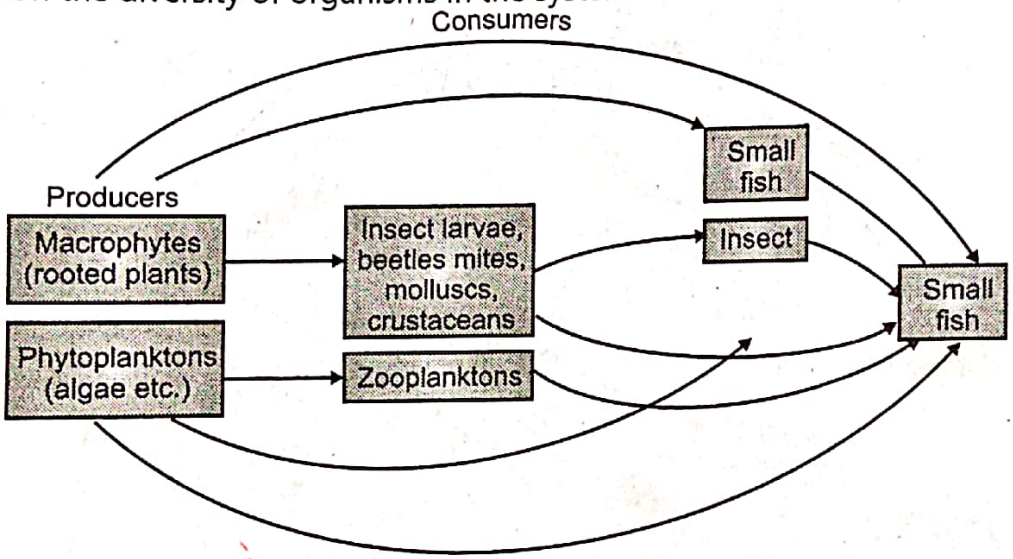

Fig. 2.10: Diagrammatic Sketch Showing the Food Web in a Pond

2.6.3 Ecological Pyramids

The number, biomass and energy of organisms gradually decrease from the producer level to the consumer level. These few steps of tropic level can be expressed in a diagrammatic way and are referred to as **ecological pyramids**. Ecological pyramid is the graphic representation of the number, biomass, and energy of the successive trophic levels of an ecosystem. Charles Elton in 1927, first used and described the term ecological pyramid. In the ecological pyramid, the producers form the base and the final consumer occupies the apex. The ecological pyramids are of three types:

(1) Pyramid of numbers, (2) Pyramid of biomass and (3) Pyramid of energy.

(1) Pyramid of Numbers

They show the relationship between producers, herbivores and carnivores at successive trophic levels in terms of their number. The number of individuals at the trophic level decreases from the producer level to the consumer level. The number of producers in an ecosystem is very high. The number of herbivores is lesser than the producers.

Similarly, the number of carnivores is lesser than the herbivores. For example, in crop lands the producers or crops are more in number and the grasshoppers feeding on crop plants are lesser in number. The frogs feeding on grasshoppers are still lesser in number. The

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snakes feeding on frogs are still fewer in number. In a pond ecosystem, the number decreases in the following order:

Phytoplankton > Zooplankton > Fishes > Snakes

Thus, the pyramid is upright. In a forest ecosystem, however, the pyramid of numbers is somewhat different in shape. The producers are large sized trees which are lesser in number and form the base of the pyramid. The herbivores, fruit eating birds, elephants, deers etc. are more in number than the producers. Then, there is a gradual decrease in the number of successive carnivores, thus making the pyramid upright again.

However, in a parasitic food chain, the pyramids are always inverted. This is due to the fact that a single plant may support the growth of many herbivores and each herbivore in turn may provide nutrition to several parasities which support many hyper-parasites. Thus, from the producers towards consumers, there is reverse position, i.e. the number of organisms gradually shows an increase making the pyramid inverted in shape.

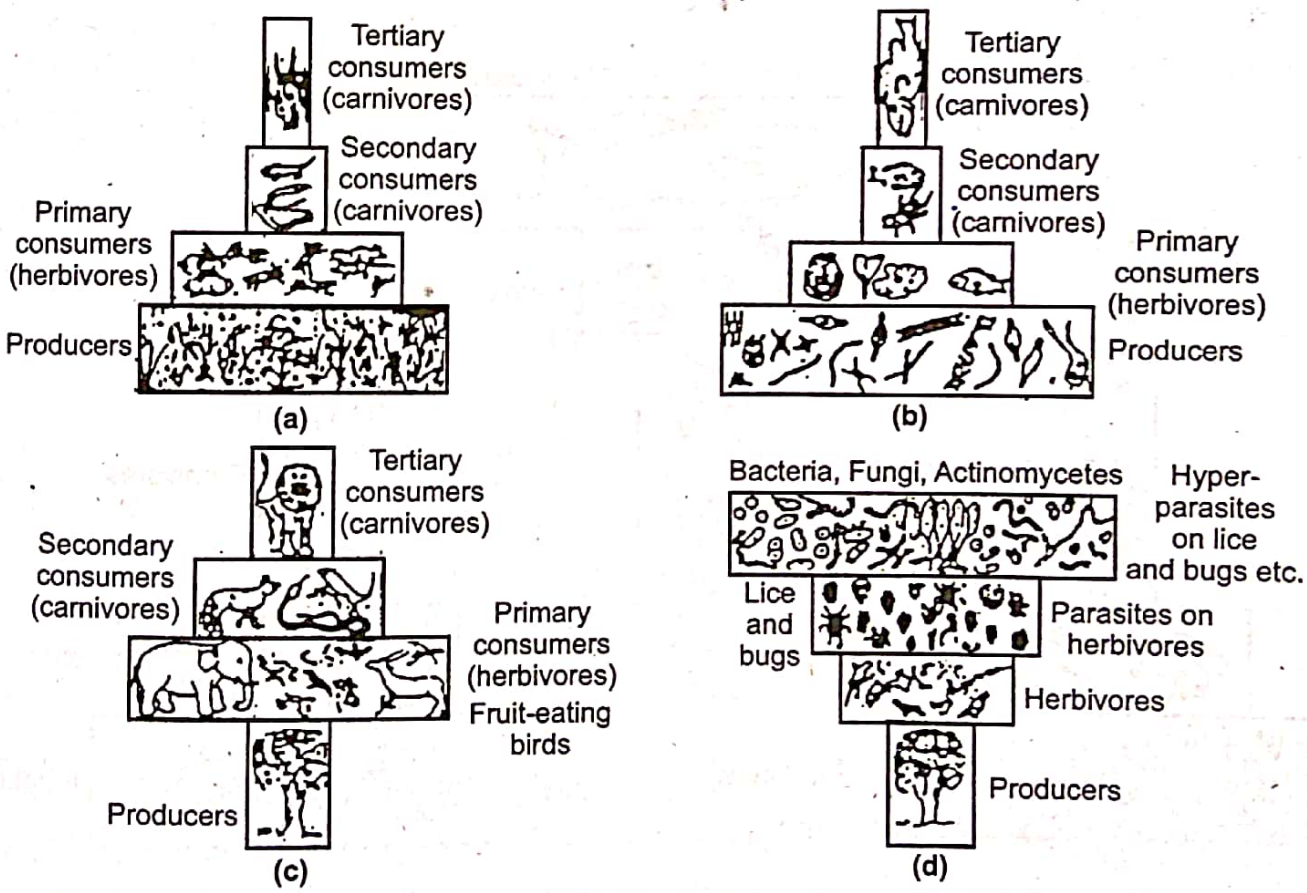

Fig. 2.11: Pyramids of Numbers (individuals per unit area) in Different Kinds of Ecosystem/Food Chains

(a) Grassland ecosystem, (b) Pond ecosystem, (c) Forest ecosystem, In (a) – (c) parasitic micro-organisms and soil animals are not included, (d) Parasitic food chain.

Actually, the pyramids of numbers do not give a true picture of the food chain as they are not very functional. They do not indicate the relative effects of the 'geometric' 'food chain' and size factors of the organisms. They generally vary with different communities with different types of food chains in the same environment. It becomes sometimes very difficult to represent the whole community on the same numerical scale (for example; forest).

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(2) Pyramid of Biomass

Biomass refers to the total weight of living matter per unit area.

Therefore, the pyramid of biomass is to weigh individuals in each trophic level instead of counting them. This would give us a pyramid of biomass i.e. the total weight of all organisms at a given level. In an ecosystem, the biomass decreases from the producer level to the consumer level. For most ecosystems on land, the pyramid of biomass has a large base of primary producers with a small trophic level perched on the top. In grassland and forest, there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. Thus, pyramids are upright. However, in a pond or aquatic ecosystem as the producers are small organisms, their biomass is least, this value gradually shows an increase towards the apex of the pyramid, thus pyramid becomes inverted in shape.

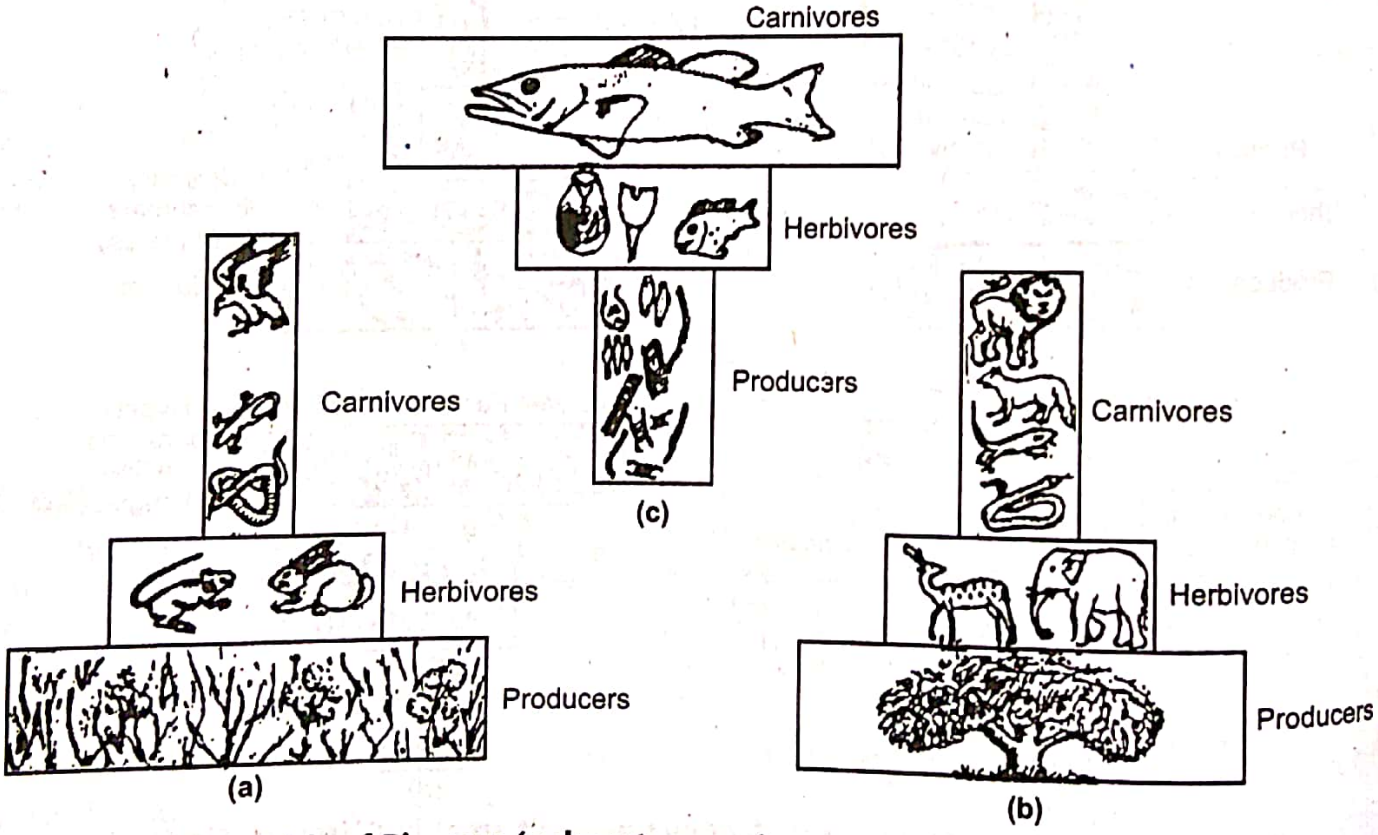

Fig. 2.12: Pyramids of Biomass (g dry wt. per unit area) in different Kinds of Ecosystems (a) Grassland, (b) Forest, (c) Pond

(3) Pyramid of Energy

Of the three types of ecological pyramids, the pyramid of energy is the most informative and gives the best picture of the overall nature of the ecosystem. The energy in an ecosystem flows from the producer level to the consumer level. At each trophic level 80 to 90% of energy is lost. Hence, the amount of energy decreases from the producer level to the consumer level. This can be represented by the pyramid of energy.

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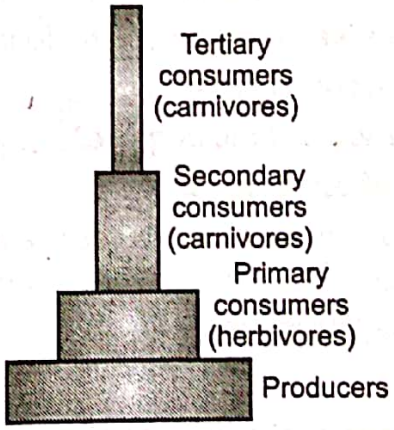
An energy pyramid more accurately reflects the laws of thermodynamics; hence the pyramid is always upright, with a large energy base at the bottom. A pyramid of energy must be based on the determination of the actual intake of energy of an individual, how much is utilised during metabolism, how much remains in the waste products and how much is stored in the body tissues.

The energy inputs and outputs are calculated so that energy flow can be expressed per unit of land or water per unit time. For example, an ecosystem receives 1000 calories of light energy in a given day. Most of the energy is not absorbed; some is reflected back to space. Of the energy absorbed, only a small portion is utilised by green plants, out of which the plant uses some part of the energy for respiration, growth and repair. Of the 1000 calories, therefore only 100 calories are stored as energy rich materials. Now suppose an animal, say a deer, eats the plant containing 100 calories of food energy. The deer uses some of it for its own metabolism and stores only 10 calories as food energy. A lion that eats the deer gets an even smaller amount of energy. Thus, usable energy decreases from sunlight to producer to herbivore to carnivore. Therefore, energy pyramid will always be upright.



(kcal per unit area within unit time, season or years) in any ecosystem

Fig. 2.13: Pyramid of Energy

2.7 INTRODUCTION, TYPES, CHARACTERISTIC, FEATURES, STRUCTURE AND FUNCTION OF SOME ECOSYSTEMS

Types of Ecosystems

Terrestrial Ecosystems	Aquatic Ecosystems
(1) Forest	(1) Pond
(2) Grassland	(2) Lake
(3) Semi arid areas	(3) Wetland
(4) Deserts	(4) River
(5) Mountain	(5) Delta
(6) Islands	(6) Marine

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Different Types of Ecosystems

There are two major types of ecosystems; the terrestrial and aquatic.

Terrestrial ecosystem consists of

(i) Forest ecosystem (ii) Grassland ecosystem (iii) Desert ecosystem.

Aquatic ecosystems are further distinguished as:

(i) Freshwater ecosystems which may be *lotic* (running water as spring, stream, or river) or *lentic* (standing water as lake, pond, pools, puddles, ditch, swamp etc.)

(ii) Marine ecosystem includes deep bodies as an ocean or shallow ones as a sea.

(iii) Estuarine ecosystem is a transitional ecosystem between fresh water and marine ecosystem.

Sometimes ecosystems are broadly classified into two types namely,

(i) Natural ecosystems and

(ii) Artificial ecosystems (man engineered ecosystems).

Natural ecosystem includes terrestrial and aquatic ecosystems; and artificial ecosystem includes crop lands like maize, wheat, rice fields etc. where man tries to control the biotic community as well as physico-chemical environment. Another type is a space ecosystem.

While studying the ecosystems we must understand four basic issues.

(1) Nature, structure and function of ecosystem.

(2) Who use the ecosystem? What is the purpose?

(3) Reasons of degradation of ecosystems.

(4) Efforts for protection and conservation of ecosystems in long term.

Ecosystem Goods and Services:

Ecosystems shows Direct values and Indirect values.

Direct values:

(1) **Consumptive use value:** Provides fruits, fodder, firewood which are used by people who collect them from surrounding.

(2) **Productive use value:** Commercial value of timber, fish, medicinal plants etc. that people collect and sale.

Indirect values:

(1) **Non-consumptive use value:** Scientific research, bird watching, ecotourism etc.

(2) **Option value:** Maintaining options for future, so that by preserving them one could reap economic benefits in the future.

(3) **Existence value:** Ethical and emotional aspects of the existence of wildlife and nature.

2.7.1 Forest Ecosystem

Forests are formed by a community of plants which include trees, shrubs, grasses, climbers and ground cover. Some forests are homogenous in which majority of plants are of same kind and some are heterogenous forests contains plants of different species. We can

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see the most natural and undisturbed forests in our National Parks and Wildlife Sanctuaries. Forests ecosystem has two parts. Approximately 30% of the land is covered under forest. Due to human encroachment the forest area all over the world is gradually declining.

There are many kinds of forests.

(1) Equatorial forests
(2) Tropical forests
(3) Temperate forests
(4) Deciduous forests
(5) Thorny forests
(6) Polar forests
(7) Evergreen forests etc.

Forest ecosystem is very significant and it consists of abiotic and biotic components.

(1) Abiotic Components: Forest type is decided by the type of soil, organic and inorganic mineral contents of the soil. Forests on mountains and hills differ from those along river valleys. Vegetation is also specific to the amount of rainfall and temperature and it varies according to latitude and altitude.

(2) Biotic Components:

(i) Producers: The plants and animals form communities that are specific to each forest type. Large number of trees, herbs, shrubs, climbers, lichens, algae and wide variety of plants in tropical rain forests. Coniferous trees occurs in Himalayas. Mangrove trees occur in river deltas. Thron trees grow in desert and arid areas. There are also flowering and non-flowering plants such as ferns, bryophytes, fungi and algae.

(ii) Consumers: Snow leopard (Himalayas), leopard and tiger are found in forests. Wild sheep and goats live high up in the Himalayas. Many of the birds are found in Himalayan forest. Evergreen forests of the western Ghats and North East India are most rich in plant and animal species. The animal species include mammals, birds, reptiles, amphibians, fishes, insects and other invertebrates and a variety of microscopic animals. The small animals such as ants, flies, beetles, leaf hoppers, bugs, spiders, squirrels and large animals like elephants, neelgai, deer, wild buffaloes etc. are primary consumers. The secondary consumers are the carnivores like snakes, birds, lizards, foxes, feeding on the herbivores. Tertiary consumers are the top carnivores like lion, leopard, tiger etc. that feed upon the carnivores of secondary consumers level.

(iii) Decomposers: Microorganisms such as fungi, bacteria, actinomycetes play an important role of decomposers. Decomposition is faster in tropical forests in comparison to temperate and polar forests.

Plant and animal species are closely dependent on each other and they form different types of forest communities. Man is also a part of these forest ecosystems. Local people depend directly on the forest for several natural resources. Man gets wood and paper from forest. Those who are not living in or near forest they use forest produce indirectly from the market.

Types of Forests in India

In India, forests are broadly classified into coniferous forests and broad leaved forests.

Depending on the nature of the tree species forests are classified as evergreen, deciduous, xerophytics or thorn trees, mangroves etc. Depending on the most abundant species of trees such as Sal or Teak forests.

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(i) **Coniferous forests:** These forests grow in the Himalayan mountain region where the temperature is low. Leaves of the trees are needle like and branches are sloping so that snow can slip off the branches. They have cones instead of seeds and are called gymnosperms.

(ii) **Broad leaved forests:** They are evergreen forests, deciduous forests, thorn forests and mangrove forests. These trees have large leaves of various shapes.

(iii) **Evergreen forests:** They grow in high rainfall areas of the western Ghats, North east India and Andaman and Nicobar islands. In these areas, monsoon lasts for several months. These trees shed few of their leaves throughout the year. They look green throughout the year. Very little sunlight reach to the floor of forest. Only shed loving plants can grow in these forests. Forest is reach in orchids and ferns. Animal life is rich and insects are abundant.

(iv) **Deciduous forests:** These forests are found in regions with moderate amount of seasonal rainfall. Teak trees are more common. The trees shed leaves in winter and hot summer months. In March or April, plants regain their fresh leaves. There is thick undergrowth as light penetrates easily onto the forest floor.

(v) **Thorn forests:** These forests are found in semi-arid regions of India. Trees are sparsely distributed and they are surrounded by open grassy area. Xerophytic plants conserve water. Leaves are waxy to conserve water. Thorns are also helpful to reduce transpiration and also protected from herbivores.

(vi) **Mangrove forests:** They are found along the coast especially in the river deltas, the plants grow in saline and freshwater and muddy areas. Mangrove trees have breathing roots that emerge from mud banks.

Uses of Forests

Variety of forest products are used by the local people but due to overuse forests are completely degraded. Forests provide timber, fire wood. Forest ecosystem plays an important role in controlling local climate and water regimes. Due to loss of forests soil erosion and floods occur. They also provide shelter to wild animals.

Forest Products:

Local people collects fruits, roots, herbs and medicinal plants. Forests also provide fodder, fire wood, building material, fibre, cane, gum, honey etc.

Threats to the Forest Ecosystem:

Overutilization of forest resources is an unsustainable way of misuse. This leads to the degradation and finally it is converted into wasteland. Deforestation has created several problems. Population growth, urbanisation, industrialisation and increased use of consumer goods lead to overutilization of forest products. It is estimated that India's forest cover has decreased from about 33% to 11% in the last century. The increasing use of wood for timber, wood pulp for paper and the extensive uses of firewood results in continual forest loss. Forests are also lost by mining and building dams. Wild life is also seriously threatened.

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If forest will disappear, the tribal people will not survive. Agricultural people do not get enough fuel wood, small timber for making houses and farm implements. Urban people in turn depend on neighbouring forest ecosystems have to pay a higher price for food as human population grows. Insect population will decrease and there will be no effective pollination. This leads to a decrease in agricultural yields. There will be no rain due to absence of forests. People thus do not get enough water. Thus, agriculture is seriously affected. The animal lose their habitat. This leads to extinction of our precious species.

Conservation of Forest Ecosystem

(1) Use of alternate sources of energy instead of firewood.
(2) There is need to grow more frees.
(3) Afforestation needs to be done.
(4) National parks and Wildlife sanctuaries should be set up where plants and animals can be preserved.

2.7.2 Grassland Ecosystem

Grassland cover areas where rainfall is usually low and soil depth and quality is poor. Due to low rainfall the growth of trees and shrubs is prevented, but it supports the growth of grass cover during monsoon. In summer months the grass and herbs dies. In the next monsoon, again grass cover grows back from root stock and the seed of the previous year. In the grassland ecosystem grasses, herbs and several species of insects, birds and mammal are adapted to wide open grass covered areas. These animals are able to live where food is ample after rains. Thus, they store this food as a fat that they use during dry period when there is very little to eat. Man is using these grasslands as pastures to feed his livestock when he began to domesticate animals.

Types of Grasslands in India:

(1) In Himalayan mountains, there are high cold Himalayan pastures.
(2) Thracts of tall elephant grass in low lying Terai belt south of Himalayan foot hills.
(3) Semi-arid grasslands in western India and in the Deccan plateau, parts of Central India.

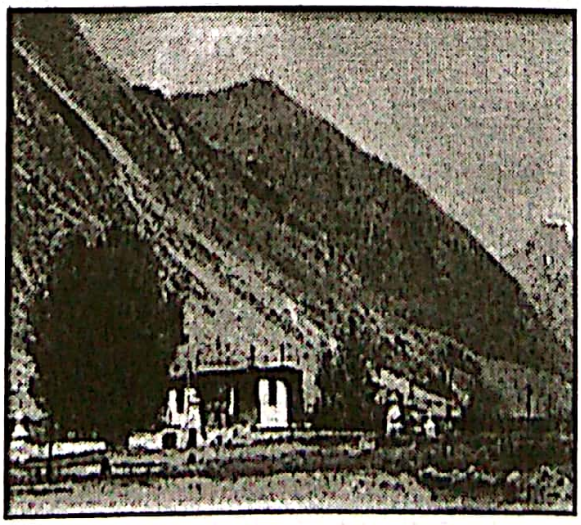

Fig. 2.14: Himalayan Pastures

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(I) Himalayan pasture extends upto the snow line. The grasslands at a lower level form patches along with coniferous or broad leaved forests. The Himalayan wildlife required both the forest and the grassland ecosystem as important parts of their habitat. During summer, the animals migrate up into the high altitude grassland and move down into the forest in winter when snow covers the grassland. The Himalayan pastures have a large variety of grasses and herbs. Himalayan hills slopes are covered with thousands of colourful flowering plants. There are also a large number of medicinal plants.

(II) The Terai consists of patches of tall grasslands inter-spread with a Sal forest ecosystem. The patches of tall elephant grass, which grow to a height of about 5 metres, are located in low-laying water logged areas. The sal forest patches cover the elevated regions and the Himalayan foothills. The terai also includes marshes in low laying depressions. This ecosystem extends as a belt of the Himalayan foothills.

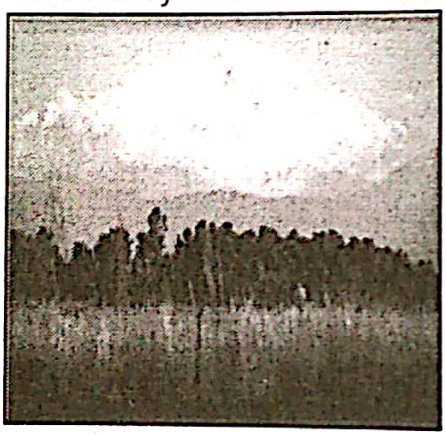

Fig. 2.15: Terai Grassland

(III) The Semi-arid plains of western India, Central India and the Deccan are covered by grassland tracts with patches of thorny forest. Several mammals such as wolf, blackbuck, chinkara, birds such as bustards and floricans are very well adapted to these arid conditions. The scrublands of Deccan plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It is teaming with insect life on which the insectivorous birds feed.

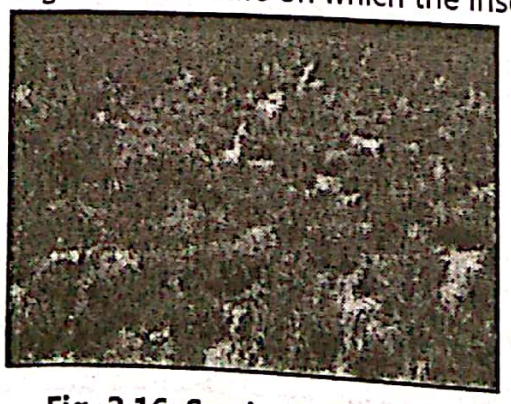

Fig. 2.16: Semiarid Grassland

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(IV) The Shola grassland consist of patches on hill slopes along with the shola forests on the western Ghats, Nilgiri and Annamalai ranges. This forms a patch work of grassland on the slopes and forest habitats along the streams and low lying areas.

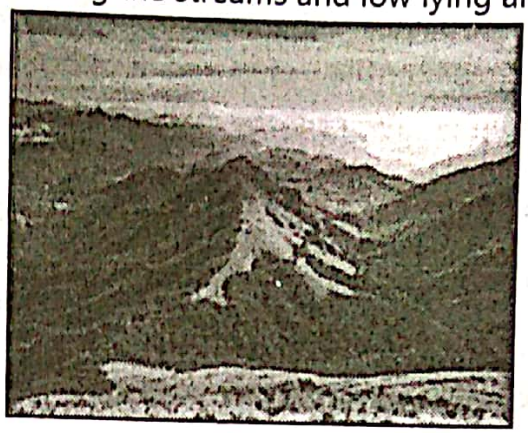

Fig. 2.17: Shola Grassland

2.7.3 Desert Ecosystem

In India, deserts and semi-arid areas are situated in Western India and Deccan plateau. Temperatures are high in such areas hence they are extremely dry. There are also cold deserts such as Ladakh located in the high plateaus of Himalayas. The most typical is Thar desert in Rajasthan. In desert areas, rainfall is very scanty and sporadic. In an area, it may rain only once every few years. The Rann of Kutch is highly specialised arid ecosystem. In summer, it is similar to desert. During monsoons they get converted to salt marshes and they attract large number of birds such as ducks, geese, cranes, storks etc. The great Rann is famous for breeding colonies of flemingos. It is also the only home of wild ass in India.

There are three major types of Deserts found in world.

(1) Tropical Deserts: Sahara, Namib (Africa), Rajasthan, Arebian desert (Saudi Arabia)

(2) Temperate Deserts: American Desert of California, Arizona, Mixico etc.

(3) Cold Deserts: Gobi desert (Mangolia), Tibetian desert.

Producers: Small shrubs, bushes, some grasses and very few trees. Microphyllus plants and spreading trees with deep roots. Fibrous type plants, cacti, succulent plants, xerophytes and lichens etc.

Consumers: Number of highly specialised insects and reptiles. Uromastix, kangaroo rats, Indian wolf, desert cat, desert fox and birds like Great Indian Bustard and the florican. Some common birds include patridges, quails and sandgrouse. Tortoise and sand snakes are common in dessert.

Decomposers: Due to hot and cold climatic conditions the process of decomposition is very less. There are some thermophilic bacteria and fungi. Since, there is poor vegetation, the decomposers or microbes are found in small proportion in desert.

These ecosystems with scanty vegetation have been used for camel, cattle and goat grazing in Rajasthan and Gujarat and for sheep grazing in the Deccan plateau. Areas with some moisture are used for growing crops such as Jowar and Bajra. The natural grasses and

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local varieties of crops have adapted to grow at very low moisture levels. These can be used for genetic engineering and developing arid land crops for the future.

Threats to Desert Ecosystems

(1) Human population growth and different development strategies have begun to affect the natural ecosystem of the desert and semi-arid land.

(2) Due to extensive irrigation systems the natural characteristics of this region are changing.

(3) Rapid evaporation of canal water brings the salts to the surface. Soil becomes saline and unproductive.

(4) Pulling excessive groundwater tube wells lowers the water table creating more drier environment.

(5) Human activities are also responsible for damaging naturalness of this unique ecosystem.

Conservation of Desert Ecosystems

These ecosystems are extremely sensitive. The habitat and ecological balance is easily distributed. Desert people traditionally protect their meager water resources. The Bishnois in Rajasthan protect their khejdi trees and black buck antelope for several generations.

There is an urgent need to protect residual patches of this ecosystem within National Parks and Wildlife Sanctuaries. Because of Indira Gandhi canal in Rajasthan the land is being used in extensive agriculture, destroying important natural ecosystem. The habitat of wild ass will be destroyed by the spread of salt works.

Development project also alter the desert and arid landscape. Due to reduction in habitat the specialised species are bringing to the verge of extinction. Therefore for the protection of these ecosystems, there is special need of sustainable development.

2.7.4 Aquatic Ecosystems

Aquatic ecosystems are classified into fresh water ecosystems, (stream, river, pond, wetland and lake ecosystem) and marine ecosystem. Also brackish water or estuarine ecosystems are present. These ecosystems provide human beings with a wealth of natural resources. They provide fishes, prawns, crabs, lobsters as a protein rich food. Rivers and seas also help in breakdown organic and inorganic wastes created by man, but this function has certain limitations. Now man is over utilizing these ecosystems hence exploiting their natural resources. Overfishing leads to a fall in the fish catch. Due to construction of big dams for electricity and irrigation people staying in downstream areas do not get continuous water supply. When wetlands are drained their connected rivers tend to cause floods. These are all examples of unsustainable changes in the use of natural resources.

Water is important component of all our ecosystems. Several ecosystems exist in fresh water and marine salt water. There is very little about 3% fresh water on the earth and it is the only source for people all over the world.

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What is an Aquatic Ecosystem?

Plants and animals, microorganisms live in water. The animals are adapted to live in different types of habitat. Abiotic factors are clarity, salinity, oxygen content, pH, mud, light etc. Mud gravel or rocks of bed influence its plant and animal species composition. Some fresh water ecosystems are stagnant or running water ecosystems. Wetlands are special ecosystems in which water level fluctuates dramatically in different seasons. These ecosystems are expanses of shallow water with aquatic vegetation and it forms an ideal habitat for fish, crustacea and aquatic birds.

Marine ecosystems are nothing but seas with highly saline water. In brackish water ecosystem water is less saline such as in river deltas. Coral reefs which are very rich in species are found in few shallow seas. The richest coral reefs in India are found in Andaman and Nicobar islands and in the Gulf of Kutch.

In Brackish water ecosystems, mangrove forests are present in river deltas and these are world's most productive ecosystems in terms of biomass production. The largest mangroves swamps are in the Sunderbans in the delta of the Ganges.

Lake Ecosystem: The large number of algae are the producers of this system and they derive the energy from sun. Aquatic plants also play an important role. The microscopic organisms consume algae. Fishes are also herbivores, they feed on algae and aquatic weeds. Snails are eaten by small carnivorous fish which in turn are eaten by larger carnivorous fish. Thus, energy is transferred to herbivores and carnivores. The waste of animals settle on the bottom of the lake which is broken down by small animals that live in mud at the bottom of lake. This acts as nutrient material for aquatic plants for their growth. During the process of photosynthesis CO_2 is used and O_2 is released which is used by aquatic animals, which filter water through their respiratory system.

Stream and River Ecosystems: These are flowing water ecosystems and living forms are adapted to different rates of flow. In case of hill streams, rate of water flow is very rapid, though plants and burrowing animals like snails can withstand the rapid flow. Some species of fishes like Mahseer, go upstream from river to hill streams for breeding. They need very clean and clear water to breed. The females lay eggs only in clear water so that their young can grow. Due to deforestation, hill streams have become seasonal. This leads to flash floods in the rain and shortage of water once the streams dry up after the monsoon. Fauna and flora depends on the clarity, dissolved oxygen, rate of flow and nature of their beds. Beds may be sandy, rocky or muddy and accordingly they have their own species of plants and animals.

Marine Ecosystems: Marine ecosystems of India are Arebian sea, Bay of Bengal and Indian ocean. In Costal area, sea is shallow and while further away, it is deep and both shows different ecosystems. Algae and sea weeds are the producers. There are millions of zooplankton and large number of invertebrates on which fish live. Fish is the food of

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crocodiles and marine mammals. Coral reefs are also rich in species. Silt is carried out to the sea due to deforestation of mangroves. This still is deposited on the coral reefs which then dies. Fishermen collect fish from sea for their livelihood. In past, fishing was done at a sustainable level. But now due to intensive fishing with giant nets and mechanized boats, fish catch in the Indian ocean has dropped significantly.

Sea Shore Ecosystems: Sea shores or beaches are rocky, sandy, shell covered or muddy. Depending on the nature of beach there are different specific species. Different crabs are present which make holes in the sand. The various aquatic birds feed on their prey by probiting sand or mud on the sea shore. Fishermen catch several different species of fish. Due to over fishing number of fishes has decreased during last decade or two.

Uses of Aquatic Ecosystems:

(1) We need clean water to drink and for other domestic purposes.

(2) Water is essential for agriculture and industries.

(3) Fishermen catch fishes and crabs and sale in market.

(4) Marshes and wetlands are of great economic importance as they provide fish, crustacea, grasses and other produces.

(5) Dams are constructed on rivers to generate electricity and for irrigation purpose. But poor tribal people are displaced. Poor people become more poor. Large proportion of electricity is used by urban people. Dams have created serious ill effects on river ecosystems.

(6) Due to over irrigation the soil becomes saline and unproductive.

Threats to the Aquatic Ecosystems

(1) Water pollution due to sewage and solid waste dumping in aquatic ecosystems is a serious problem.

(2) Due to eutrophication oxygen content is severely reduced which destroys life in the water. Natural flora and fauna is destroyed.

(3) Overuse of nitrogenous fertilizers lead to eutrophication.

(4) Use of pesticides, herbicides pollute water and kills off aquatic animals.

(5) Industrial effluents are released in aquatic ecosystems which cause chemical pollution and kills a large number of aquatic animals. Contamination of heavy metals and other toxic chemicals affect the health of people who live near these areas as they depend on this water.

Conservation of Aquatic Ecosystems

(1) For sustainable use of an aquatic ecosystem water pollution must be prevented.

(2) Big dams change the nature of aquatic ecosystem from a flowing water ecosystem to a static ecosystem which destroys its natural biodiversity.

(3) Wetland ecosystems need protection by including them in National parks or Sanctuaries. Endangered species like Mahseer can be protected by this.

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Pond Ecosystem

A pond as a whole serves a good example of a freshwater ecosystem. A pond is a self sufficient and a self regulating system. It consists of both living (plants and animals) components as well as non-living components such as light, temperature and water in which nutrients, O_2, other gases and organic matter are dissolved.

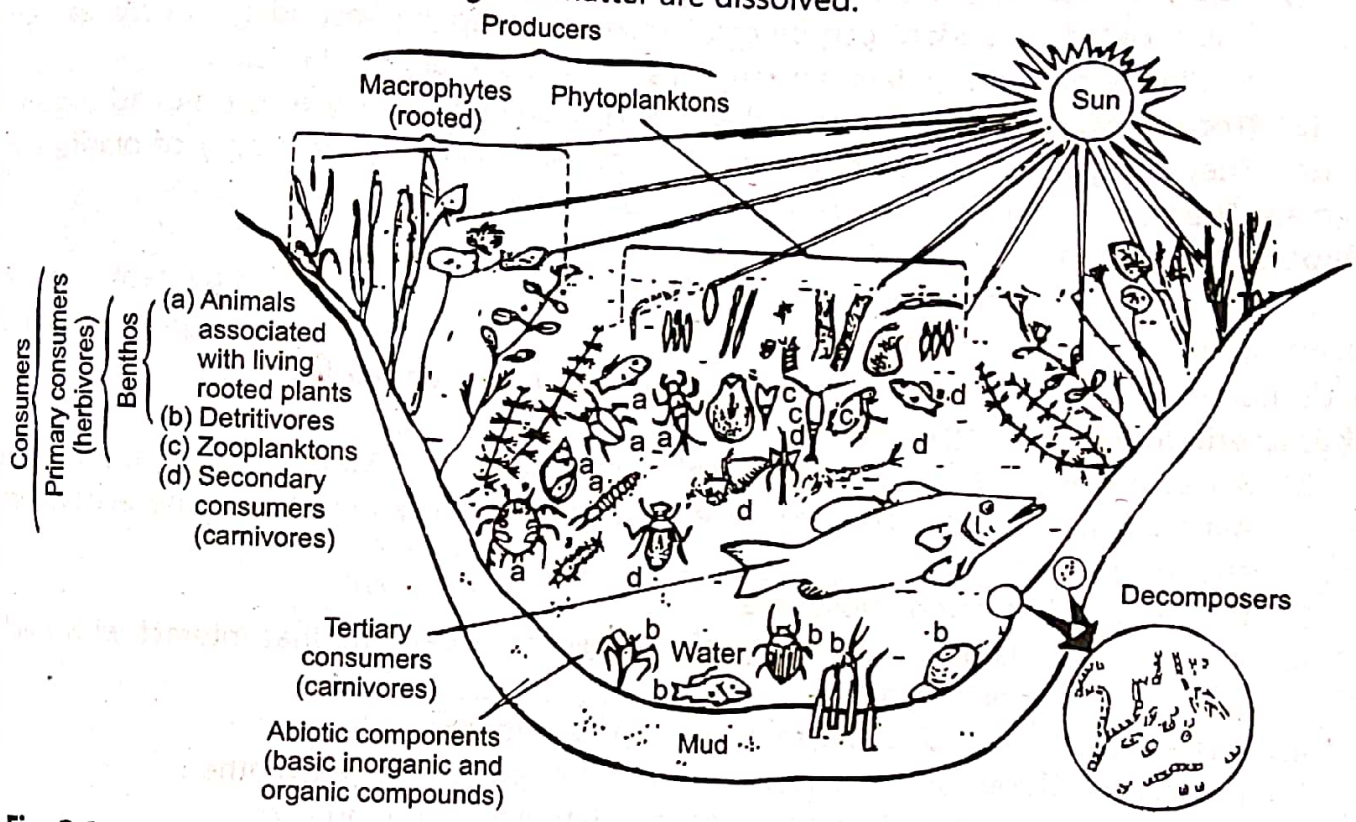

Fig. 2.18: Diagram of the Pond Ecosystem, Showing its Basic Structural Units, the Abiotic (Inorganic and Organic Compounds) and Biotic (Producers, Consumers and Decomposers) Components

Biotic Components

(1) Producers: The green plants and some photosynthetic bacteria are autotrophs. They fix the radiant solar energy and produce carbohydrates by the process of photosynthesis.

Producers are of two types:

(i) ***Macrophytes:*** These are rooted, larger plants which are partly or completely submerged, floating and emergent hydrophytes. The common plants are *Typha, Nymphaea, Chara, Hydrilla, Vallisneria, Utricularia, Eichhornia, Spirodela, Lemna.*

(ii) ***Phytoplankton:*** These are small minute, floating or suspended lower plants. They are filamentous algae as *Zygnema, Ulothrix, Spirogyra, Diatoms, Volvox, Anabaena, Spirulina.*

(2) Consumers: These are animals and heterotrophs which depend for their nutrition on producers. Most of the consumers are herbivores which feed on plant material, whereas insects, fish, frog etc. are carnivores as they feed on herbivores. Some organisms which feed on both plants and animals are called omnivores.

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(i) ***Herbivores:*** They directly feed on living plants. They may live at the bottom called *benthos*. e.g. insect larvae, beetles, mites, molluscs, crustaceans etc. Zooplanktons which are small, microscopic forms that live on the surface of water include rotifers, protozoans (*Euglena*, *Coleps*), Crustaceans (*Cyclops*). Herbivores are also called primary consumers.

(ii) ***Carnivores:*** These may feed on herbivores e.g. insects, fish, water beetles. They are also called secondary consumers. Those that feed on secondary consumers are called tertiary consumers. e.g. larger fish, frog, duck, aquatic birds.

(3) Decomposers: These are also called microconsumers as they feed on dead organic matter. They bring about the decomposition of complex dead organic matter of plants and animals. They are chiefly bacteria, actinomycetes and fungi.

Abiotic Components

In pond, the several non-living or abiotic factors that are present are water, temperature (heat), light, pH, inorganic compounds such as CO_2, O_2, calcium, nitrogen, phosphates, amino acids, humic acid etc. These constituents are essential for the survival of living factors.

Characteristics of an Ecosystem

1. An ecosystem is an open system with a continuous, but variable influx and loss of materials and energy. The flow of energy and materials depend on the ecosystem structure.
2. It is the smallest unit of biosphere.
3. An ecosystem is an overall integration of all the organisms that interact with each other and their environment.
4. It is a basic, functional unit with no limits of boundaries.
5. It consists of biotic and abiotic components interacting with each other.
6. It is capable of energy transformation, circulation and accumulation.
7. An ecosystem is an overall integration of all the organisms that interact with each other and their environment.

The organisation of various species in the ecosystem, their abundance, reproduction and other strategies determine the functioning of an ecosystem. The organisms in an ecosystem are interconnected and interdependent through activities like predation, symbiosis, parasitisation etc. Study of the energy flow, food webs and ecological pyramids are essential for the complete understanding of an ecosystem.

Function of An Ecosystem

Plants use solar energy for their production of food. Very limited amount i.e. about 1/50 millionth of the total solar radiation reaches the earth's surface. The solar radiation travels through the space in the form of waves during which most of it is lost in the space. The solar energy which reaches the earth surface is largely of visible light (45%), infrared components (45%) and ultraviolet rays (10%). Plants mostly absorb red and blue light.

Thus, in ecological energetics we study the following aspects:

(1) Amount of solar energy reaching an ecosystem.

(2) Amount of solar energy used by green plants for the process of photosynthesis and

(3) Path and amount of energy flow from producers to consumers.

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About 34% of the sunlight reaching the earth's atmosphere is reflected back into its atmosphere. 10% is absorbed by ozone layer, water vapour and other atmospheric gases. The remaining amount of solar radiation i.e. around 56% reaches the earth's surface. A very small fraction, about 1-5% of solar energy is utilised by the plants for photosynthesis. The remaining energy is absorbed as heat by ground vegetation or water. In true sense, only about 0.02% solar energy is used by the plants for photosynthesis. Despite of this; the survival of living organisms depends on this small fraction in an ecosystem.

Energy Flow in an Ecosystem

The behaviour of energy in ecosystem is called energy flow. The flow of energy is unidirectional. In ecological energetics, we can study the following aspects:

(1) The efficiency of the producers in absorption and conversion of solar energy.
(2) Use of this chemical energy by the consumers.
(3) The total input of energy in the form of food and its efficiency of assimilation.
(4) The loss through respiration, heat excretion etc.
(5) The gross net production.

The principle of food chains and working of thermodynamics can be explained by energy flow diagram.

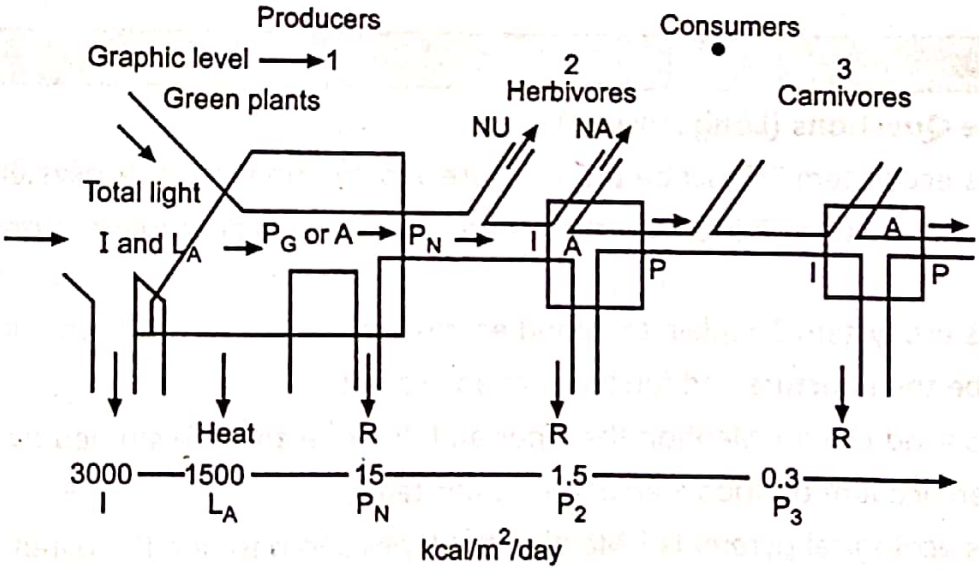

Fig. 2.19: Simplified Energy Flow Diagram Depicting Three Trophic Levels (Boxes Numbered 1, 2, 3) in a Linear Food Chain

I – Total energy input; L_A – Light absorbed by plant cover; P_G – Gross primary production; A – Total assimilation; P_N – Net primary production; P – Secondary (consumer) production; N_U – Energy not used (stored or exported); N_A – Energy not assimilated by consumers (egested); R – Respiration. Bottom line in the diagram shows the order of the magnitude of energy losses expected at major transfer points, starting with a solar input of 3,000 kcal per square metre per day. (E.P. Odum, 1963)

The transfer of energy from one trophic level to another trophic level is called energy flow. The flow of energy in an ecosystem is unidirectional, i.e. it flows from the producer level to the consumer level and never in the reverse direction. Hence, energy can be used only once in the ecosystem.

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The figure represents a very simplified energy flow model of free trophic levels, from which it becomes evident that the energy flow is greatly reduced at each successive trophic level from producers to herbivores and then to carnivores.

Thus, during each transfer of energy from one level to another level, major part of energy is lost as heat or in any other form.

In the above figure, the boxes represent the trophic levels and the pipes depict the energy flow in and out of each level. Energy inflows balance outflows as required by the first law of thermodynamics and energy transfer is accompanied by dispersion of energy into unavailable heat i.e. respiration as required by the second law.

Thus, as shown in figure, about 3000 kcal of total light falls on the green plants, of this approximately 50% i.e. 1500 kcal is absorbed, of which only 1% (15 kcal) is converted at first trophic level. Thus, the net primary production is merely 15 kcals. Secondary productivity (P_2 and P_3 in diagram) tends to be about 10% at successive consumer trophic levels i.e. herbivores and the carnivores although efficiency may be sometimes higher as 20%, at the carnivore level as shown (or P_3 = 0.3 kcal) in the diagram.

QUESTIONS

(A) Essay Type Questions (Long Answer) :

1. What is ecosystem ? Describe the structure and components of ecosystem.
2. What is ecosystem ? Mention the different types and describe any one studied by you.
3. What is ecosystem ? Explain the pond ecosystem.
4. Describe the structure and functions of an ecosystem.
5. What is food chain ? Mention the types and describe any one studied by you.
6. Write an account on food web and its importance.
7. What is ecological pyramids ? Mention the types and describe the pyramid of energy.

(B) Define/Explain the Following Terms:

(a) Habitat
(b) Ecosystem
(c) Abiotic components
(d) Biotic components
(e) Consumers
(f) Decomposers
(g) Carnivores
(h) Flora and fauna
(r) Grazing food chain
(i) Omnivores
(j) Food chain
(k) Food web
(m) Pyramid of energy
(n) Pyramid of biomass
(o) Trophic level
(p) Producers/Autotrophs
(q) Forest ecosystem
(s) Detritus food chain

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