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INTRODUCTION

No life exists in a vacuum. Materials and forces which constitutes its environment and from which it must derive its needs surround every living organism. Thus, for its survival, a plant, an animal, or a microbe cannot remain completely aloof in a shell. Instead, it requires from its environment a supply of energy, a supply of materials, and a removal of waste products

For various basic requirements, each living organism has to depend and also to interact with different non-living or abiotic and living or biotic components or the environment.

Abiotic

The abiotic environmental components include basic inorganic elements and compounds such as water and carbon dioxide, calcium and oxygen, carbonates and phosphates besides such physical factors as soil, rainfall, temperature, moisture, winds, currents, and solar radiation with its concomitants of light and heat.

Biotic

The biotic environmental factors comprise plants, animals, and microbes; They interact in a fundamentally energy-dependent fashion. In the words of Helena Curtis "The scientific study of the interactions of organisms with their physical environment and with each other, is called ecology". According to Herreid II "It mainly concerns with the directive influences of abiotic and biotic environmental factors over the growth, distribution behaviour and survival of organisms.

Ecology Defined

(1) ***Ernst Haeckel*** (1866) defined ecology "as the body of knowledge concerning the economy of nature-the investigation of the total relations of animal to its inorganic and organic environment.

(2) ***Frederick Clements*** (1916) considered ecology to be "the science of community.

(3) ***British ecologist Charles Elton*** (1927) defined ecology as "the scientific natural history concerned with the sociology and economics of animals."

(4***) Taylor*** (1936) defines ecology as "the science of the relations of all organisms to all their environments."

(5) ***Allee*** (1949), considered ecology as "the science of inter-relations batwing living organisms and their environment, including both the physical and biotic environments, and emphasizing inter-species as well as intra-species relations.

ECOSYSTEM

At present ecological studies are made at Eco-system level. At this level the units of study are quite large. This approach has the view that living organisms and their non-living environment are inseparably interrelated and interact with each other. A.G. Tansley (1935) defined the Ecosystem as 'the system resulting from the integrations of all the living and non-living actors of the environment'. Thus, he regarded the Eco-systems as including not only the organism complex but also the whole complex of physical factors forming the environment.

HISTORICAL BACKGROUND

The idea of Ecosystem is quite an old one. We find in literature some such parallel terms as (i) biocoenosis (Karl Mobius, 1977), (ii) microcosm (S.A. Forbes, 1887),(iii) Geobiocoenosis (V.V. Doduchaev, 1846-1903); G.F. Morozov; see Sukachev, 1944),(iv) hlocoen (Friederichs, 1930), (v) biosystem (Thienemann, 1939), (vi) bioenert body(Vernadsky, 1994), and ecosom etc. use for such ecological systems. The terms ecosystems is most preferred, where 'eco' implies the environment, and 'system' implies an interacting, inter-dependent complex. In this way, it can be said that any unit that includes all the organisms i.e. the communities in a given area, interact with the physical environment so that a flow of energy leads to clearly defined trophic structure, biotic diversity and material cycle (i.e. exchange of materials between living and non-living components) within the system, is known as an ecological system or eco-system. Eco-system may be visualized as 3-dimensional cut-outs from the ecosphere. All primary and secondary producers composing the ecosystem are its essential elements. The unique feature of eco-systems is the maintenance of their chemical state and of their environment. Thus, an eco-system is an integrated unit, consisting of interacting plants and animals whose survival depends upon the maintenance of abiotic i.e. physicochemical environment and gradients such as moisture, wind and solar radiation with its concomitants of light and heat, as well as biotic structures and functions. The integrated unit may or may not be isolated but it must have definable limits within which there are integrated functions. Physiologists study various functions in individual plants or animals, but the ecologists study them at the ecosystem level. A real ecologist endeavours for maintaining holistic or ecosystem perspective of the process being studied by him.

Species: A species is a group of organisms capable of interbreeding and producing viable offspring. Eg: *Panthera tigris* is tiger and all the tigers in the world are capable of breeding with each other to produce cubs, which when mature can continue the process.

ASPECTS OF ECOSYSTEM: The ecosystem can be defined as any spatial or organizational unit including living organisms and non-living substances interacting to produce an exchange of

materials between the living and non-living parts. The eco-system can be studied from either structural or functional aspects.

1. *Structural Aspect*

The structural aspects of ecosystem include a description of the arrangement, types and numbers of species and their life histories, along with a description of the physical features of the environment.

2. *Functional*

The functional aspects of the ecosystem include the flow of energy and the cycling of nutrients.

Habitat

The non-living part of the eco-system includes different kinds of habitats such as air, water and land, and a variety of abiotic factors. Habitat can be defined as the natural abode or locality of an animal, plant or person. It includes all features of the environment in a given locality. For example, water is used as habitat by aquatic organisms and it comprises three major categories-marine, brackish and freshwater habitats. Each of these categories may be subdivided into smaller unit, such a freshwater habitat may exist as a large lake, a pond, a puddle, a river or a stream. The land is used as a habitat for numerous terrestrial organisms. It includes many major categories of landmasses, which are called biomes. Biomes are distinct large areas of earth inclusive of flora and fauna, e.g. deserts, prairie, tropical forests, etc. Soil is also used as a habitat by a variety of microbes, plants and animals.

Relationships

In an ecosystem, there exist various relationships between species. The relationship may be as under:

(1) Effects

Two species may have any of the following kind of effects:

(i) They may have a negative effect upon one another (competition).

(ii) They may have a neutral effect (neutralism).

(iii) They may have beneficial effect (proto-cooperation and mutualism).

(2) *Other kinds of Relationship*

The species may aggregate, or separate, or show a random relationship to one another.

Population

A population is a group of inter-acting individuals, usually of the same species, in a definable space. In this way we can speak of population of deer on an island, and the population of fishes in a pond. A balance between two aspects determines the size of a population of any given species:

(i) Its reproductive potential,

(ii) Its environmental resistance.

In this way population size is determined by the relative number of organisms added to or removed from the group as under:

(i) *Addition*

Recruitment into the population is a function of birth rate and immigration rate.

(ii) *Removal*

Loss from the population is a function of death rate and emigration.

Factors Regulating Population

Following factors does population regulation:

(i) Physical attributes of the environment (e.g. climate),

(ii) Food (quantity and quality),

(iii) Disease (host-parasite relationships).

(iv) Predation,

(v) Competition (inter-specific and intra-specific).

An ecosystem contains numerous populations of different species of plants, animals and microbes; all of them interact with one another as a community and with the physical environment as well. A community or biotic community, thus, consists of the population of plants and animals living together in a particular place.

Division of Ecosystem

The ecosystem can be divided, from the energetic view point into three types of organisms: producers, consumers, and reducers. These can be explained as under:

(1) *Producer*

Photosynthetic algae, plants and bacteria are the producers of the ecosystem; all other organisms depend upon them directly or indirectly for food.

(2) *Consumers*

Consumers are herbivorous, carnivorous, and omnivorous animals; they eat the organic matter produced by other organisms.

(3) *Reducers*

Reducers are heterotrophic organisms like animals; they are fungi and bacterial that decompose dead organic matter.

GENERAL CHARACTERISTICS OF AN ECOSYSTEM

According to Smith following are the general characteristics of eco-system.

(1) The ecosystem is a major structural and functional unit of ecology.

(2) The structure of an eco-system is related to its species diversity; as such the more complex ecosystem has high species diversity.

(3) The relative amount of energy required to maintain an ecosystem depends on its structure. The more complex the structure, the lesser the energy it requires to maintain itself.

(4) The function of the ecosystem is related to energy flow in material cycling through and within the system.

(5) Ecosystems mature by passing from less complex to more complex states. Early stages of such succession have an excess of potential energy. Later (mature) stages have less energy accumulation.

(6) Both the environment and the energy fixation in any given ecosystem are limited. They cannot be exceeded in any way without causing serious undesirable effect.

(7) Alterations in the environments represent selective pressures upon the population to which it must adjust. Organisms, which fail to adjust to the changed environment, must vanish.

To conclude the eco-system is an integrated unit or zone of variable size, it comprises vegetation, fauna, microbes and the environment. Most ecosystems process a well-defined soil, climate, flora and fauna and their own potential for adaptation, change and tolerance. The functioning of any

ecosystem involves a series of cycles. These cycles are driven by energy flow, the energy being the solar energy.

STRUCTURE OF ECOSYSTEMS

Meaning of Structure

By structure of an eco-system we mean as under.

(i) The composition of biological community including species, numbers, biomass, life history and distribution in space etc.

(ii) The quantity and distribution of the non-living materials, such as nutrients, water etc.

(iii) Structure of an ecosystem the range, or gradient of conditions of existence, such as temperature.

Natural and Function of Structure of Eco-system

The structure of an ecosystem is in fact, a description of the species of organisms that are present, including information on their life histories, population and distribution in space. It guides us to know who's who in the ecosystem. It also includes descriptive information on the non-living features of ecosystem give us information about the range of climatic conditions that prevail in the area. From structural point of view all ecosystems consist of following two basic components:

1. Abiotic Substances (*Non-Living Components*)

The Abiotic substances include basic inorganic and organic compounds of the environment or habitat of the organism.

(a) ***Inorganic Components***: The inorganic components of an ecosystem are as under carbon dioxide, water, nitrogen, calcium, and phosphate. All of these are involved in matter cycles (biogeochemical cycles).

(b) ***Organic Components***: The organic components of an ecosystem are proteins, carbohydrates; lipids and amino acids, all of these are synthesized by the biota (flora and fauna) of an ecosystem and are reached to ecosystem as their wastes, dead remains, etc.

(c) ***The climate, temperature, light, soil etc.***, are other abiotic components of the eco-system.

(3) ***Biotic Substances (Living Components***): This is indeed the trophic structure of any ecosystem, where living organisms are distinguished on the basis of their nutritional relationships. From this trophic (nutritional) standpoint, an ecosystem has two components:

(a***) Autotrophic Component of Producers***

These are the components in which fixation of light energy use of simple inorganic substances and build-up of complex substance predominate.

(i) The component is constituted mainly by green plants, including photosynthetic bacteria.

(ii) To some lesser extent, chemosynthetic microbes also contribute to the build-up of organic matter.

(iii) Members of the autotrophic component are known as eco-system producers because they capture energy from non-organic sources, especially light, and store some of the energy in the form of chemical bonds, for the later use.

(iv) Algae of various types are the most important producers of aquatic eco-systems, although in estuaries and marshes, grasses may be important as producers.

(v) Terrestrial ecosystems have trees, herbs, grasses, and mosses that contribute with varying importance to the production of the eco-systems.

(b) ***Heterotrophic Component or Consumers***

These are the components in which utilization; rearrangement and decomposition of complex materials predominate. The organisms involved are known as consumers, as they consume autotrophic organisms like bacterial and algae for their nutrition, the amount of energy that the producers capture, sets the limit on the availability of energy for the ecosystem. Thus, when a green plant captures a certain amount of energy from sunlight, itis said to produce the energy for the ecosystem. The consumers are further categorized as:

(i) ***Macroconsumers***

Marcoconsumers are the consumers, which in a order as they occur in a food chain are,herbivores, carnivores (or omnivores).

(a) Herbivores are also known as primary consumers.

(b) Secondary and tertiary consumers, if preset, are carnivores of omnivores. They allphagotrophs that include mainly animals that ingest other organic and particulate organic matter.

(ii) Microconsumers

These are popularly known as decomposers. They are saprotrophs (=osmotrophs) they include mainly bacteria, actinomycetes and fungi. They breakdown complex compounds of dead or living protoplasm, they absorb some of the decomposition or breakdown products. Besides, they release inorganic nutrients in environment, making them available again to autotrophs. The biotic component of any ecosystem may be thought of as the functional kingdom of nature. The reason is, they are based on the type of nutrition and the energy source used. The trophic structure of an ecosystem is one kind of producer consumer arrangement, where each "food" level is known as trophic level.

Standing Corp

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

(i) Number of organisms per unit area,

(ii) Biomass i.e. Organism mass in unit area, we can measure it as living weight, dry weight, ash-free dry weight of carbon weight, or calories or any other convenient unit suitable.

Decomposers

In the absence of decomposers, no ecosystem could function long. In their absence, dead organisms would pile up without rotting, as would waste products, It would not be long before and an essential element, phosphorus, for example, would be first in short supply and then gone altogether, the reason is the dead corpses littering the landscape would be hoarding the entire supply. The decomposers tear apart organisms and in their metabolic processes release to the environment atoms and molecules that can be reused again by autotrophic point of view. Instead they are important from the material (nutrient) point of view. Energy cannot be recycled, but matter can be. Hence it is necessary to feed Energy into ecosystem to keep up with the dissipation of heat or the increase in entropy. Matter must be recycled again and again by an ecological process called biogeochemical cycle.

An Illustration

The Structure of ecosystem can be illustrated as under with the help of ponds example.

1. *Abiotic Part*

The abiotic or non-living parts of a freshwater pond include the follwing:

(i) Water,

(ii) Dissolved oxygen,

(iii) Carbon Dioxide,

(iv) Inorganic salts such as phosphates, nitrates and chlorides of sodium, potassium,

and calcium

(v) A multitude of organic compounds such as amino acids, humic acids, etc. according

to the functions of the organisms, i.e., their contribution towards keeping the ecosystem operating as a stable, interacting whole.

(a) Produces

In a freshwater pond there are two types of producers,

(i) First are the larger plants growing along the shore or floating in shallow, water,

(ii) Second are the microscopic floating plants, most of which are algae,These tiny plants are collectively referred to as phytoplankton. They are usually not visible. They are visible only when they are present in great abundance and given the water a greenish tinge. Phytoplankton are more significant as food producers for the freshwater pond ecosystem than are the more readily visible plants.

(b) Consumers

Among the macro consumers or phagotrophas of pond ecosystems include insects and insect larvae, Crustaceans, fish and perhaps some freshwater clams.

(i) ***Primary Consumers***: Primary consumers such as zooplankton (animal plankton) are found near the surface of water. Likewise, benthos (bottom forms) are the planteaters (herbivores).

(ii) ***Secondary consumers***: The secondary consumers are the carnivores that eat theprimary consumers. There might be some tertiary consumers that eat the carnivores (secondary consumers).

Saprotrophs

The ecosystem is completed by saprotrophs or decomposer organisms such as bacteria, flagellate protozoans and fungi, they break down the organic compounds of cells from dead producer and consumer organisms in any of these ways-

(i) Into small organic molecules, which they utilize themselves, or

(ii) Inorganic substances that can be used as raw materials by green plants.

ECOLOGICAL PYRAMIDS

The main characteristic of each type of Ecosystem in Trophic structure, i.e. the interaction of food chain and the size metabolism relationship between the linearly arranged various biotic components of an ecosystem. We can show the trophic structure and function at successive trophic levels, as under :-

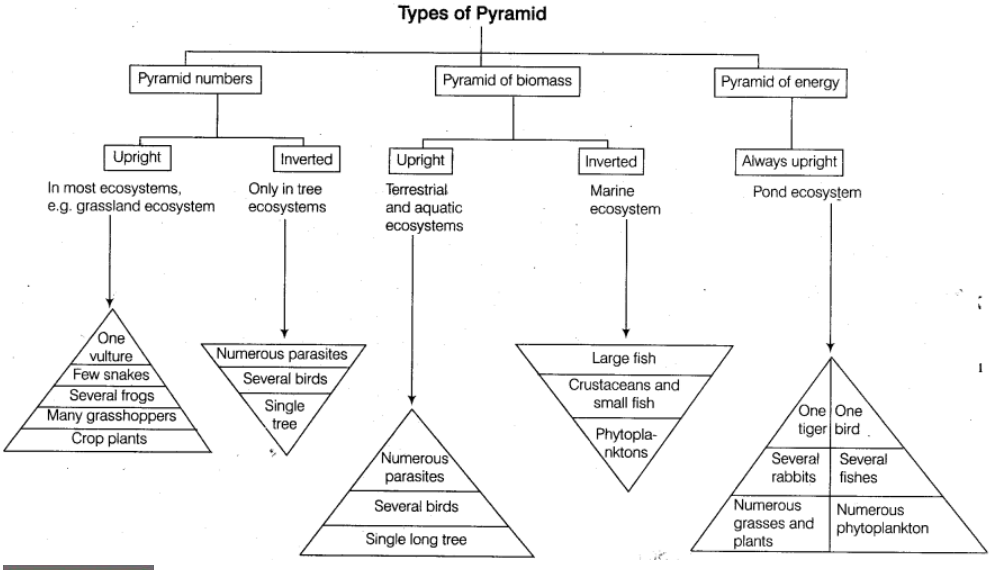
Producers →Herbivores→ Carnivores

It may be known by means of ecological pyramids. In this pyramid the first or producerlevel constitutes the base of the pyramid. The successive levels, the three make the apex. Ecological pyramids are of three general types as under:

(i) ***Pyramid of numbers***: It shows the number of individual organisms at each level,

(ii) ***Pyramid of biomass***: It shows the wet or dry weight of organisms at successive trophic levels.

(iii) ***Pyramid of energy***: It shows the rate of energy flow and/or productivity at successive trophic levels.



The first two pyramids

That is the pyramid of numbers and biomass may be upright or inverted. It depends upon the nature of the food chain in the particular ecosystem, However, the pyramids of energy are always upright.

A brief description of these pyramids is as under:

1. Pyramids of numbers

The pyramids of numbers show the relationship between producers, herbivores and carnivores at successive trophic levels in terms or their numbers.

(i) In a grassland the producers, which are mainly grasses, are always maximum in number.

(ii) This number shows a decrease towards apex, the reason is obvious, number than the grasses.

(iii) The secondary consumers, snakes and lizards are less in number than the rabbits and mice.

(iv) In the top (tertiary) consumers hawks or other birds, are least in number.

In this way the pyramid becomes upright. In a pond ecosystem, also the pyramid is upright as under:

(i) The producers, which are mainly the phyto-planktons as algae, bacteria etc. aremaximum in number;

(ii) The herbivores, which are smaller fish; rotifers etc are less in number than the producers;

(iii) The secondary consumers (carnivores), such as small fish which eat up each other,water beetles etc. are less in number than the herbivores;

(iv) Finally, the top (tertiary) consumers, the bigger fish are least in number.

However, the case is not so in a forest eco-system. There the pyramid of numbers is somewhat different in shape:—

(i) Producer, here the producers, are mainly large-sized trees, they are less in number, and form the base of the pyramid.

(ii) The herbivores, which are the fruit-eating birds, elephants, deer etc. are more in number than the producers.

(iii) Thereafter there is a gradual decrease in the number of successive carnivores.

In this way the pyramid is made again upright. However, in a parasites food chain the pyramids are inverted. This is for the reason that a single plant may support the growth of many herbivores. In its turn, each herbivore may provide nutrition to several parasites, which support many hyper parasites. Consequently, from the producer towards consumers, there is a reverse position. In other words, the number of organisms gradually shows an increase, making the pyramid inverted in shape.

2. Pyramids of biomass

The pyramids of biomass are comparatively more fundamentalism; as the reason is they instead of geometric factor; show the quantitative relationships of the standing crops. The pyramids of biomass in different types of ecosystem may be compared as under:

In grassland and forest there is generally a gradual decrease in biomass of organisms at successive levels from the producers to the top carnivores. In this way, the pyramids are upright. However, in a pond the producers are small organisms, their biomass is least, and this value gradually shows an increase towards the apex of the pyramid and the pyramids are made inverted in shape.

3. Pyramid of energy

The energy pyramid gives the best picture of overall nature of the ecosystem. Here, number and weight of organisms at any level depends on the rate at which food is being produced. If we compare the pyramid of energy with the pyramids of numbers and biomass, which are pictures of the standing situations (organisms present at any moment), the pyramid of energy is a picture of the rates of passage of food mass through the food chain. It is always upright in shape.

Functions of Eco-system

The functions of Ecosystem are as under:

1. ***Transformation of Solar Energy into Food Energy***

The solar radiation is major source of energy in the ecosystem. It is the basic input of energy entering the ecosystem. The green plants receive it. And is converted into heat energy. It is lost from the ecosystem to the atmosphere through plant communities. It is only a small proportion of radiant solar energy that is used by plant to make food through the process of photosynthesis. Green plants transform a part of solar energy into food energy or chemical energy. The green

plants to develop their tissues use this energy. It is stored in the primary producers at the bottom of trophic levels. The chemical energy, which is stored at rapid level one, becomes the source of energy to the herbivorous animals at trophic level two of the food chain. Some portion energy is lost from trophic level one through respiration and some portion is transferred to plant-eating animals at trophic level two.

2. *The Circulation of elements through Energy Flow*

It is seen that in the various biotic components of the ecosystem the energy flow is the main driving force of nutrient circulation. The organic and inorganic substances are moved reversibly through various closed system of cycles in the biosphere, atmosphere, hydrosphere and lithosphere. This activity is done in such a way that total mass of these substances remains almost the same and is always available to biotic communities.

3. The Conversion of Elements into Inorganic Flow

The organic elements of plants and animals are released in the under mentioned ways:

(i) Decomposition of leaf falls from the plants dead plants and animals by decomposers and their conversion into soluble inorganic form.

(ii) Burning of vegetation by lighting, accidental forest fire or deliberate action of man. When burnt, the portions of organic matter are released to the atmosphere and these again fall down, under the impact of precipitation, on the ground. Then they become soluble inorganic form of element to join soil storage, some portions in the form of ashes are decomposed by bacterial activities.

(iii) The waste materials released by animals are decomposed by bacteria. They find their way in soluble inorganic form to soil storage.

4. *The Growth and Development of Plants*

In the biogeochemical cycles are included the uptake of nutrients of inorganic elements by the plants through their roots. The nutrients are derived from the soil where these inorganic elements are stored. The decomposition of leaves, plants and animals and their conversion into soluble inorganic form are stored into soil contributing to the growth and development of plants. Decompositions are converged into some elements. These elements are easily used in development of plant tissues and plant growth by biochemical processes,mainly photosynthesis.

5. *Productivity of ecosystem*

The productivity of an ecosystem refers to the rate of production i.e. the amount of organic matter, which is accumulated in any unit time. Productivity is of the following types:

(1) Primary productivity: It is associated with the producers which are autotrophic, Most of these are photosynthetic, Thus, they are, to a much lesser extent the chemosynthetic microorganisms. These are the green plants, higher saprophytes as well as lower forms, the phytoplankton's and some photosynthetic bacteria. We can define Primary productivity as "the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers." Primary productivity is further distinguished as:

Gross primary productivity: Gross Primary Productivity is the rate of storage of organic matter in plant tissues in excess of the respiratory utilization by plants during the measurement period. This is, thus, the rate of increases of biomass. In this way, net primary productivity refers to balance between gross photosynthesis and respiration and other plant losses as death etc.

(2) ***Secondary productivity***: These are the rates of energy storage at consumer level. Since consumers only utilize food materials (already produced) in their respiration, simply covering the food matters to different tissues by an overall process. The secondary productivity is not divided into 'gross' and 'net' amount.

(3) ***Net Productivity***: Net productivity refers to the rate of storage of organic matter not used by the heterotrophs (consumer) i.e. equivalent to net primary production minus consumption by the heterotrophs during the unit period. It is thus the rate of increase of biomass of the primary producers, which has been left over by the consumers.

(4) ***Stability of Ecosystem***: The stability of ecosystems refers to the balance between production and consumption of each element in the ecosystem. In other words, balance between input and output of energy and normal functioning of different biogeochemical cycles and stable conditions of equilibrium as under:-

(i) ***The Equilibrium Model***: The equilibrium model states that an ecosystem always tends towards stability. As soon as the community of an ecosystem is disturbed due to external environmental change, it quickly returns to original state.

(ii) ***The non-equilibrium model***: The non-equilibrium model states that an ecosystem stability is rarely attained because disturbances caused by frequent external environmental change do not allow to develop ordered state of species assemblages in an ecosystem.

DECOMPOSERS

In this world all living organisms require a constant supply of nutrients for growth. The death and decomposition of plants and animals, with release of nutrients constitutes an essential link in the maintenance of nutrient cycles. When an organism dies, an initial period of rapid leaching takes

place and populations of macromolecules. The dead organism is disintegrated beyond recognition. Enzymic action breaks down the disintegrating parts of the litter. Animals invade and either eat the rapidly recolonized by micro- organisms, and the litter biomass decreases. It becomes simpler in structure and chemical composition.

Process of Decomposition

The process of decomposition involves three interrelated components, viz.

(i) Leaching (ii) Catabolism, (iii) Comminution.

1. *Leaching*

Leaching is a physical phenomenon operating soon-after litter fall. Soluble matter is removed from detritus by the action of water. Sometime over 20% of the total nitrogen content of litter maybe leached off.

2. *Catabolism*

The process in a plant or animal by which living tissue is changed into waste products.

3. *Comminution*

Comminution to make small to reduce to power or minute particles. Comminution means the reduction in particle size of detritus. During the course of feeding, the decomposer animals community detritus physically. And utilize the energy and nutrients for their own growth (***secondary production***). In due course, the decomposers themselves die and contribute to the detritus.

Function of Decomposition

The two major functions of decomposition within ecosystems are as under:-

(1) The mineralization of essential elements,

(2) The formation of soil organic matter to inorganic form. The formation of soil organic matter in nature is a slow process. The decomposition of any piece of plant detritus may take hundreds of years to complete. However, some residues of decomposition within this period do contribute to the formation of soil organic matter.

ENERGY-ITS FLOW IN ECOSYSTEM

Energy-Defined

Energy can be defined as the capacity to do work, whether that work be on a gross scaleas raising mountains and moving air masses over continents, or on a small scale such as transmitting a nerve impulse from one cell to another.

Kinds of Energy

There are two kinds of energy, potential and kinetic. They can be explained as under:-

1. *Potential Energy*

Potential energy is energy at rest. It is capable and available for work.

2. *Kinetic Energy*

Kinetic energy is due to motion, and results in work. Work that results from the expenditure of energy can be of two kinds:

(1) It can store energy (as potential energy).

(2) It can order matter without storing energy.

3. *Laws of Thermodynamics*

The expenditure and storage of energy is described by two laws of thermodynamics :-

(i) Law of conservation of energy: The law of conservation of energy states that energy is neither created nor destroyed. It may change forms, pass from one place to another, or act upon matter in various ways. In this process no gain or loss in total energy occurs. Energy is simply transferred from one form or place to another.

Two Reactions

There may be either of the two reactions:

1. Exothermic Reaction

When wood is burnt the potential energy present in the molecules of wood equals the kinetic energy released, and heat is evolved to the surroundings. This is an exothermic reaction.

2. Endothermic Reaction

In an endothermic reaction, energy from the surrounding may be paid into a reaction. For example, in photosynthesis, the molecules of the products store more energy than the reactants. The extra energy is acquired from the sunlight yet there is no gain or loss in total energy.

(ii) ***Law of Decrease in Energy***: The second law of thermodynamics states that on the transformation of from one kind to another, there is an increase in entropy a decrease in the amount of useful energy. In this way, when coal in burned in a boiler to produce steam, some of the energy creates steam that performs work, but part of the energy is dispersed as heat to the surrounding air.

Three Sources of Energy

Three sources of energy account for all the work of the ecosystem. These sources are gravitation. Internal forces within the earth and solar radiation. The last one is significant for ecosystem. The solar radiation, which originates from sun is the source of energy for life and is what sets the ecosystem, besides other natural system.

Energy Flow

Due to unidirectional flow of energy, the behaviour of energy in ecosystem is called Energy Flow. From the energetics point of view, energy flow is explained as under:

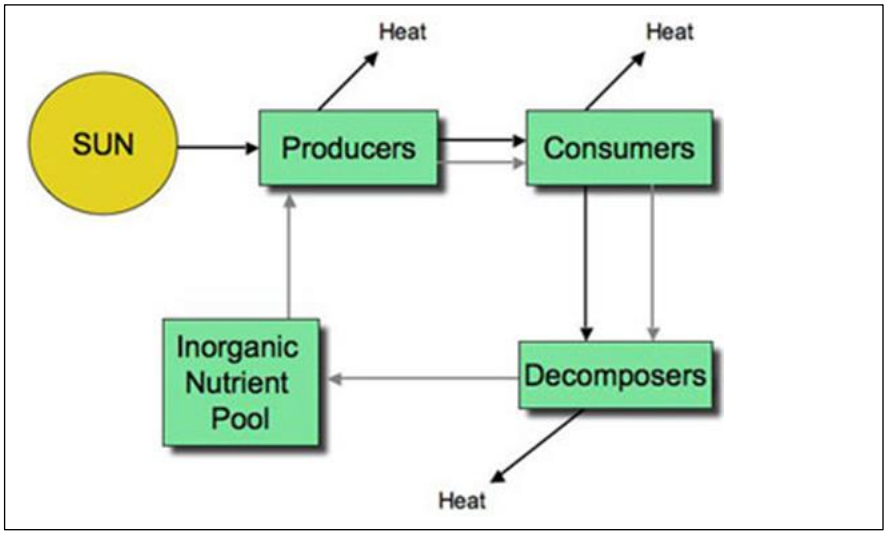
(i) The efficiency of the producers in absorption and conversion of solar energy.

(ii) The use of the above said converted chemical form of energy by the consumers.

(iii) The total input of energy in form of food and its efficiency of assimilation.

(iv) The loss caused through respiration, heat, excretion etc.

(v) The gross, net production.

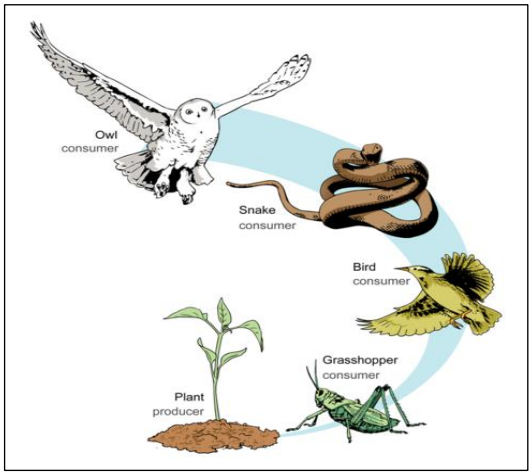


FOOD CHAINS, FOOD WEBS

The transfer of energy from the source in plants through a series of organisms by eating and being eaten constitutes food chains. At each transfer, a large proportion of energy is lost in the form of heat. These food chains are not iso-lated sequences but are interconnected with each other. This interlocking pattern is known as the food web. Each step of the food web is called a trophic level. Hence green plants occupy the first level, herbivores the second level, carnivores the third level and secondary carnivores the fourth level. These trophic levels to-gather form the ecological pyramid.

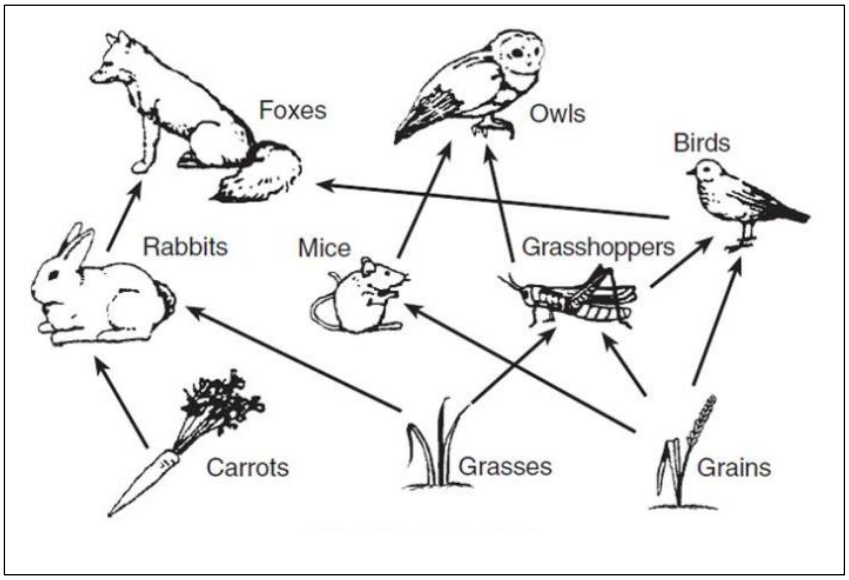
The food chains

The most obvious aspect of nature is that energy must pass from one living organism to an-other. When herbivorous animals feed on plants, energy is transferred from plants to animals. In an ecosystem, some of the animals feed on other living organisms, while some feed on dead or-ganic matter. The latter form the 'detritus' food chain. At each linkage in the chain, a major part of the energy from the food is lost for daily ac-tivities. Each chain usually has only four to five such links. However, a single species may be linked to a large number of species.



The food webs

In an ecosystem there are a very large number of interlinked chains. This forms a food web. If the linkages in the chains that make up the web of life are disrupted due to human activities that lead to the loss or extinction of species, the web breaks down.



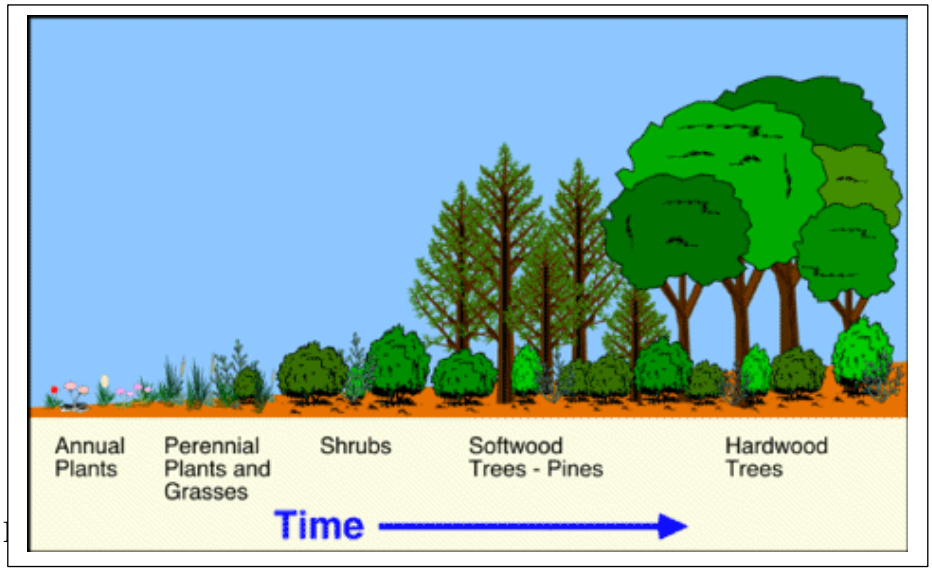
ECOLOGICAL SUCCESSION-MEANING AND TYPES

Meaning of Succession

Biotic communities are not static. Instead they change through time. This change can be understood on several levels. The simplest level is the growth, interaction and death of individual organisms as they pass through their life cycles, affected by the cycles of seasons and other natural phenomena. Some other levels of community change act over longer time spans and that account for much larger changes in community composition and structure. These include ecological succession and community evolution.

It is evident from the above said that the term succession denotes a sequence of changes in the species composition of a community, which is generally associated with a sequence of changes in its structural and functional properties. The term is generally used for temporal sequence (in terms of years, decades or centuries) of vegetation on a site; although only short-term changes can be observed directly, and the long-term ones are inferred from spatial sequences.

The changes associated with succession are usually progressive or directional. This fact enables one to predict which species are likely to replace other in the course of a succession. Succession tends to continue until the species combinations best suited to the regional climate and the particular site are established.



Ecological succession can be explained with the help of illustrations as under: -

1. *Lake*

When a lake fills with silt it changes gradually from a deep to a shallow lake of pond, then to a marsh, and beyond this, in some cases, to a dry-land forest.

2. *Crop field*

When a crop field is deserted or a forest is severely burned over, it is just like a plot of bare ground and a series of plant communities grow up there and replace on another -firest annual weeds, then perennial weeds and grasses, then shrubs, and trees-until a forest ends the development.

In this way, ecological succession is an orderly and progressive replacement of one community by another until a relatively stable community, called the climax community, occupies the area.

(1) In the first example the principal cause of the change in the community was physical process- the filling in of the lake with silt.

(2) In the second example, a principal cause was the growth of plants on an existing soil.

Development

Ecological succession develops as under:

1. **Pioneers**

The first organisms to become established in an ecosystem undergoing succession are called pioneers; the stable community that ends the succession is termed the climax community.

2. **Sere**

The whole series of communities which are involved in the ecological succession at a given area. For example, from grass to shrub to forest, and which terminates in a final stable climax community is called as sere.

3. ***Seral stage***

Each of the changes that take place is a seral stage.

4. ***Community***

Each seral stage is a community, although temporary, with its own characteristics. It may remain for a very short time or for many years.

Classification of Seres

Seres are sometimes classified according to the predominant force that is bringing them about. These forces are biotic, climatic, physiographic, and geologic. Their resultant seres are commonly called bioseres, cliseres, eoseres and geoseres.

Types of Succession

The succession may be of the following two types:

1. ***Primary Succession***

Primary Succession is the process of species colonization and replacement in which the environment is initially virtually free of life. In the other words the process starts with base rose or sand dune or river delta or glacial debris and it ends when climax is reached. The sere involved in primary succession is called presere.

2. **Secondary Succession**

Secondary succession is the process of change that occurs after an ecosystem is disrupted but not totally obliterated. In this situation, organic matter and some organisms from the original community will remain; thus the successional process does not start from scratch.As a result,

secondary succession is more rapid than primary. It is seen in areas burned by fire or cut by farmers for cultivation. The sere involved in secondary succession is calledsubsere.

Types of Succession

The primary and secondary successions may be of three types. The classification is on the basis of the moisture contents:

(a) ***Hydrach or Hydrosere***

The succession when starts in the aquatic environment such as ponds, lakes, streams,swamps, bogs, etc. is called hydrach or hydrosere.

(b) **Mesarch**

The succession when begins in and area, where adequate moisture is present, is called mesarch.

(c) **Xerach or Exerosere**

The succession when starts in xeric or dry habitat having minimum amounts of moisture, such as dry deserts, rocks, etc. is called xerach. A temporary community in an ecological succession on dry as sterile habitat is called xerosere. It may be of three types as under:-

(1) Iithosere-succession initiating on sand;

(2) Psammosere-succession initiating on sand;

(3) Halosere-succession starting on saline water or soil.

Autogenic Community

Autogenic community is the succession progressing entirely as a result of interactions of the organisms and their environment (i.e. “driving force” is internal to the community) for example succession on sand dunes.

Allegonic Community

Allegonic community is the succession moving under the influence of external factors, as input of nutrients, succession in a small pond or bog.

Autotrophic And Heterotrophic Succession

Sometimes, succession is classified as autotrophic and heterotrophic on the basis ofcommunity metabolism

(1) Autotrophic succession is characterized by early and continued dominance of autotrophic organisms like green plants. It begins in a predominantly inorganic environment. In it the energy flow is maintained indefinitely.

(2) Heterotrophic succession is characterized by early dominance of heterotrophs, such as bacteria, actinomycetes, fungi and animals. This sort of succession begins in a predominantly organic environment and there is a progressive decline in the energy content.

Serule

The miniature succession of micro-organic environment and different types of fungi on the fallen logs of the decaying wood, tree bark, etc. is called serule. Drury and Nisbet (1973) classified succession into three main types:

(a) Category I includes many classical types of secondary succession and some primary successions. It involves temporal sequences on one site with climate and physiography mostly remaining stable.

(b) Category II includes many primary successions (especially those in ponds and lakes) and a few secondary successions. In this, temporal sequences on site with the local environment changes under the influence of such external factors as climate, erosion, drainage, nutrient inputs, etc.

(c) Category III includes those changes, which take place over long (geological) timescale, and cover spatial sequences on adjacent sites.

SUCCESSION: GENERAL PROCESS, CLIMAX

General Process

The process of succession being with a bare area or nudation formed by several reasons,such as volcanic eruption, landslide, following sequential steps.

1. ***Nudation***

The process of succession begins with a bare area or nudation formed by several reasons, such as volcanic eruption, Landslide, flooding, erosion, deposite, fire, disease, or other catastrophic agency. Man also may be reason of formation of new lifeless bare areas for example, walls, stone quarrying, burning, digging, flooding large land areas under reservoirs,etc.

2. ***Invasion***

The invasion means the arrival of the reproductive bodies or propagules of various organisms and their settlement in the new or bare area. Plants are the first invaders (pioneers) in any area the animals depend on them for food. The invasion includes the

following three steps:

(a) *Dispersal or migration*: The seeds, spores or other propagules of the species reach the bare area through air, water or animals.

(b) ***Ecesis: Ecesis*** is the successful establishment of migrated plant species into the, new area. It includes germination of seeds or propagules, growth of seedlings and starting of reproduction by adult plants.

(c) ***Aggregation***: In this stage, the successful immigrant individuals of a species increase their number by reproduction and aggregate in large population in the area. As a result, individuals of the species come close to one another.

Different Types of Ecosystem and Their characteristics

Forest ecosystem

Forests are formed by a community of plants which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks vastly different from a group of planted trees, which are in orderly rows. The most 'natural' undisturbed forests are located mainly in our National Parks and Wild-life Sanctuaries. The landscapes that make up various types of forests look very different from each other. Their distinctive appearance is a fascinating aspect of nature. Each forest type forms habitat for a specific community of animals that are adapted to live in it.

What is a forest ecosystem?

The forest ecosystem has two parts:

• ***The non-living or abiotic aspects of the forest***: The type of forest depends upon the: abiotic conditions at the site. Forests on mountains and hills differ from those along river valleys. Vegetation is specific to the amount of rainfall and the local temperatrue which varies according to latitude and altitude. Forests also vary in their plant com-munities in response to the type of soil.

• ***The living or the biotic aspects of the forest***: The plants and animals form communities that are specific to each forest type. The plants and animals form communities that are specific to each forest type. For instance, coniferous trees occur in the Himalayas. Mangrove trees occur in river

deltas. Thorn trees grow in arid areas. The snow leopard lives in the Himalayas while the leopard and tiger live in the forests of the rest of India. Wild sheep and goats live high up in the Himalayas. Many of the birds of the Himalayan forests are different from the rest of India. Evergreen forests of the Western Ghats and North East India are most rich in plant and animal species.

Grassland ecosystems

A wide range of landscapes in which the vegetation is mainly formed by grasses and small annual plants are adapted to India's various climatic conditions. These form a variety of grass-land ecosystems with their specific plants and animals.

What is a grassland ecosystem?

Grasslands cover areas where rainfall is usually low and/or the soil depth and quality is poor. The low rainfall prevents the growth of a large number of trees and shrubs but is sufficient to support the growth of grass cover during the monsoon. Many of the grasses and other small herbs become dry and the part above the ground dies during the summer months. In the next monsoon the grass cover grows back from the root stock and the seeds of the previous year. This change gives grasslands a highly seasonal appearance with periods of increased growth followed by a dormant phase.

A variety of grasses, herbs, and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grasses covered areas. These animals are able to live in conditions where food is plentiful after the rains, so that they can store this as fat that they use during the dry period when there is very little tat. Man began to use these grasslands as pastures to feed his livestock when he began to domesticate animals and became a pastoralist in ancient times.

Desert ecosystem

Desert and semi-arid lands are highly specialised and sensitive ecosystems that are easily destroyed by human activities. The species of these dry areas can live only in this specialised habitat.

What is a desert or a semi-arid ecosystem?

Deserts and semi-arid areas are located in West-ern India and the Deccan Plateau. The climate in these vast tracts is extremely dry. There are also cold deserts such as in Ladakh, which are located

in the high plateaus of the Himalayas. The most typical desert landscape that is seen in Rajasthan is in the Thar Desert. This has sand dunes. There are also areas covered with sparse grasses and a few shrubs, which grow if it rains. In most areas of the Thar the rainfall is scanty and sporadic. In an area it may rain only once every few years. In the adjoining semi-arid tract the vegetation consists of a few shrubs and thorny trees such as kheer and babul.

Aquatic ecosystems

The aquatic ecosystems constitute the marine environments of the seas and the fresh water systems in lakes, rivers, ponds and wetlands. These ecosystems provide human beings with a wealth of natural resources. They provide goods that people collect for food such as fish and marine salt water. There is very little fresh water on earth, which is a key resource for people all over the world.

What is an aquatic ecosystem?

In aquatic ecosystems, plants and animals' live-in water. These species are adapted to live indifferent types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. Aquatic ecosystems may be classified as being ***stagnant*** ecosystems, or ***running water*** ecosystems. The mud gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition. The aquatic ecosystems are classified into ***freshwater, brackish*** and ***marine*** ecosystems, which are based on the salinity levels.

The fresh water ecosystems that have running water are streams and rivers. Ponds, tanks and lakes are ecosystems where water does not flow. Wetlands are special ecosystems in which the water level fluctuates dramatically in different seasons. They have expanses of shallow water with aquatic vegetation, which forms an ideal habitat for fish, crustacea and water birds.

Marine ecosystems are highly saline, while brackish areas have less saline water such as in river deltas. Coral reefs are very rich in species and are found in only a few shallow tropical seas.

The richest coral reefs in India are around the Andaman and Nicobar Islands and in the gulf of Kutch. Brackish water ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sundarbans in the delta of the Ganges.

The Pond ecosystem

The pond is the simplest aquatic ecosystem to observe. There are differences in a pond that is temporary and has water only in the monsoon, and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year When a pond begins to fill during the rains, its life forms such as the algae and microscopic animals, aquatic insects, snails, and worms come out of the floor of the pond where they have remained dormant in the dry phase. Gradually more complex animals such as crabs, frogs and fish return to the pond. The vegetation in the water consists of floating weeds and rooted vegetation on the periphery which grow on the muddy floor under water and emerge out of the surface of the water.

As the pond fills in the monsoon a large number of food chains are formed. Algae is eaten by microscopic animals, which are in turn eaten by small fish on which larger carnivorous fish depend. These are in turn eaten by birds such as kingfishers, herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond. The temporary ponds begin to dry after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals such as frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.

Lake ecosystem

A lake ecosystem functions like a giant permanent pond. A large amount of its plant materialism the algae, which derives energy from the sun. This is transferred to the microscopic animals, which feed on the algae. There are fish that are herbivorous and are dependent on algae and aquatic weeds. The small animals such as snails are used as food by small carnivorous fish, which in turn are eaten by larger carnivorous fish. Some specialised fish, such as catfish, feed on the detritus on the muddy bed of the lake.

Energy cycles through the lake ecosystem from the sunlight that penetrates the water surface to the plants. From plants energy is transferred to herbivorous animals and carnivores. Animals excrete waste products, which settle on the bottom of the lake. This is broken down by small animals that live in the mud in the floor of the lake. This acts as the nutrient material that is used by aquatic plants for their growth. During this process plants use Carbon from CO2 for their growth and in the process release Oxygen. This Oxygen is then used by aquatic animals, which filter water through their respiratory system.

Stream and River ecosystems

Streams and rivers are flowing water ecosystems in which all the living forms are specially adapted to different rates of flow. Some plants and animals such as snails and other burrowing animals can withstand the rapid flow of the hill streams. Other species of plants and animals such as water beetles and skaters can live only in slower moving water. Some species of fish, such as Mahseer, go upstream from rivers to hill streams for breeding. They need crystal clearwater to be able to breed. They lay eggs only in clear water so that their young can grow successfully.

As deforestation occurs in the hills the water in the streams that once flowed throughout the year become seasonal. This leads to flash floods in the rains and a shortage of water once the streams dry up after the monsoon.

The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds the stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

Marine ecosystems

The Indian Ocean, the Arabian Sea and the Bayou Bengal constitute the marine ecosystems around peninsular India. In the coastal area these is shallow while further away, it is deep. Both these are different ecosystems. The producers in this ecosystem vary from microscopic algae to large seaweeds. There are millions of zooplankton and a large variety of invertebrates on which live fish, turtles and marine mammals.

The shallow areas near Kutch and around the Andaman and Nicobar Islands are some of the most incredible coral reefs in the world. Coral reefs are only second to tropical evergreen forests in their richness of species. Fish, crustacea, starfish, jellyfish and the polyps that deposit the coral are a few of the thousands of species that form this incredible world under the shallow sea.

Deforestation of adjacent mangroves leads to silt being carried out to sea where it is deposited on the coral which then dies. There are many different types of coastal ecosystems which are highly dependent on the tide.

The marine ecosystem is used by coastal fisherfolk for fishing which forms their livelihood. In the past, fishing was done at a sustainable level. The marine ecosystem continued to maintain its abundant supply of fish over many generations. Now with intensive fishing by using giant nets and mechanised boats, fish catch in the Indian Ocean has dropped significantly.

Seashore ecosystems

Beaches can be sandy, rocky, shell covered or muddy. On each of these different types, there are several specific species which have evolved to occupy a separate niche. There are different crustacea such as crabs that make holes in these and Various shore birds feed on their prey by probing into the sand or mud on the sea shore. Several different species of fish are caught by fishermen. In many areas the fish catch has decreased during the last decade or two.

What are the threats to aquatic ecosystems?

Water pollution occurs from sewage and poorly managed solid waste in urban areas when it enters the aquatic ecosystem of lakes and rivers. Sewage leads to a process called eutrophication, which destroys life in the water as the oxygen content is severely reduced. Fish and crustacea cannot breathe and are killed. A foul odour is produced. Gradually the natural flora and fauna of the aquatic ecosystem is destroyed. In rural areas the excessive use of fertilisers causes an increase in nutrients, which leads to eutrophication. Pesticides used in adjacent fields pollute water and kills off its aquatic animals. Chemical pollution from industry kills a large

number of life forms in adjacent aquatic ecosystems. Contamination by heavy metals and other toxic chemicals affects the health of people who live near these areas as they depend on this water.

CASE STUDY

Threats to wetlands in Assam -Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Centre (ARSAC), Guwahati, and the Space Research enter, Ahmadabad, has revealed that1367 out of 3513 wetlands in Assam are under severe threat due to invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the State in terms of fisheries and tourism. Though the wetlands of Assam have the capacity of producing 5,000 tons of fish per hectare per year, around 20,000 tonnes of fish have to be imported to meet local demands. This is primarily due to poor wetland management.

How can aquatic ecosystems be conserved?

For sustainable use of an aquatic ecosystem, water pollution must be prevented. It does not make sense to allow water to be polluted and then try to clean it up. Changing the nature of the aquatic ecosystem from a flowing water ecosystem to a static ecosystem destroys its natural biological

diversity. Thus, dams across rivers decrease the population of species that require running water, while favouring those that need standing water. Aquatic ecosystems, especially wetlands, need protection by including them in Sanctuaries or National Parks in the same way in which we protect natural forests. These sanctuaries in aquatic ecosystems protect a variety of forms of life as well as rare fish which are now highly endangered such as the Mahseer. Wetland Sanctuaries and National Parks are of greatest

importance as this is one of the most threatened of our ecosystems. As the proportion of the earth's surface that is naturally covered by wetlands is very small compared to forests or grasslands, the wetland ecosystems are very highly threatened.