Unit- 4: Ecosystem

Sub-unit-4.1: Introduction-

In nature, plants do not live by themselves/alone. They are always associated with small or large animals belonging to different levels of food habits and evolutionary scale. Plants and animals not only influence one another but also interact with their non-living environment. The interactions of plants and animals with one another and with their non-living environment form a complex system known as ecosystem/ ecological system.

The term ecosystem was first used by A. G. Tansely (1935). He defined the ecosystem as the system resulting from interaction of all the living and non-living factors of the environment.

According to E. P. Odum (1963), the ecosystem is the basic functional unit of ecology which includes both the living organisms and the non-living environment interacting with each other. Thus ecosystem is the major ecological unit. It represents highest level of ecological integration which is based on the flow of energy.

Ecosystem has both structure and function. The structure is related to the species diversity which is very complex. The function of ecosystem is related to flow of energy and recycling of material. The structure and function of an ecosystem depends on the dimensions of space and time. An important feature of an ecosystem is that it is capable of self maintenance and self regulation. It has a tendency to resist the change and to remain in a state of equilibrium- a phenomenon known as Homeostasis (Homo = Same/similar and Stasis = State/ standing).

General Characters of ecosystem: (Smith, 1966).

1) It is a major structural and functional unit of ecology.
2) The ecosystems have both structure and function.
3) The structure of ecosystem is related to its species diversity. More the species diversity ultimately more the complex ecosystem and vice versa.
4) The function of an ecosystem is related to energy flow and recycling of material through and within the ecosystem.
5) The relative amount of energy required to maintain an ecosystem depends upon its structure.
6) The ecosystem matures by passing from less complex/ simple to more complex stages through the process of succession.
7) The changes within the environment represent selective pressure upon the population to which the organisms must adjust.

Sub-unit 4.2: Types and Components of Ecosystems:

1. Types of Ecosystems:

According to habitat the ecosystems are classified into 2 main types namely natural and artificial ecosystem.

Types of Ecosystems

A) Natural ecosystem		**B) Artificial ecosystem**
i) Terrestrial ecosystem	**ii) Aquatic ecosystem**	
Grassland	a) Fresh water	b) Marine water
Desert		
Forest (Subtropical rain, Deciduous, etc)	Lotic- running water	
	Lentic- Standing water	

A) **Natural ecosystem:**

The ecosystem operates by themselves under natural conditions without any major interference by man is known as natural ecosystem. Based on the type of **habitat**, natural ecosystems are further divided into 2 groups as –terrestrial and aquatic ecosystem.

i) Terrestrial ecosystem: This type of ecosystem occurs on **land** and shows different types of habitat such as forest, grassland, desert, etc.

The forest ecosystems are further divided into different types on the basis of type of forest e.g. Tropical rain forest, Sub-tropical forest, Deciduous forest, etc.

ii) Aquatic ecosystem: The ecosystem which occurs in **water** is called as aquatic ecosystem. On the basis of salt concentration in water the aquatic ecosystems are either fresh water or marine water ecosystem.

The fresh water ecosystems are again classified into 2 types as -

a) **Lotic ecosystem**- ecosystem which occurs in **running water** as in river, stream, etc
b) **Lentic ecosystem**- ecosystem in **standing water** as lake, pond, pool, swamp, etc

B) Artificial ecosystem:

The ecosystem which is maintained and managed by man is known as artificial ecosystem. In artificial ecosystem due to addition of energy and planned manipulation the natural balance is disturbed regularly. e.g. Crop ecosystem like maize, wheat, sugarcane, etc.

E. P. Odum (1959) has classified the ecosystems on the basis of **ratio of photosynthesis** (P) to **respiration** (R) (basis of community metabolism). He recognised 3- types of ecosystems as

i) Stable community- where P/R = 1.
ii) Autotrophic community- where P/R > 1 (i.e. Photosynthesis is more than the respiration).
iii) Heterotrophic community- where P/R < 1 (i.e. respiration is more than photosynthesis).

2. Components of Ecosystem:

An ecosystem contains 2 major components as the living organism and the non-living environment. Thus the entire living community constitutes the biotic component and other parts of the environment constitute the abiotic components.

Components of ecosystem

Abiotic/ Non-living	Biotic/ Living
1. Inorganic substances	1. Producers
2. Organic compounds	2. Consumers- Primary, Secondary, Tertiary
3. Physical/Climatic factors	3. Decomposers

1) Abiotic components:

The abiotic components of an ecosystem include the non-living substance of environment. e. g. water, soil, air, light, temperature, etc.

Odum (1971) classified the abiotic components into **3** types as –

a) Inorganic substances:

These are nutrients or raw materials for green plants and it shows recycling. e.g. soil, water, mineral elements (Ca, P, K, Mg, Fe, etc) and gases like N_2, O_2, CO_2, etc.

b) Organic compounds:

These include lipids, proteins, carbohydrates, products of dead plants and animals like urea and humus. These are derived from organisms.

c) Physical or Climatic factors:

It comprises the light, moisture, wind, temperature, etc. The principle component is solar energy which is trapped by green plants and stored in the form of chemical energy.

2) Biotic Components:

The biotic components include all living organisms present in the environmental system. From **nutritional point** of view the biotic components are classified into 3 types by Odum (1971). These three types are as follows-

a) Producers:

The producers are mainly the green plants. They are specifically called as producers because on the earth only green plants can synthesis the food material. The green plants use the radiant energy of sun and converted into chemical energy by the process known as photosynthesis. These are needed by the plants for their own growth and reproduction. The oxygen evolved as a byproduct in photosynthesis is essential for all living organism for respiration.

Not only the green plants but some bacteria are also included in this group of producer. Actually the producers manufactures the food and do not produce the energy. Thus they only convert the radiant energy into chemical energy hence the green plants are also designated as converter or transducer. The producers form the base on which entire biotic community in the ecosystem depends.

b) Consumers:

Those living organisms of an ecosystem which consume/take the food material synthesized by the producers are known as consumers. They can not prepare/ synthesize their own food but dependent on other organisms for food. Therefore their mode of nutrition is heterotrophic.

All animals including human beings are consumers. Depending upon the **feeding habit** consumers are further grouped into 3 categories.

i) Primary Consumers:

They are purely herbivorous animals that are dependent for their food on green plants or producers. They are all live directly upon the green plants therefore known as herbivores. The animals like cow, ship, goat, buffalo, rabbit, deer, insect, rodents are primary consumers.

ii) Secondary Consumers:

These are carnivores or omnivores. The carnivores directly eat the herbivores and omnivores are the animals which consume producers as well as herbivores as their food. e.g. Dog, cat, snakes, fox, wolves, man, etc.

iii) Tertiary Consumers:

These are the top grade carnivores which prey upon other carnivores, omnivores and herbivores. These are not killed and eaten by other animals. Lion, tiger, hawk, vulture, etc are examples of tertiary or top consumers.

3) Decomposers:

The producers and consumers have their own life cycle. After completion of their life cycle die, undergoes the process of decomposition and become food for bacteria and fungi. They degrade or break down the complex organic substances into simpler components and finally into H_2, CO_2 and nitrogenous compounds which are recycled back into the soil and atmosphere. The chemical substances which are passed from organism to organism ultimately go back to the non-living environment and once again made available to the producers. Thus the decomposers play a very special and important role in an ecosystem.

Some Examples of Ecosystems:

1) **Aquatic ecosystem: Fresh water- (Pond ecosystem)**

A fresh water pond is an example of typical ecosystem. It is self sufficient, self regulating ecosystem with basic components like abiotic and biotic components.

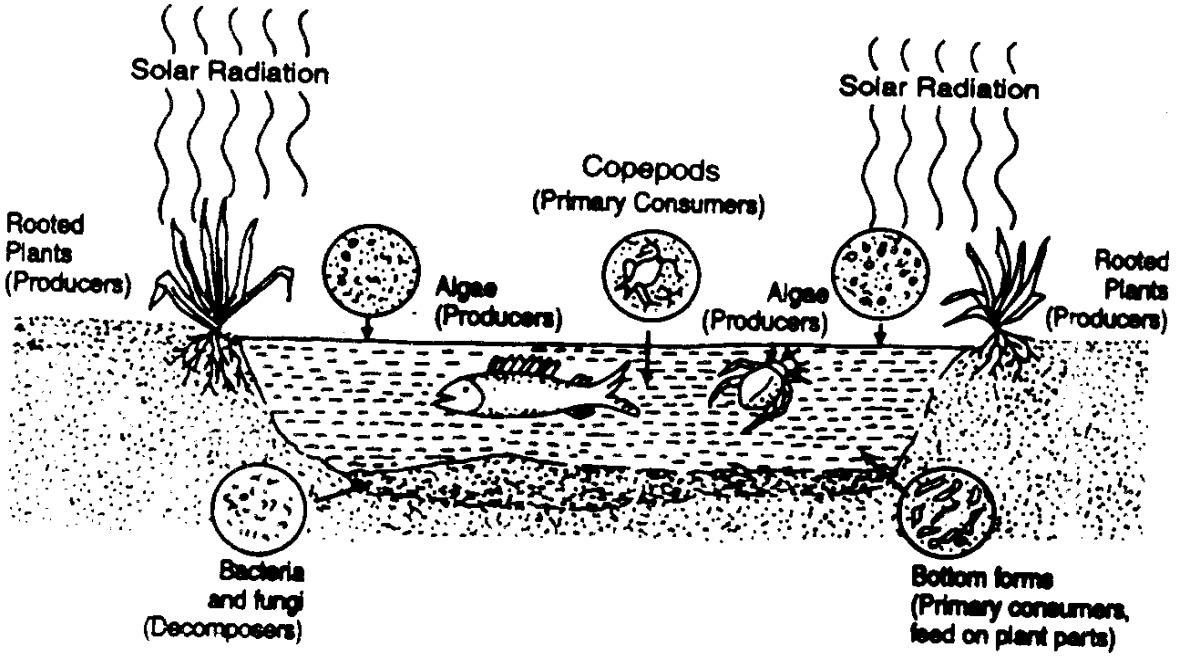
a) Abiotic components: It includes water, dissolved minerals like chlorides, iron, calcium, atmospheric gases like oxygen and carbon dioxide, etc. Solar radiations are main source of energy. These factors affect growth of plants and animals in ponds.

b) Biotic components: The chief biotic components of pond ecosystem include- producers, consumers and decomposers.

i) Producers: The producers of this ecosystem are algae, photosynthetic bacteria and other green plants. These are either floating or rooted at the bottom. (*Spirogyra, Cladophora, Volvax, Ulothrix, Cosmarium, Macrocystis, Oscillatoria, Hydrilla, Azolla*, etc). These green plants trap solar energy and with the help of minerals manufacture the food material during photosynthesis.

ii) Consumers: The primary consumers (herbivores) in pond ecosystem are tadpole larvae of frog, fishes and other small aquatic animals which consume green plants and algae as their food. These herbivorous aquatic animals are the food of secondary consumers like insects, frogs, larger fishes, water snakes, crabs, etc. These secondary consumers are further eaten by still upper grade of consumers like birds, cranes, herons, etc.

iii) Decomposers: They are also known as micro-consumers. They feed on dead organic matter, remains of animals and plants. It includes mainly bacteria and fungi. *Aspergillus, Cladosporium, Penicillium, Fusarium, Rhizopus,* etc.



2) Terrestrial ecosystem: Grass land Ecosystem

The various components of grass land ecosystem are as follows-

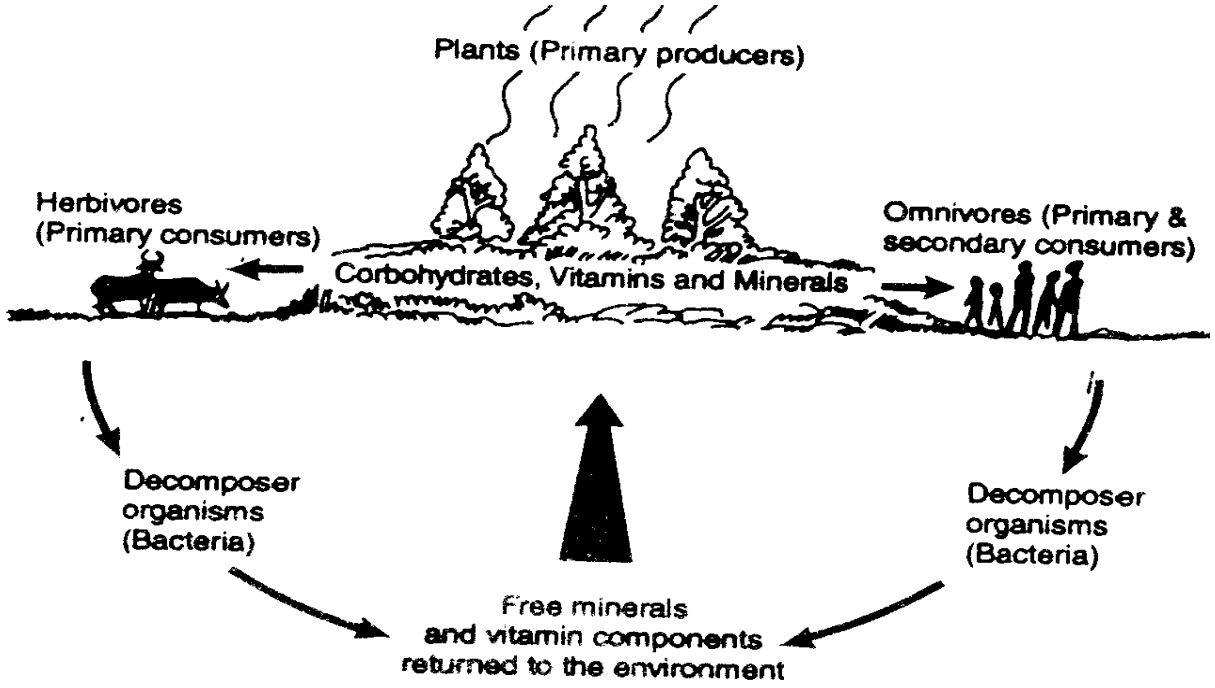
a) Abiotic components: It includes soil substratum, soil water, dissolved mineral nutrients like calcium, phosphate, nitrate, sulphate, etc. Other abiotic components are carbon dioxide, oxygen, sunlight, temperature, etc. which influences the growth of plants.

b) Biotic components:

i) Producers: In grass land ecosystem, different types of grasses like *Cyandon, Setaria, Eleusine, Digitaria*, etc forms the producers. In addition to this some herbs and shrubs also constitute producers. They manufacture their own food material by photosynthesis.

ii) Consumers: There are number of consumers which may be grouped as primary, secondary and tertiary consumers. The primary consumers (herbivores) includes rabbit, sheep, deer, mouse, buffaloes, cow, many insects, etc. which feed on the grasses. These primary consumers are eaten by animals like fox, snake, frog, lizard, etc. which constitutes secondary consumers. However, lion, tiger, hawk, vulture are consumers of top level.

iii) Decomposers: The dead bodies of all the consumers are acted upon by microorganism and convert complex organic compounds into simpler forms. These free elements again return to the environment and are reutilized by the producers once again for manufacturing of organic compounds.



Sub-unit 4.3 Dynamics of ecosystem:

The dynamics of an ecosystem revolves round the living plants and animals and it is also intimately related with their behaviour and interactions. Plant life has been found to be most important for the functioning of an ecosystem. Plants play three important roles in the ecosystem.-

1) They modify the environment and determine the types of organisms that can live in a particular ecosystem.
2) The plants have an ability to trap the solar energy and convert it into chemical forms which is the ultimate source of energy for all other organism in the ecosystem.
3) The plants are also capable of absorbing the essential elements (like nitrogen, calcium, phosphorous, etc) form the soil and made them available to animals for their growth and development.
4) Plants are also important in maintaining the balance of certain important gases like CO_2 and O_2 in the atmosphere.

a) Food chains and their types:

The transfer of food energy from producers through a series of organisms (herbivores, carnivores to decomposers) with repeated eating and being eaten is known as food chain. Each step in food chain is called as trophic level or energy level. The green plants in any ecosystem utilize the radiant energy of sun and transformed into chemical energy. Thus green plants occupy first trophic level i.e. primary producers. Same chemical energy is made available for different grades of consumers.

e.g. In a grass ecosystem, grasses are producers. These grasses are eaten by grasshopper. The grasshoppers are eaten by birds and finally by hawk. Thus a food chain is formed and it is shown as below-

i) Grasses ---------- Grasshopper --------- Birds ---------- Hawk.

ii) Grasses ---------- Insects/Grasshopper ---------Frog ---------- Snake ---------- Hawk.

In any ecosystem, food chain runs directly in which green plants i.e. producers are eaten by herbivores, herbivores are eaten by carnivores and carnivores are eaten by top grade carnivores.

Producers -------- Herbivores ------- Carnivores ---------- Top grade carnivores.

Types of food chains: There are **3- types** of food chains.

i) Grazing food chain: (Predator food chain)-

This type of food chain starts from living green plants goes to grazing herbivores and then to various grades of carnivores. It goes from smaller to larger organisms. This food chain is directly dependent on influx of solar radiations. Majority of ecosystem in nature follow this type of food chain. e.g.

1) Grasses---- Rabbit----- Hawk

2) Grasses -------- Grasshopper ------- Lizard --------- Hawk.

3) Grasses --------Cow -------- Tiger/Lion.

ii) Parasitic food chain:

The plants and animals in an ecosystem are infected by various parasitic insects. Thus the parasites derive their food energy from their host. That is it goes from larger to smaller organisms. e.g.

1) Plants ---------- Aphids 2) Larger animals ---------- Lice.

iii) Detritus food chain: (Saprophytic food chain)-

[Detritus means dead organic remains including metabolic wastes and exudates derived from different organisms].

It goes from dead organic matter into micro-organism and ends into inorganic substances. Some micro-organisms like bacteria, fungi attack on the dead organic matter and liberate the energy and inorganic substances into the environment.

Dead organic matter ------ Micro-organisms ------ Energy and inorganic substances.

These ecosystems are thus less dependent on direct sunlight but are dependent on the influx of organic matter produced in another ecosystem. A good example of detritus food chain is found in **mangrove ecosystem** which grows in luxuriantly into estuarine environment.

b) Food Webs:

Many food chains occur in an ecosystem but these are not independent. These various food chains are interconnected with each other forming a sort of interlocking or overlapping pattern known as food web. A food web always shows several alternative pathways for the flow of energy. The food web helps to maintain stability of ecosystem. An organism in any trophic level may utilize the food from 2 or more different organisms of lower trophic level. e.g. In a grassland ecosystem, the grasses are eaten by variety of animals like grasshopper, mouse, rabbit, etc. These are eaten by several predators which ultimately forms a network of food chain i.e. food web.

Grasshopper Lizard

Grasses Rabbit Hawk

Mouse Snake

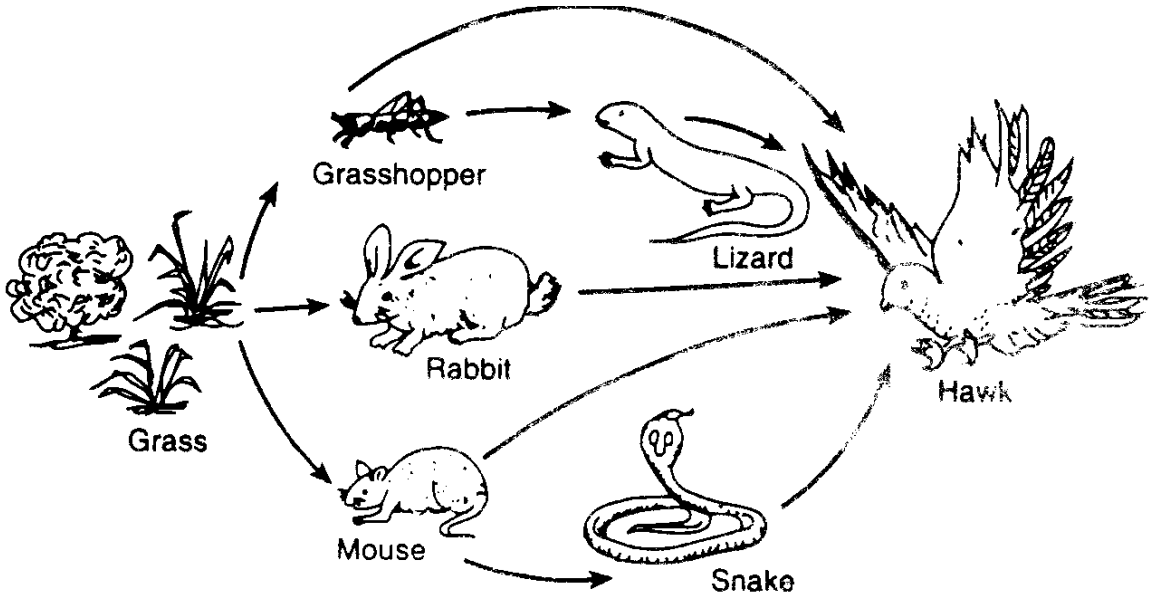


Fig. 6.28 (a) : Diagrammatic sketch showing a food web in a grassland ecosystem. There may be seen five possible food chains interlocked together making the food web.

c) Trophic Levels:

The position occupied by an organism in the food chains is known as trophic level. The word trophic derives from the Greek term trophē referring to food or feeding. A food chain represents a succession of organisms that eat another organism and are, in turn, eaten themselves. Thus in the ecosystem there are mainly three basic trophic levels as producers, consumers and decomposers.

1. **Producers** (autotrophs) are typically plants or algae.
2. **Consumers** (heterotrophs) are species that cannot manufacture their own food and need to consume other organisms.
3. **Decomposers** (detritivores) break down dead plant and animal material and wastes and release it again as energy and nutrients into the ecosystem for recycling.

d) Ecological Pyramids and their types:

The food chain in an ecosystem consists of several food/trophic levels extending from primary producers to the top carnivores. Each food level is a step in the food chain. These various steps are interconnected with each other giving a definite trophic and functional structure to the ecosystem. The interrelationship between the successive food levels may be expressed in terms of number of individuals, biomass or energy flow. This relationship can be expressed graphically/in the form of pyramids is known as Ecological pyramids. In short, ecological pyramid is a graphical representation of the number, biomass and energy flow of successive trophic levels of an ecosystem. The use of ecological pyramids was first described by an ecologist Charles Elton in 1927. In each ecological pyramid, the producers form the base and top carnivores occupy the apex. Depending upon the number of organism in each trophic level, the biomass and energy flow there are -3 types of ecological pyramids. These three are 1) Pyramid of numbers 2) Pyramid of biomass and 3) Pyramid of energy.

1) Pyramid of Numbers:

The relationship between the number of producers, primary, secondary and tertiary consumers forms the pyramid of number. Here the number of individuals in various trophic levels per unit area at any time is taken into consideration. The shape of pyramid depends upon the size of individuals. That means the pyramids are either upright or inverted.

If the producers are smaller in size i.e. their number is more as compared to the number of consumers, the pyramid is upright. E.g. In pond ecosystem, the producers are diatoms and green algae which are minute but their number is very large. Thus they form a broad base of the pyramid. Above this the small fishes forms the herbivores, then larger fishes forms carnivores group followed by top carnivore like heron having less number. Here the number of individuals goes on decreasing in the successive trophic level results in an upright pyramid. Similar types of pyramids are also observed in grassland ecosystem, forest ecosystem and crop ecosystem.

On the other hand a single tree ecosystem shows an inverted pyramid. In a tree ecosystem, the number of primary producer is least and that of the consumers is maximum. A single tree i.e. producer supports a large number of fruit eating birds which then support a still higher number of parasites like bugs and lice. This relationship of increasing number from producer to consumers of different grades constitutes an inverted pyramid.

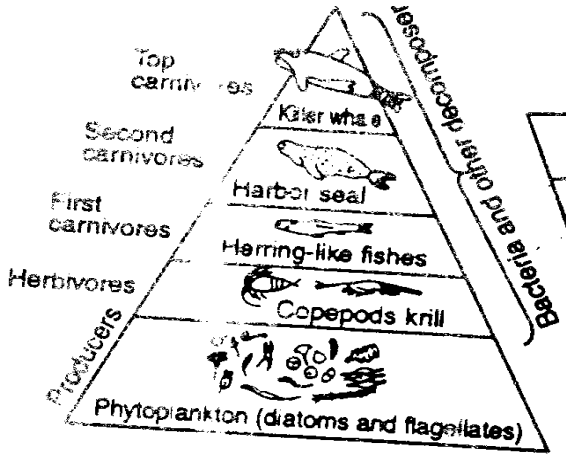


Fig. 6.20 : Upright pyramid of numbers for pond

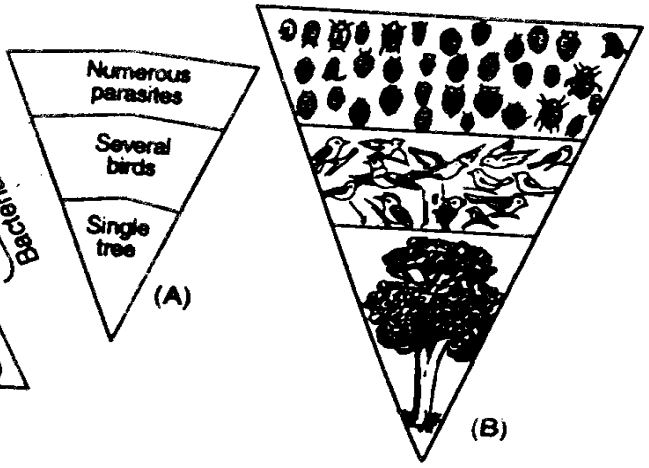


Fig. 6.22 : Inverted pyramid of number for single tree ecosystem A and B

2) **Pyramid of Biomass:**

Biomass is nothing but the fresh weight or dry weight (organic matter) of individuals in the ecosystem at any one time per unit area. The biomass of different trophic level also constitutes a relationship among them and forms a pyramid.

In terrestrial ecosystem like those of grass land or a single tree, the biomass of producer is always highest and therefore they form a broad base or upright pyramid. In grass land ecosystem, grasses in the form of producers produces sufficiently large biomass which is consumed by herbivores (rabbit, deer, cow) then by different grades of consumers (Fox, tiger, lion). Not only the number of producers goes on decreasing but its biomass also decreases hence the biomass pyramid is upright.

Similarly in case of a single tree ecosystem, the biomass of a tree is always highest than the biomass of consumers like birds and parasites on them. Therefore a single tree ecosystem, though number of consumers goes on increasing the biomass goes on decreasing resulting into upright pyramid. On the other hand, in a aquatic ecosystem like pond the situation is entirely different. The biomass of primary producers such as phytoplankton, green algae and other small green plants is very less as compared to biomass of fishes and other animals which feed on the phytoplankton.

Thus in an aquatic ecosystem the relationship between the biomass of producers and consumers forms an inverted pyramid.

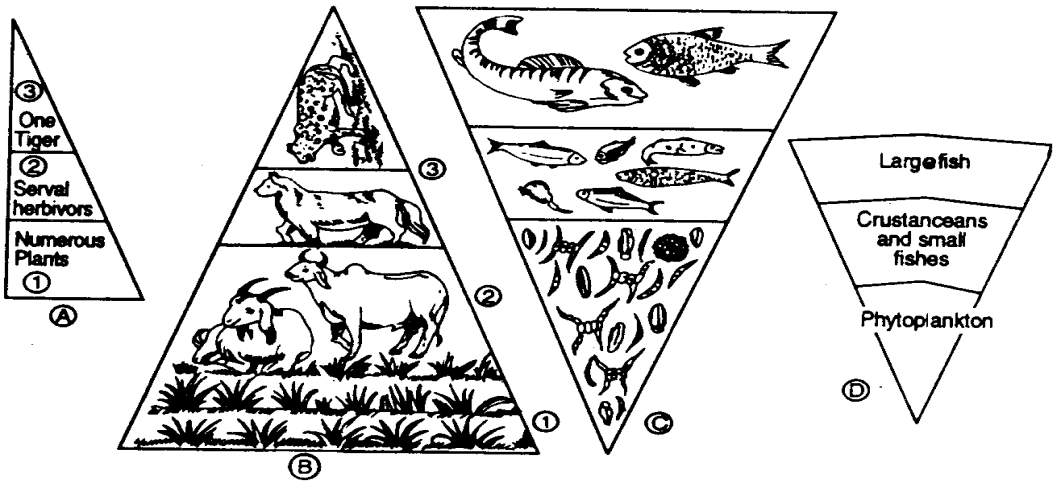


Fig. 6.23 : A and B upright biomass pyramid for grassland ecosystem and C and D inverted biomass pyramid for pond ecosystem.

3) **Pyramid of Energy:**

In nature, sun is the main source of energy for all living organisms. On earth planet, only green plants are capable to convert the radiant energy into chemical energy. Therefore all the living organisms depend directly or indirectly on green plants for their energy source. The energy trapped by the green plants passes from one organism to other organism and slowly its amount goes on decreasing.

Green plants in this energy pyramid functions as primary producers and come at the base of pyramid. They consume certain amount of energy for their own growth and excess is stored in fruits, seeds, etc. The herbivorous animals directly consume this stored energy from the producers. It is used for their own growth and extra amount is again stored in the form of proteins. Lipids, etc. The different grades of carnivores feed on them and thus they indirectly consume energy present in the plants. Thus every time when energy passes from one trophic grade to another it goes on decreasing. When the organisms die the decomposers act on and release the energy present in different tissue in the form of heat. It is lost in the atmosphere. Thus energy pyramid in any ecosystem is always upright and energy flow is unidirectional.

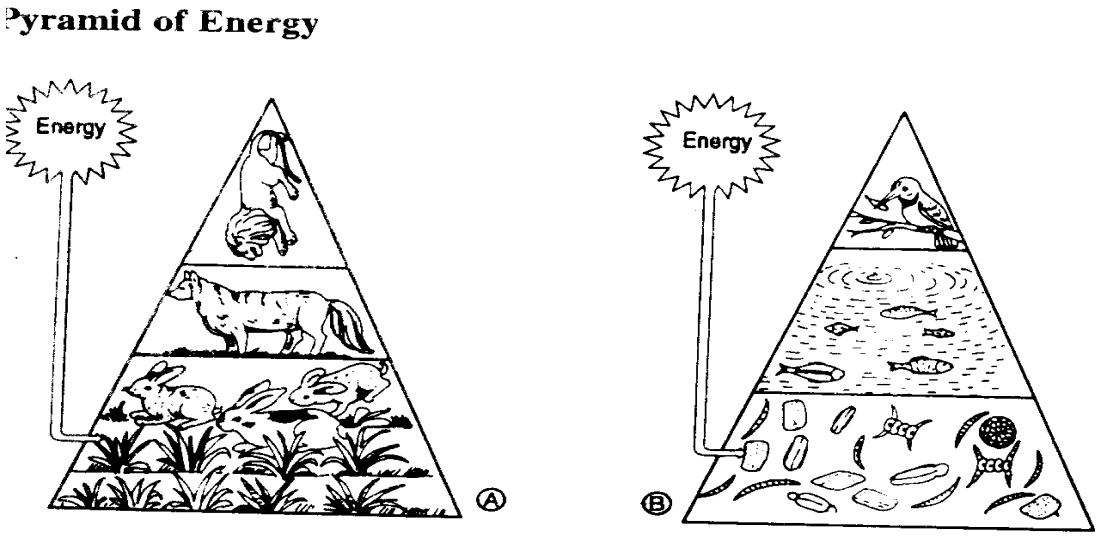


Fig. 6.24 : Pyramid of energy (A) in grass land ecosystem and (B) in aquatic ecosystem.

e) Energy flow in Ecosystem:

The energy used by all living organism for their life processes is derived from solar energy. The sun gives out vast quantities of heat, light and X-irradiations. Much of the heat and ultraviolet light are absorbed by the atmosphere (Ozone layer) and never reach the earth surface. Thus only one percent of light energy is utilized by green plants for food synthesis in photosynthesis. The green plants convert the light/radiant energy into chemical energy which is then incorporated as food. Some amount of food energy is used the plants for their own growth and remaining is stored in the seed and fruit. The herbivorous animals feed on this food material and it is then passes from one trophic level to another in ecosystem. During this transition from one trophic level to other less and less energy is made available and every time some amount of energy is lost as heat into the atmosphere.

In an ecosystem, the energy flow is always unidirectional and follows two important laws of thermodynamics. According to first law of thermodynamics energy of the universe is constant and it is neither created as fresh nor destroyed but only transformed from one form to another form. Thus green plants convert the radiant energy into chemical energy. The herbivores feed on plant products. During digestion of food material the organic compounds are converted into simpler forms and some amount of energy is released in the form of heat. Here the energy follows the second law of thermodynamics. During transformation of energy from one form to another, some energy is lost in the form of heat.

The food energy from producers is transferred to herbivorous animal, different grades of consumers and finally to decomposers in an ecosystem. At each step in energy flow large amount of energy is lost as heat. The amount energy available to one trophic level from previous level is approximately 10% of the energy to received (Kozlwosky, 1968). Raymond Lindemann (1942) for the first time determined the energy flow through whole ecosystem. To explain the energy flow in an ecosystem different models have been proposed by different scientists.

1) Y-shaped energy model of Odum: (Box and Pipe Model of energy flow):

To explain one way flow of energy in an ecosystem E. P. Odum (1963) proposed this Y-shaped energy model. In this model boxes represents the biomass of the trophic level and pipes as the flow of energy between various trophic levels like producers, consumers and decomposers.

The green plants absorb the solar radiations during photosynthesis. The total light is represented by L and the absorbed light as La. During this process only 1 to 5% of absorbed light is converted into chemical energy (food). The primary productivity (Pg or A) is the total organic matter produced by green plants including the respiration loss. However, the net primary production (Pn) represents the available food to the heterotrophs. Under ideal conditions the rate of gross production will be 90% and 10% loss of energy during respiration. However, under normal conditions net production rate is about 50% only. Out of this only small amount is made available as energy source for herbivores, carnivores and decomposers. At every step some amount of energy is lost during respiration (R).

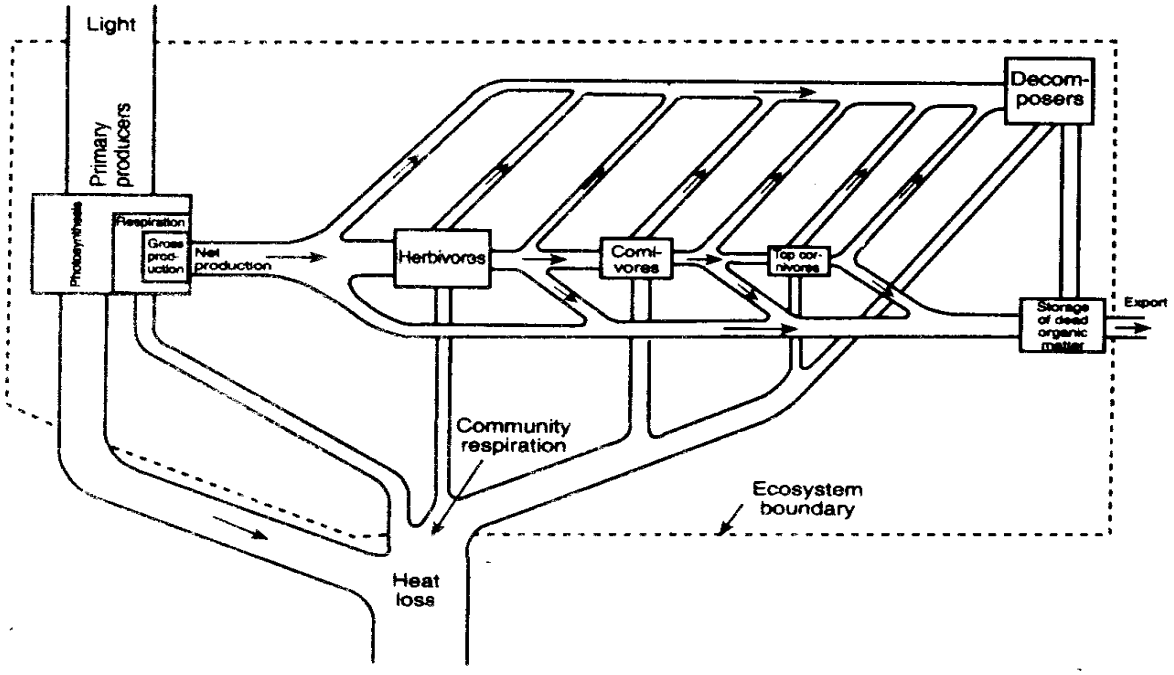


Fig. 6.30 : Y Shaped Energy Flow Model

Sub-unit 4.4- Phases and Types of Biogeochemical Cycles:

There are many nutrients which are required for normal growth and development of plants and animals. These nutrients are obtained from the environment. The essential nutrients/ elements are gases like CO_2, O_2, N_2 of atmosphere and water, mineral nutrients like calcium, potassium, iron, magnesium, phosphorus, etc are present in the soil. The gases, water and minerals are absorbed by the green plants from the environment, passes in food chains via many organisms and ultimately returned to the environment. These nutrients are again reutilized by the green plants. Thus the mechanism by which various nutrients circulate between the environment and biological community is called as Biogeochemical cycle.

There are two types of biogeochemical cycles-

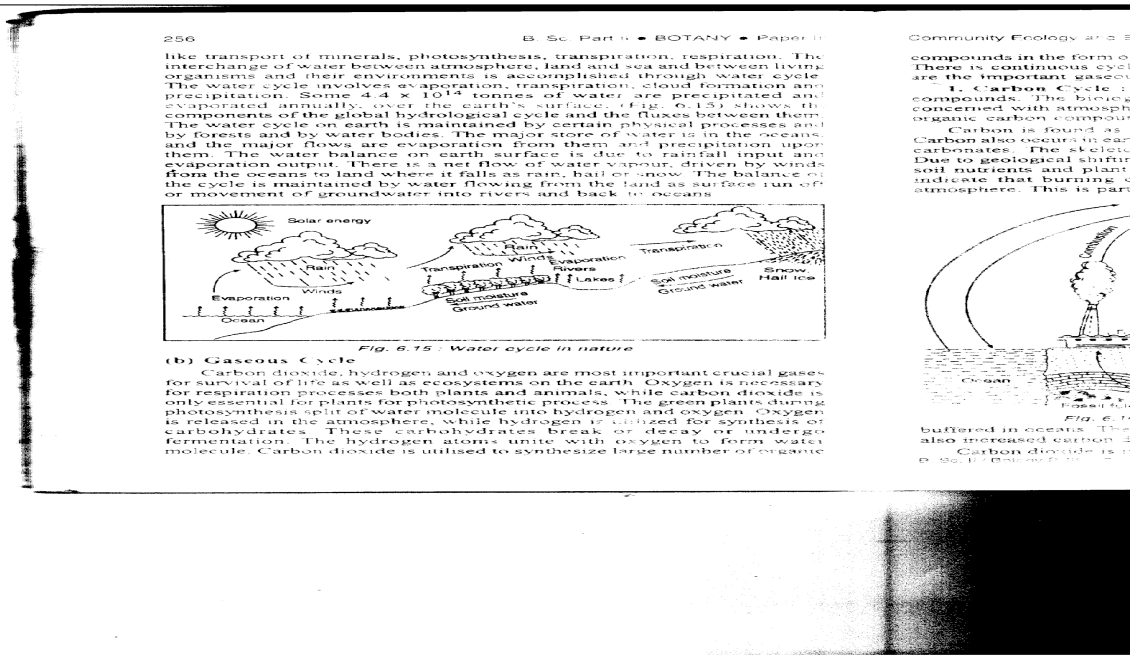
1) **Gaseous type**: (Nutrients are present in the **atmosphere** and in **gaseous** state) and
2) **Sedimentary type**: (Nutrients are present in the **soil** and in **solid** state).

1) **Hydrological cycle/ Water cycle:**

Ecologically water is most important factor which controls the whole ecosystem. The circulation of water between atmosphere, land, sea and living organism with their environment forms the water cycle. It involves evaporation, transpiration, cloud formation and precipitation. Water cycle determines the distribution, structure and function of organism in ecosystem.

Water of atmosphere reaches the earth surface through precipitation and from the earth surface. It reaches the atmosphere through evaporation and transpiration. Water from lake, steam, pond, and ocean evaporates due to heat of sun. The vapours are then driven by wind from ocean to land where it forms cloud on cooling. The precipitate falls on the earth surface in the form of rain or snow. The precipitated water again gather in lakes, ponds, rivers, ocean, etc.

The entry of mineral elements in the plant body is controlled by water because it acts as a universal solvent. Very small amount of it is consumed by plants and animals. The water cycles through the food chain in the combined form and part of it is again released in evaporation and transpiration. Thus water balance on earth surface is maintained due to rain fall input and evaporation output.

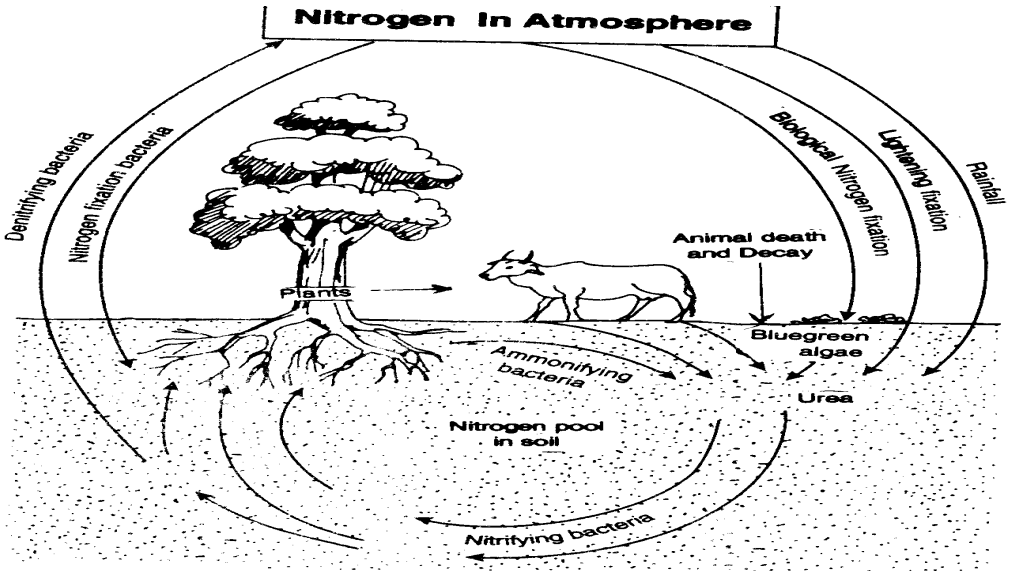


2) **Nitrogen cycle:**

Nitrogen is an important gas present in the atmosphere. Even though large amount of nitrogen (about 78%) is present in the atmosphere it can not be directly utilized by the green plants and animals. The free gaseous atmospheric nitrogen is first converted into nitrate (by oxidation) or ammonia (by reduction).

In nature only few bacteria and blue green algae can convert the atmospheric nitrogen into nitrogenous compounds. The nitrate thus formed is further reduced to ammonia which is then utilized for synthesis of amino acids and finally proteins. The proteins are eaten by the animals. The excreta of animals and dead bodies of plants and animals are attacked by different bacteria which convert into the nitrogen or ammonia. The ammonia is later oxidized by nitrifying bacteria and again converted into nitrate (Nitrification).

The nitrate present in the soil is absorbed by plants or it may convert to free nitrogen by denitrifying bacteria (Denitrification). The free atmospheric nitrogen is fixed by symbiotic bacteria present in the root nodules of legumes (Nitrogen fixation). In nature there is also one more method of fixation of nitrogen and that is b the way of lighting and thundering. During lighting free atmospheric nitrogen combine with oxygen and forms nitrate. This nitrate mixes with the rain water and come into the soil from where it is again reutilized by plants. A part of soluble soil nitrate is washed into ocean through river. In ocean it is utilized by marine autotrophs in the formation of organic matter and some amount of it is deposited on the ocean bottom.



3) **Phosphorous cycle:**

Phosphorous is an important mineral nutrient for both plants and animals because it is a constituent of DNA, RNA, AMP, ADP, ATP, NADP, etc .

The primary source of phosphorous is the apatite group of minerals. However, it is normally available following mineralization and nitrification of dead organic matter. Because of the strong affinity of phosphorus for certain kinds of clay particles i.e. kaolinite it is not readily available to plants. Phosphorous occurs in the soil rocks as calcium phosphate, iorn phosphate or aluminum phosphate, etc.

Green plant obtain phosphorous via labile inorganic phosphorous pool. The water soluble phosphate becomes available to aquatic plants. The dissolved phosphorous is absorbed by the plants and converted into organic forms. This organic phosphorous is then travel through various trophic levels in the food chain. After the death of plants and animals the decomposers attack them and liberate phosphorous in the environment.

Some amount of phosphorous is also returned to the earth in the form of bird excreta, fish excreta and died fishes.

It should be noted that phosphorous together with nitrogen represents the major source of pollution of natural water and is responsible for the phenomenon known as eutrophication.

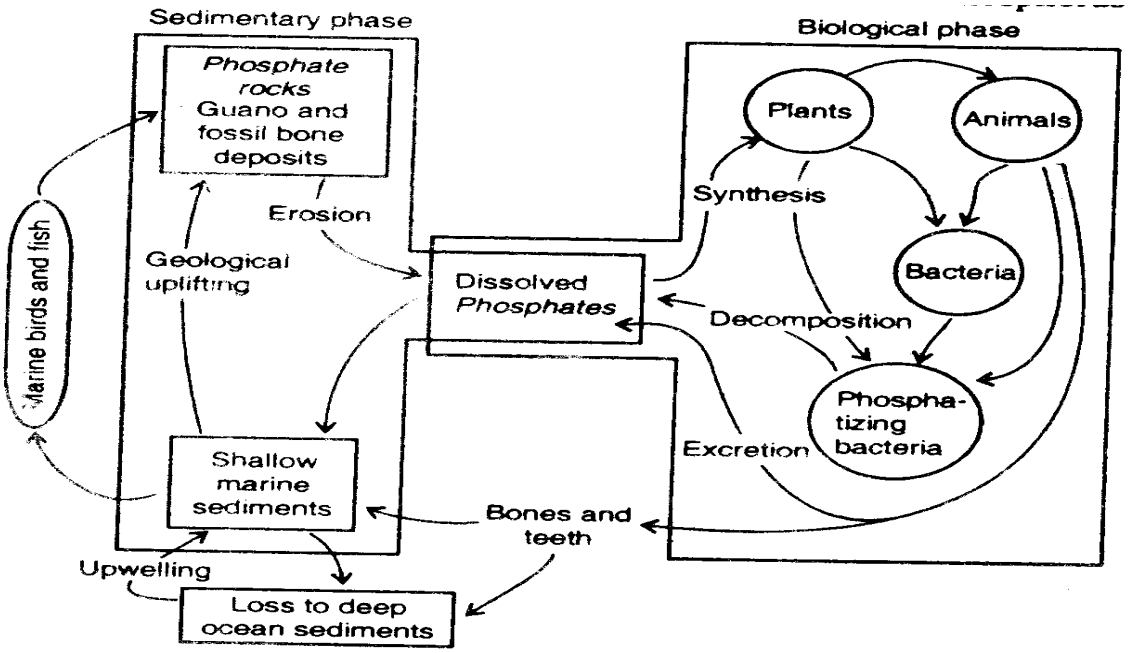


Fig. 6.18 : Phosphorus Cycle

c) Trophic organization: An ecosystem is the basic functional unit of ecology. It has two components as abiotic and biotic. The biotic components include all living organisms. They are interdependent and always live in harmony on the principle of 'give and take' basis to maintain equilibrium and to establish stable and self regulating ecosystem.
Depending upon the mode of nutrition all these biotic components are classified into -3 categories as a) Autotrophy b) Heterotrophy and c) Parasitism.
a) Autotrophy: All green plants, algae and chlorophyll bearing bacteria are included in this group. They can convert radiant energy into chemical energy with the help of CO2, H2O and chlorophyll during process of photosynthesis. That means they prepare their own food material hence they are known as autotrophs or producers in an ecosystem. These organisms will become source of food material for heterotrophs.
b) Heterotrophy: Those organisms unable to prepare their own food but depends on the autotrophs for their food requirement are known as heterotrophs. The heterotrophs include consumers of different grades, saprophytes and certain parasites.

The herbivorous animals like sheep, cow, rabbit, deer feeds on the grasses or leaves of plants forms a consumers of first order. These herbivores are consumed by carnivores like tiger, lion, etc. These carnivores form second order consumer. The animals like man, rat feed on both plant as well as animals are known as omnivores. However, the animals like hawk, eagle are called as top consumers. These consumers are placed at definite position and their number decreases in the food chain.
c) Parasitism: Parasites are those organisms which depend for their nutrition on other living plants or animals. Their mode of nutrition is heterotrophic. Parasitism is an association of two dissimilar organisms in direct contact where one partner is beneficial and it causes harm to other. In parasitism, the plant which supplies food to other plant is known as host and the plant which takes food is called as parasite. The host plants are autotrophic and parasites may grow on any part of the host plant. The parasite plant is not in contact with soil but produces special types of root like structure known as haustoria. These haustoria penetrate into the host tissue and absorb necessary food material. This parasitic relationship leads to changes in the host to a considerable extent leading to economic losses.

The parasites may be ectoparasites (Leach- living on the body of host animal with temporary attachment) or endoparasites (tapeworm- living permanently inside the host body). The parasites may be total or partial and are confined to either roots or stem of host plants. Some of the common examples of parasites are as follows-
a) Stem parasites: i) Cuscuta- Clerodendron ii) Viscum- Sandlewood iii) Loranthus- Mango.
b) Root parasites: i) Striga- Jowar, sugarcane ii)Orobanche- Tobacco, Brinjal iii) Reflesia – Vitis.

Ecosystem Productivity:

The productivity of an ecosystem is the rate at which solar energy is fixed by green plants of an ecosystem. In other words the amount of organic matter accumulated in any unit time. The productivity is generally measured in terms of energy i.e. Calories produced in a unit area per unit time. The productivity is variable in different ecosystem. The productivity is of following different types as ---
1) Primary productivity: Green plants fix solar energy and accumulate it in organic forms as chemical energy. Since it is the first and basic form of energy storage in producers known as primary productivity. In short the primary productivity is defined as the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producers. The primary productivity is further distinguished as –
a) Gross primary productivity: The total amount of dry matter made by plants (producers) in photosynthesis is called as gross primary productivity. This is the maximum amount of energy available to the plants themselves and to other organism in the ecosystem. It depends on the

chlorophyll content. (The rate of primary productivity are estimated in terms of either chlorophyll contents as chl/g dry wt/unit area or photosynthetic number as amount of CO_2 fixed /g chl/hour).

b) Net primary productivity: All organisms in an ecosystem including producers respires and during respiration some amount of food material from gross productivity is converted into CO_2 and water due to this some dry weight is decreased/ lost. Thus the amount of energy bound in organic matter per unit area and time that is left after respiration is called as net primary productivity. Thus the relation between gross primary productivity, net primary productivity and respiration can be represented as –

Net primary productivity (NPP) = Gross primary productivity (GPP) – Respiration.

2) Secondary Productivity: The rate or production of new biomass by the heterotrophic organisms (consumers) in the ecosystem is known as secondary productivity. OR The amount of energy available to other trophic levels is called as secondary productivity. The secondary productivity actually remains mobile i.e. keeps on moving from one organism to another.

Population ecology

Sub-unit-3.1: Concept of population:

The term population is derived from Latin word 'Populus' meaning people and hence it is referred to a group of people occupying in a particular area. However, the population is a group of individuals of the same species in a given area at a specific time. OR A group of individuals of a particular species which occurs in a particular space and interbreeding takes place among themselves are known as population.

Population ecology is the study of populations and their interactions with the environment.

OR

Population ecology is the study of individuals of the same species where the processes as aggregation, interdependencies between individuals, etc and the various factors governing such processes are emphasized. That means in the population ecology the focus in on the environmental factors that affects the population size of a given species, population growth rate, special dispersion of individuals with the populations and how they interact with their environment.

There are two types of populations namely-

1) **Monospecific population:** The population which has the individuals of only one species is known as monospecific population.

2) **Polyspecific / Mixed population**: It is the population of individuals of more than one species. However, in ecology the polyspecific population is generally referred to as a community.

Sub-unit 3.2: Density, Natality and Mortality:

Each population shows specific characteristics:--

1) Population density:

The size of a population is generally expressed as number of individuals in a population. The density is nothing but the number of individuals per unit area of space. The number of individuals in a population in relation to a definite unit area of space is termed as population density. The density may be expressed e.g. number of bacteria / phytoplankton per liter of water or per cubic meter water. The organisms like larger trees may be expressed as the number of trees per acre or hector. That means the dimension of unit area of space is depends upon the size of organisms. Larger the size of organism larger is the size of space and vice versa.

There are two types of density:--

a) Crude density: It is the density/ number of organisms per unit total space.

b) Specific/ Ecological/ Economic density: It is the density/ number of organisms per unit of habitat space (i.e. available space) or volume that can actually be colonized by the population.

The density of a population is always dependent upon the factors like birth rate, death rate, emigration, immigration, migration and many other environmental factors like season, weather conditions, food availability, etc.

The population density mathematically can be determined by using following formula-

$$D = \frac{n/a}{t}$$

where, D = population density

n = number of individuals

a = unit area

t = time unit

If we plot a time on X- axis and the density on Y- axis for a population a typical growth curve of 'S' shape is obtained.

2) Natality:

Natality, in population ecology, is the scientific term for birth rate. The natality or birth rate of a population means simply the number of new individuals produced by birth, germination or fission per unit time. OR Natality is the ability of any population to increase through birth rate. It is a positive force for the increase of population density. Natality varies a great deal among different organism.

Along with mortality rate, natality rate is used to calculate the dynamics of a population. They are the key factors in determining whether a population is increasing, decreasing or staying the same in size. The natality rate is measured as number of birth per 1000 individuals per year. However, plant natality is more difficult to determine/ measure than animals. The factors that make it difficult to measure are—

1) Seed production of individual plant varying year to year.
2) Seed production will also vary with age classes.
3) The seeds will become dormant for long period of time before germination.

Thus among the plants, for the expression of natality, emphasis is generally given on the reproductive capacity which is the number of individuals that can be raised from each parent individuals after successful germination of seed.

The natality is divided into 2 types as –

1) Maximum / Physiological natality: It is also known as absolute or potential natality. The number of births or theoretical maximum production of new individuals under ideal conditions is known as maximum / physiological natality. In this type, the reproduction is being limited by physiological factors (of the individual organism) and not by any ecological factors. That means there is abundance of resources such as food, water, etc and no competition among the new individuals. This is also called Fecundity rate.

2) Ecological / Realised natality: It refers actual increase in number of individuals in the population existing in specific environmental conditions. The environmental / ecological factors have some influence on the birth rate.

The natality rate of a population can be calculated by following formula—

$$B = \frac{Nn}{t}$$

Where- B = birth rate/ unit time
Nn = new individuals born
t = time

3) Mortality:

Mortality means death of members/ individuals among the population. The mortality rate means the death of individuals per unit time. In other words, it is also expressed as loss of individuals from the population per unit time. Mortality is always dependent on the conditions of habitat under which that organism is surviving.

The mortality rate differs for individuals of different age groups i.e. seedling die at the time of establishment and a tree can survive for a long time. Like natality, mortality is also divided into 2 types as—

a) Minimum Mortality: It is also called specific or potential mortality. It is theoretical number of death which occurs under ideal conditions due to old age. That means even under the best conditions individuals would die due to old age which is determined by their physiological longevity. It is a constant for a population.

b) Ecological Mortality: It is the actual loss of individuals from the population under a given environmental conditions. The ecological mortality is not constant and varies with population and environmental conditions.

Mortality of an individual can occur in any one of the phase as juvenile phase, adult phase and reproductive or old phase.

For a population the important thing is survival of members but not which members die. Thus survival rates are of much interest than the death rate. The survival rates are generally expressed by survivorship curve / survival curve. If we plot, number of survivors in a population against time a curve is obtained which is known as survival curve.

There are three general types of survival curves which represent the different nature of survivors in different types of populations. These three are as follows-

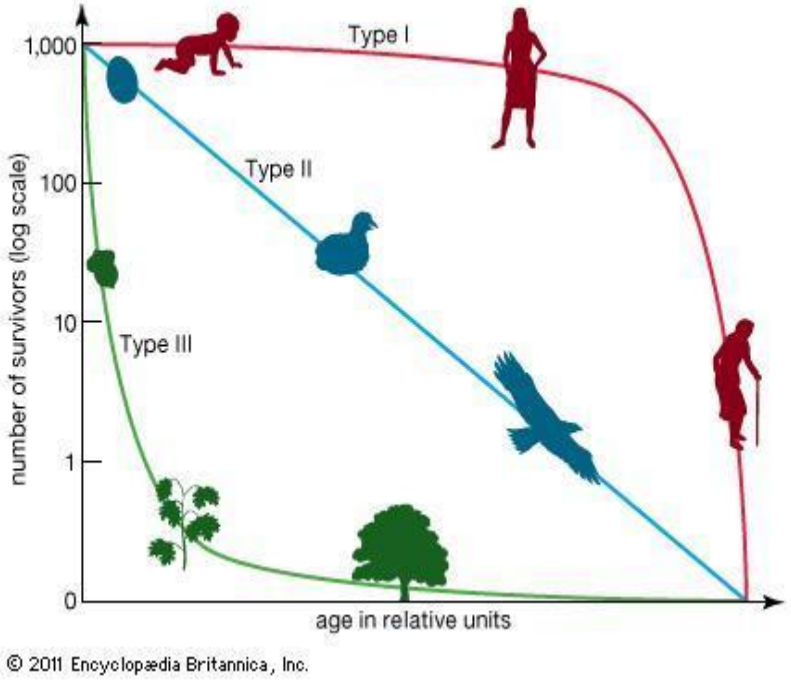
a) Highly convex curve: This type of is obtained in the populations of many perennial plants and trees where mortality rate is low until near the end of the life span of the species. That means the

mortality is very low during juvenile stage and adult stage but die after reaching post reproductive (old) phase within a short period of old age.

b) Highly concave curve: In many annual herbaceous plants and weeds there is a high mortality rate during juvenile phase. These plants show this type of survival curve.

c) Diagonal curve: The bushes or shrubs having life span of few years exhibit more or less uniform or even death rate during all the stages of life span, such a curve is known as diagonal curve.

Survivorship curve:



Population often can be divided into one of two extreme types based on their life history strategy-

1) r- selection: The herbaceous plants and weeds generally grow rapidly and utilize most of the food in the production of flowers, fruits and seeds. i.e. during reproductive phase. Such plants are also called r-selection type.

2) k- selection: The plants like trees and shrubs which live for larger period follows convex and diagonal curve remains survival in climax stage during the development of population. These are known as k- selection type.

In any population/ community when r- selection type of plants are more in number the community is not in equilibrium stage whereas the population/ community with more number of k-selection plants it is fairly stable. However, no population in the world has a constant age specific survival rate throughout the whole life span.

Sub-unit-3.3: Limiting (regulatory) factors of population-

The population once established in any habitat or region reaches equilibrium. Later on the number of individuals in that population may fluctuate up and down due to variations in environmental resistance or seasonal or annual changes in availability of resources. The fluctuations in the number of individuals are also due to dispersal of the organism in the population. There are number of reasons for population dispersal like obtaining food, avoid overcrowding, effect of environmental factors like wind, water, light, temperature, etc. The various factors which affect the growth, development and distribution of number of organisms of the population are classified into two types as 1) Abiotic factors and 2) Biotic factors.

1) Abiotic factors: These are also known as **environmental** factors. The abiotic factors include both climatic factors like rainfall, temperature, etc and edaphic factors like soil composition, soil moisture, minerals, etc.

a) Nutrients- Plants absorb nutrients, for their growth, from the soil in the form of dissolved minerals. These mineral elements are dissolved in soil water hence soil water is also important for population growth. Mineral elements play vital role in plants metabolism. e.g. Sodium level have regulatory role in the control of the population size of the meadaw vole (*Microtus pennsylvanicus*). The mangrove population can survive only when it receives dully tidal includations in an estuarine environment. The successful population increase is found when there is sufficient amount of nutrients and moisture is available.

2) Biotic factors:

The biotic factor includes different kinds of plants, animals and microorganisms. These different organisms play a well defined role in a stable ecosystem. These organisms live together influencing each other's life and also modifies the surrounding environment.

a) Competition: The competition between individuals of a species occurs whenever there are limited environmental resources like food, space, light, water, minerals, etc. The competition may be interspecific or intraspecific type. As per Darwin's theory of natural selection, the dominant species survive with faster growth while weaker species are eliminated.

In plants, the competition for various purposes such as obtaining water, minerals, sunlight, space, etc. In many angiospermic plants, the increased competition for pollinators decreases seed production. This may leads to extinction of species. In order to avoid competition, many plants produce some harmful substances for life of other organisms. This phenomenon is called as antibiosis / allelopathic effect.

Competition results into elimination of weaker species, population control and regulation as well as adjustment to varied habitat.

b) Density: Density means the number of individuals of a species in a unit area / volume. It is primarily a characteristic of population and gives an idea of degree of competition. It is always dependent upon rate of birth and death of these organisms.

The density of various species in a community varies in time and space and affects the community structure. The living organisms in a community are dependent upon each other as well as on non-living environment for their survival and multification. The population densities of living organisms determine the survival of species. The stronger the species survives while weaker species are eliminated during course of development of population in a particular habitat.

If a population density of plants (producers) is more it can supports the population of herbivores as well as various grades of carnivores and which is helpful to keep the natural balance of the ecosystem.

In a stable community, the producers i.e. green plants density should be more to sustain the life of consumers. However, increase in animal population density results in increased competition. The increased density also tends adversely to affect mortality, natality and thereby population growth.

Multiple choice questions:

1. Population ecology is the study of ---------- of same species.
   a) people b) organisms c) individuals
2. ---------- refers to number of individuals per unit area.
   a) population b) abundance c) density
3. Natality is ---------- rate of individuals.
   a) birth b) death c) survival
4. ---------- means rate of death of member of population.
   a) natality b) mortality c) density
5. The theoretical maximum production of new individuals under ideal conditions is known as -----.
   a) Maximum/physiological natality b) Ecological natality c) Mortality.
6. The number of organisms per unit total space is called ----------.

a) Crude density b) Specific density c) Ecological natality