Chapter 14

Ecosystem

Ecosystem: Introduction & Types

ECOSYSTEM

- A.G.Tansley- The term "ecosystem" first of all coined by A.G. Tansley. According to Tansley - Ecosystem is symbol of structure and function of nature.
- E.P. Odum - Father of ecosystem ecology. According to E.P. Odum - Ecosystem is the smallest structural and functional unit of nature or environment.
- Karl Mobius - Used term biocoenosis for ecosystem.
- Thienmann - Used term biosystem for ecosystem.
- Koestler - Used term helon for ecosystem.
- Sukhachov - Used term biogeocoenosis for ecosystem.
- Misra - Used term ecocosm for ecosystem.
- Forbes - Used term microcosm for ecosystem.

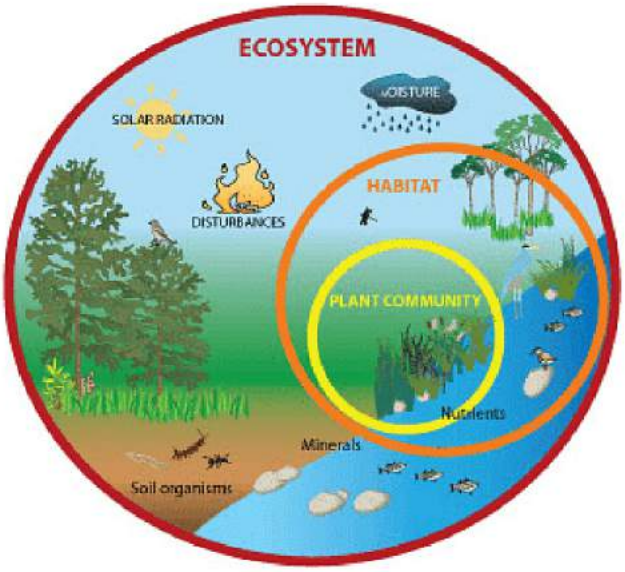


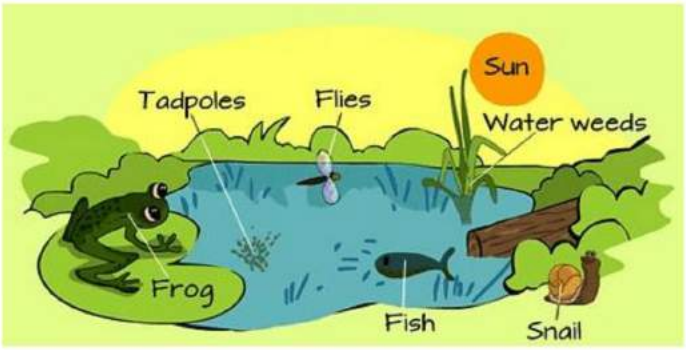
Fig: Ecosystem

Definition: Total living factor (biotic) and total nonliving factor (abiotic) of the environment present in a particular area is called ecosystem.
Note:

- The boundaries of ecosystem are indistinct and have a overlapping character over each other.
- Ecosystem is the smallest structural and functional unit of nature or environment. It is a self regulatory and selfsustaining unit.
- Ecosystem may be large or small. Single drop of water may be an ecosystem.
- Ecosystem may be temporary or permanent.

Example of Ecosystem:

Let us consider an example of puddle which can be shown in the figure below. In it, we can find several living things (such as frog, tadpole, flies, fish and snail) and non – living things (such as sun, water, temperature, weather, humidity, etc.)



TYPE OF ECOSYSTEM:

(1) Natural Ecosystem
(2) Artificial Ecosystem

1. Natural Ecosystem:

- **Terrestrial Ecosystem:** Examples are forest, grassland, tree, desert ecosystem.
- **Aquatic ecosystem:** This ecosystem is found in water and encompasses aquatic flora, fauna and water properties. Aquatic ecosystem are of two types:

The Marine Ecosystem: It is the biggest ecosystem that covers around 71% of the surface of earth. Water in marine ecosystem is salty and has high amount of minerals. Several divisions of marine ecosystem are coral reefs, oceanic, salt marshes, estuaries and hydrothermal vents.

The Freshwater ecosystem: In contrast with the marine ecosystem, the freshwater ecosystem is just 0.8% of the earth surface. Three basic kinds of freshwater ecosystem are wetlands, lentic and lotic. This ecosystem comprises of amphibians, reptiles and 41% of the fish species of the world.

2. Artificial Ecosystem: Man made, Example: Cropland, Gardens etc.

On the basis of size types of ecosystem:

(i) Mega ecosystem – Ocean/Sea
(ii) Macro ecosystem – Forest
(iii) Micro ecosystem – Pond
(iv) Nano ecosystem – Drop of water

Ecosystems & Ecological Pyramids

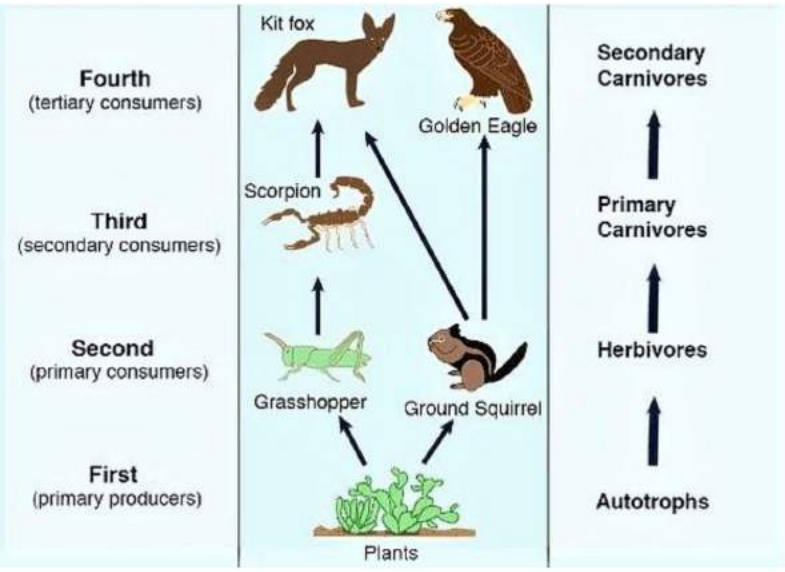
Ecosystems

Food Web

- In a big ecosystem, many food chains are interlinked together on different trophic levels to form a food web.
- In the food web, the transfer of food energy is unidirectional but from many different alternative pathways.
- In the food web members of a particular tropic level obtain their food according to their choice and taste but that type of facility is not present in the food chain.
- It means they have more than one option or alternative for getting food.

As much as the food web is complex the ecosystem is more permanent or stable. Such a type of ecosystem is not destroyed naturally and continues for a long time. This ecosystem is not affected by the loss of any organism of any particular tropic level. **Those ecosystems which have a simple food web are not very**

stable it means that they can be finished at any time if there is a change in any particular tropic level.



Homeostasis

- The ecosystem is a dynamic (functional) system because continuous interaction is going on in between abiotic or biotic components, so the ecosystem is present in an equilibrium position.
- The ecosystem is also self maintainable and self-regulatory system, which means an ecosystem maintains a balance between different tropic levels.
- Each tropic level controls the other tropic level in an ecosystem.
- If any change takes place in any tropic level of the ecosystem, the other tropic levels of this ecosystem may react according to it.
- So ecosystem always remains in equilibrium. This feature of the system is known as **homeostasis.**

Cybernetics

The science of self-control as (homeostasis) in an ecosystem is called cybernetics.

Pyramids of Ecosystem

- Graphical representation of ecological parameters at different tropic levels in the ecosystem is called pyramids.
- These parameters are Number, Biomass and Energy. First of all, the pyramid was formed by **Charles Elton**; So we called it the Eltonian pyramids.

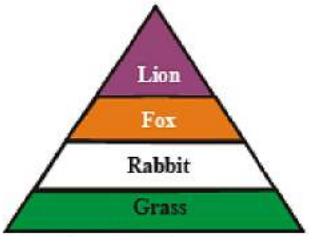
- In pyramids basal, mid and top tiers show the parameter values for producer, herbivores and carnivores in the ecosystem.

Pyramids are of Three Types:

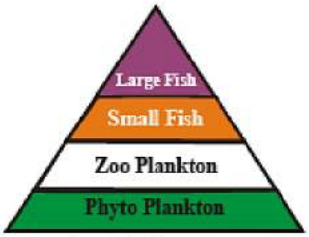
- **Pyramids of Number**
- **Pyramids of Biomass**
- **Pyramids of Energy**

1. Pyramids of Number

In this type of pyramid, the number of the individual organisms in various tropic levels is shown. These pyramids are mostly upright because the number of producers [T1] is maximum and No. of herbivores and carnivores decrease towards the apex or at successive tropic levels, such as Grassland ecosystem and aquatic ecosystem.

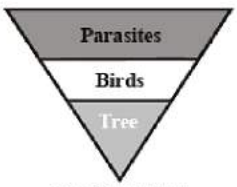


Grass land Ecosystem



Aquatic Ecosystem

But in a tree ecosystem, the pyramid of numbers is inverted. This is called a parasitic ecosystem because birds (herbivores) depend on the tree (producer) and parasites (consumer) depend on birds, therefore with an increase in the number of tropic levels, the number of the organisms increases sequentially.



Tree Ecosystem

Note:

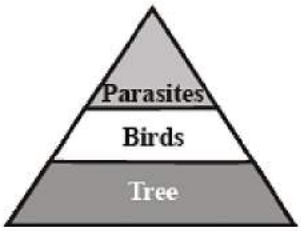
- Maximum number of producers are present in aquatic ecosystem. **The number of organisms at any tropic level depends upon the availability of**

organism which are used as food on lower level so availability of food is the main factor.

- Pyramid of number shows **biotic potential** of a ecosystem. The number of members of any particular species in favourable conditions is called their biotic potential. When the number of the members of any species increases then it is called population explosion. Because of this, existence of the species comes in danger. Human population is also near this condition at present.

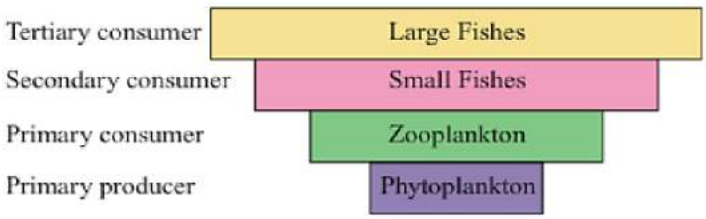
2. Pyramids of Biomass

Pyramids of biomass represent the total amount of biomass of each tropic level of the ecosystem, mostly these pyramids are also upright (erect) e.g. (tree ecosystem), forest ecosystem.



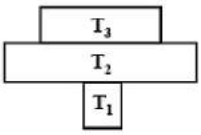
Pyramid of biomass in Tree ecosystem

Pyramids of biomass in an aquatic ecosystem are inverted because in it producers are micro-organisms and their biomass is very less.



Pond Ecosystem
(Inverted)

Note: Pyramid of lake on the basis of biomass:



Limitations of Ecological Pyramids

- It does not take into account the same species belonging to two or more trophic levels.
- It does not accommodate a food web.
- Saprophytes are not given any place.

Some Special Points related to Biomass

- **Standing crop –** Total amount of **living organic matter** present in a particular area in particular time in an ecosystem is known as standing crop. It may be expressed in terms of weight per unit area.
- Biomass is the standing crop expressed in terms of weight (i.e. organism mass). Biomass is measured by a bomb calorimeter**.**
- **Standing quality or Standing state** – Total amount of **inorganic substances** such as P, S, N, H present in a particular area at a particular time in an ecosystem is known as standing state.

Note: The pyramids of biomass show the **standing crop** of ecosystem.

3. Pyramids of Energy

It represents amount of energy at different tropic levels, energy pyramids are always upright or erect because there is a gradual decrease in energy at successive tropic levels. According to the **10% law of Lindemann**, the 90% part of obtained energy of each organism is utilized in their various metabolic activities and heat and only 10% energy is transferred to the next tropic level. So 90% energy is lost at each tropic level, therefore **top consumers like lion etc. are ecologically weakest** but physically they are strong.
Note: Pyramids of energy represent the productivity of ecosystem as well as transfer of production in ecosystem.

Some Information: The respiration cost also increases along successive higher tropic levels normally on an average respiration of **producers** consume about **20%** of its gross productivity. **Herbivores** consume about **30%** and **60%** consumed by **carnivores** in respiration.
Productivity
There are two types of productivity present:

1. Primary productivity

Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight ($g/m^2/yr$) or energy (Kcal m^{-2}). The rate of biomass production is called productivity. It is expressed in terms of $g^{-2}yr^{-1}$ or (Kcal m^{-2}) yr^{-1} to compare

the productivity of the different ecosystems. It can be divided into GPP and NPP.
It is again divided into two types:

- **Gross primary productivity (G.P.P.) –** It is the total amount of energy fixed (organic food) in an ecosystem (in producers) in unit time is called G.P.P. including the organic matter used up in respiration during the measurement period. It is also known as total (Gross) photosynthesis. A considerable amount of GPP is utilised by plants in respiration.
- **Net primary productivity (N.P.P.) –** It is the amount of stored organic matter in plant tissues after respiratory utilisation.
  NPP = GPP – R (R = Respiration + Metabolic activities)
  or GPP = NPP + R
  NPP is the available biomass for the consumption of heterotrophs.

2. Secondary productivity

Secondary productivity is the rate of formation of new organic matter by consumers.
Net community productivity or Net productivity – The rate of storage of organic matter not used by the heterotrophs.
NCP = N.P.P. – HR (HR = Energy used by Heterotrophs or consumers)

Some Information related to Productivity

- Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, like the availability of nutrients and the photosynthetic capacity of plants. Therefore it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter, productivity of the ocean are only 55 billion tons.
- In per unit area, maximum productivity is found in the tropical rain forest.
- In water, the least productive ecosystem is very deep lakes and the highly productive ecosystem is a coral reef.
- Nitrogen is the limiting factor in the ocean and phosphorus is the limiting factor in lake productivity.
- Inland – Tropical rain forest i.e. 5 kg/m^2/year.
- The lowest productivity is of Deserts, tundra.
- The most productive Agro-ecosystem is the Sugar cane and rice ecosystem –> 3-4 kg./m^2/year.

Some Information

- **Ecological efficiency:** The percentage of energy transferred from one tropic level to the next is called ecological efficiency or food chain efficiency.

$$\frac{\text{Energy in biomass production at a trophic level}}{\text{Energy in biomass production at previous trophic level}} \times 100$$

- **Assimilation efficiency:** It is the proportion of consumed energy that is assimilated.

$$\frac{\text{Food energy assimilated}}{\text{Food energy ingested}} \times 100$$

- **Net production efficiency:**

$$\frac{\text{Net pri productivity}}{\text{G.P.P.}} \times 100$$

- **Photosynthetic efficiency:**

$$\frac{\text{G.P.P.}}{\text{Incident total solar radiation}} \times 100$$

Energy Flow

Introduction

- The chemical energy of food is the main source of energy required by all living organisms.
- The transfer of energy from one trophic level to another trophic level is called energy flow.
- The flow of energy in an ecosystem is unidirectional.
- That is, it flows from the producer level to the consumer level and never in the reverse direction.
- Hence, energy can be used only once in the ecosystem.
- But the minerals circulate and recirculate many times in the ecosystem.

This energy flow is based on two different laws of thermodynamics:

- First law of thermodynamics, that states that energy can neither be created nor destroyed, it can only change from one form to another.

- Second law of thermodynamics, that states that as energy is transferred more and more of it is wasted.

Trophic level

The producers and consumers in the ecosystem can be arranged into different feeding groups and are known as trophic level or the feeding level.

1. The producers (plants) represent the first trophic level.
2. Herbivores (primary consumers) present the second trophic level.
3. Primary carnivores (secondary consumers) represent the third trophic level
4. Top carnivores (tertiary consumers) represent the last level.

Energy Flow in Ecosystem

- A large amount of energy is lost at each trophic level. It is estimated that 90% of the energy is lost when it is transferred from one trophic level to another.
- Hence, the amount of energy available decreases from step to step.
- Only about 10% of the biomass is transferred from one trophic level to the next one in a food chain.
- And only about 10% chemical energy is retained at each trophic level.
- This is called 10% law of Lindeman (1942).
- When the food chain is short, the final consumers may get a large amount of energy. But when the food chain is long, the final consumer may get a lesser amount of energy.

Food Chain

- At each step in a food chain, a portion of the energy captured by producer is lost as heat given off during the chemical breakdown of food by respiration (metabolic heat).
- Thus, energy flows through the ecosystem in a single direction and is not recycled. In contrast, nutrients cycle between organisms and the physical environment.
- The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity.
- The amount of solar radiation reaching the surface of the earth is 2 cals/sq.cm/min. It is more or less constant and is called solar constant or solar flux. About 95 to 99% of the energy is lost by reflection. Plants utilize only 0.02% of the energy reaching earth.

- The energy trapped by the producers (primary production) is utilized by the consumers. The producers are directly consumed by herbivores that are eaten by the primary carnivores that in turn are consumed by the secondary carnivores.
- The consumers store some amount of energy in their tissues. This energy, stored by the consumers, is called secondary production. Only about 10 to 20% of the primary production is converted into secondary production. The remaining 80 to 90% is lost by the consumers in the form of faeces.

Ecological Succession

Introduction

- The development of plant communities on barren area is called ecological succession or Biotic succession.
- The replacement of existing community by new ones, in an orderly sequence in barren area with time due to change in environmental conditions.
- Biotic communities are never stable. They are changing more or less over period and space, due to presence of different types of climatic & environmental conditions.
- So a continuous interaction is going on between the community and environment till state of stability.

Term for a community in succession

- **Pioneer community** – The first community to inhabit an area is called Pioneer community.
- **Climax community** – The last and stable community in an area is called climax community. This is more stable. usually **mesophytes** are present in climax community.
- **Seral communities or seral stage** – In succession, communities or stages which comes in between pioneer community and climax community is called transitional or seral communities.
- **Sere** – The entire series of communities is called sere.

The name of the sere depends on where the succession occurs or takes place.

- Succession in fresh water → **Hydrosere**
- Succession in salty water → **Halosere**
- Succession in acidic water → **Oxalosere**
- Succession at dry Region → **Xerosere**
- Succession on rocks → **Lithosere**
- Succession on sand → **Psamosere**

- Succession at moistened region → **Mesosere**
- Succession of microbes on decomposed matters → **Serula**

Characteristics of Ecological Succession

1. Gradual replacement from short lived to long lived plant.
2. Continuous change in communities towards a state of stability or climax.
3. Increases species-diversity, biomass, niche specialization, humus content.
4. Decreases – net community productivity or annual yield.
5. Future seral communities can be predicted as it is a directional process.

Causes of Succession

1. **Biotic factors –** The action of each seral community (interaction with it's environment) makes the area less favourable for itself and more favourable for next seral community in the succession.
2. **Physiographic factors –** These include climatic and other physical factors like soil erosion, soil deposition, landslide, volcanic lava. These all factors makes an area barren.

Types of Succession

1. **Primary succession –** Occurs in the barren area where there was no previously any type of living matter. e.g. volcanic lava, estuarine, mud bank, igneous rock, sand dunes.
   Note : It requires 1000(s) of years.
2. **Secondary succession –** This type of succession occurs where vegetation was present previously but vegetation was destroyed due to natural or artificial causes i.e. fire, flood, sudden changes in climate, land slide.
   Note : This succession is comparatively more rapid, requires 50-100 years for grass land and 100-200 years for forest.

Some other type of succession

On the basis of Replacement:

1. **Autogenic succession –** During the succession, the community reacts with the environment and changes it. This community is replaced by new community. This is known as autogenic succession.
2. **Allogenic succession –** Community is replaced due to external conditions or forces not by existing vegetation itself. This kind of succession is known as allogenic succession.
   e.g. Fire,Flood.

On the basis of changes in nutritional and energy contents:

1. **Autotrophic succession** – This is succession of plants communities.
2. **Heterotrophic succession** – This is succession of animal communities.
   Note: Sometimes succession is in retrogressive direction – **e.g.** Forest to grass.

General Process of Ecological Succession

1. Nudation – It involves development of barren area (i.e. removal of community) by topographic (Soil erosion, land slide, volcanic eruption), biotic (human activity) and climatic factors (fire, flood, hails). It is the early stage of soil formation.

2. Invasion – Successful establishment of a species in a barren area.

This process is complete in three steps.

- **Migration (dispersal)** – Reaching of different reproductive structures like seed, spores through water or air on barren area.
- **Ecosis (ecesis)** – Successful **establishment** of species in new environment.
- Many juvenile plants are formed due to the germination of different spores or seeds. Out of them some of the plant species are modified or adapted according to the new climatic condition and established there.
- **Aggregation** – After ecesis (establishment), as a result of reproduction members of the species increase in number.

3. Competition or co-action – Due to increasing no. of species at limited place there develops competition for habitat and nutrition. Individuals affect each other, this is co-action.

4. Reaction – Species which have survived, will react with environment and modify the environment (change soil, water, light, temperature). The modified environment is less favourable for the existing community so it is replaced by another community.

5. Stabilization (Climax) – Finally there occurs a stage in the process when the final terminal community becomes stabilized for longer period of time, maintains itself with the climate of the area. This community is called climax community. It is complex, stable, no more species can replace them.

Examples of Successions

Hydrosere

Stages of hydrosere or hydrarch succession in the newly formed pond or lake

1. **Phytoplankton stage –** It is pioneer community, first coming minute autotrophic organism. These produce organic matter. **e.g. Soft mud diatom**, ***Cyanobacteria***
2. **Rooted submerged stages –e.g.** ***Vallisneria***
3. **Rooted floating stages – e.g.** ***Nymphaea, Nelumbium, Trapa***
4. **Reed swamp stage (amphibious stage)** – Most part of these rooted plants remain exposed to air. **e.g.*Typha, Sagittaria***
5. **Sedge** (Meadow stage or marsh meadow stage) – Muddy plants **e.g.*Carex, Ipomea***
6. **Scrub stage** – woody shrubs, tolerates water logging. **e.g.*Cornus***
7. **Forest stage – e.g.** ***Tree***

Lithosere

Stages of Lithosere (Successionon rocks)

1. **Crustose lichens stage –** It is pioneer community, tolerates desiccation, produces organic acid which causes weathering of rocks, so first minerals are released for own use. **e.g.** Rhizocarpon.
2. **Foliose lichens stage –** large lichens with leafy thalli. e.g. Dermatocarpon.
3. **Moss stage** e.g. Polytrichum.
4. **Herb stage –** Annual hardy grasses
   e.g. Poa, Eleusin, Aristida.
5. **Shrub stage**
   e.g. Zizyphus.
6. **Forest stage**
   e.g. Tree.

Importance of Succession

- Information gained through biotic succession is used in having controlled growth of one or more species by preventing their superiors to invade the area, e.g., maintenance of teak forests.
- It gives information about the techniques to be used during reforestation & afforestation.
- Dams are protected by preventing situation & biotic succession to occur.
- It tells us how a biotic seral stage can be maintained by net allowing the biotic succession to proceed further through interference like grazing and fire.

Biogeochemical Cycles

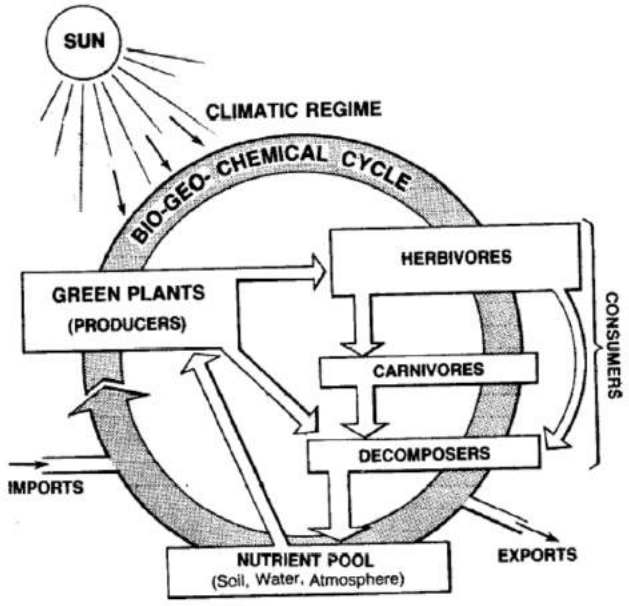
What is a Biogeochemical Cycle?

Biogeochemical cycles mainly refer to the movement of nutrients and other elements between biotic and abiotic factors.

- The term biogeochemical is derived from "bio" meaning biosphere, "geo" meaning the geological components and "chemical" meaning the elements that move through a cycle.
- The matter on Earth is conserved and present in the form of atoms. Since matter can neither be created nor destroyed, it is recycled in the earth's system in various forms.
- The earth obtains energy from the sun which is radiated back as heat, rest all other elements are present in a closed system.
- The major elements include:

1. Carbon
2. Hydrogen
3. Nitrogen
4. Oxygen
5. Phosphorus
6. Sulphur

All the types of material required by ecosystem in addition to energy, are available continuously to system through recycling. Thus there is a constant exchange of materials between the living organisms and their abiotic environment through the recycling of materials. This phenomenon is called Bio-geo chemical cycle.
The mineral elements taken up from the environment (soil as well as air) by the green plant – the producers, are again returned to the environment through consumers and decomposers.
These elements are recycled through the biotic and abiotic components of the ecosystem. The atmosphere, hydrosphere, and lithosphere are the abiotic components of the ecosystem.



Biogeochemical Cycle

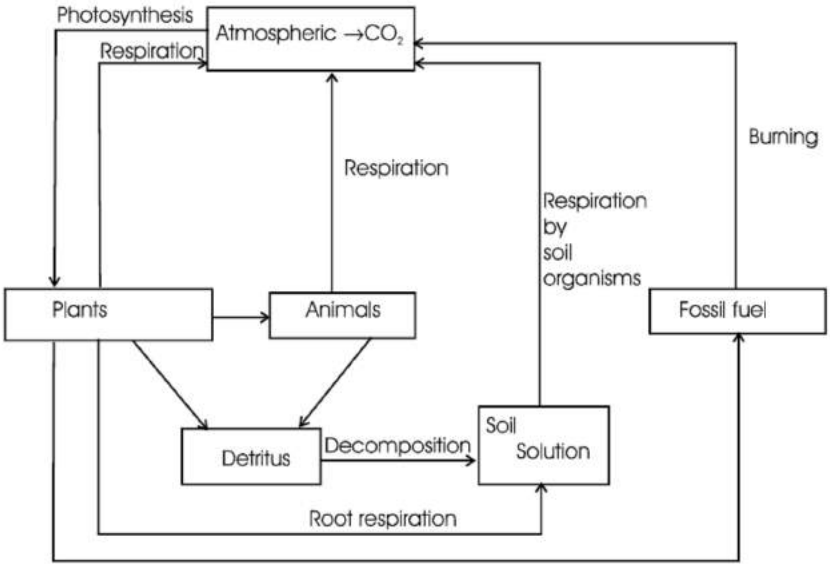
Types of Biogeochemical Cycles

The following types of cycle are found in an ecosystem:
(i) Gaseous Cycle – C, H, N, O cycles. Reservoir is in the atmosphere (air) or in Hydrosphere(water).
(ii) Sedimentary cycle – P, S, Ca cycles reservoirs are in the earth's crust (lithosphere).

Note: In these cycles, the bulk material remains in the inactive reservoir on earth's crust like sediment of sea, or water bodies.

1. Carbon Cycle

The main source of carbon is atmosphere and in hydrosphere it is rocks of carbonates. Carbon is present in lithosphere in the form of coal and petroleum. The carbon released from them is present in the atmosphere in the form of carbon dioxide. The green autotrophs utilize CO_2 from the air to synthesize food materials which is obtained by other organisms as food. Carnivores obtain their carbonic food from the herbivores. These carbonic matter produce CO_2 through the oxidation or respiration which dissolve in air or water and is again utilized by the plants.



2. Nitrogen Cycle

Atmosphere is the only source of nitrogen. 78% nitrogen is present in atmospheric air. Plants absorb nitrogen in the form of nitrate ions.
Nitrogen cycle is completed in following steps:
1. Nitrogen fixation –
In this process first of all some bacteria and blue green algae converts atmospheric nitrogen into nitrogenous compounds viz ammonia, amino acid or nitrate salts.

Bacteria – Rhizobium, Aerorhizobium, Azospirillum, Frankia, Clostridium, Azotobacter → In several tropical grasses

Blue green algae – Anabaena, Aulosira ,Nostoc → In flooded rice field in tropics.

Note:

(1) Azotobacter is aerobic bacteria.
(2) Clostridium is anaerobic bacteria.
(3) Symbiotic relationship where the nitrogen fixing bacteria does not penetrate deep into host tissue, is known as associative symbiosis.

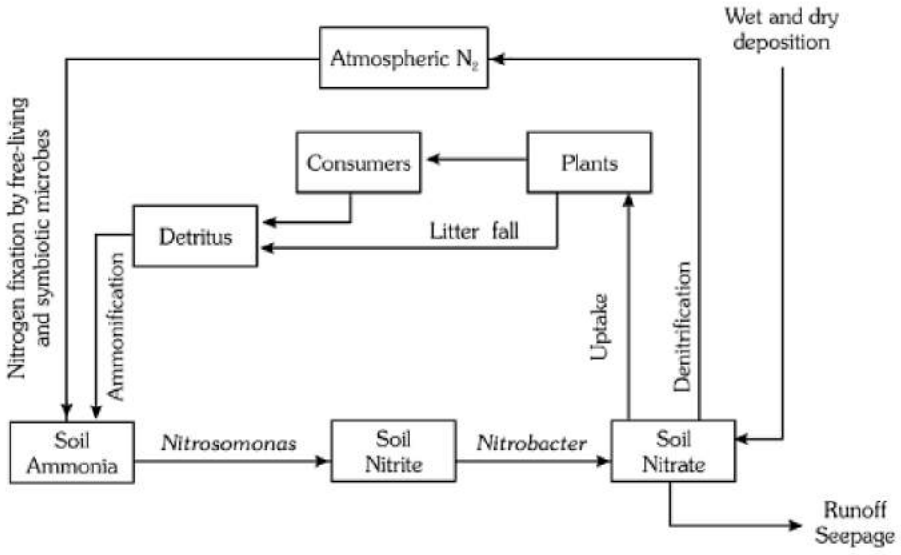
2. Nitrification –

Conversion of ammonia into nitrate is called nitrification.
Nitrification process is completed in two steps:

$$NH_3 \xrightarrow{\text{Nitrosomonas}} NO_2^- \xrightarrow{\text{Nitrobacter}} NO_3^-$$

Note:

(a) Few quantity of nitrate comes in soil by electrochemical or photochemical process.
(b) Now few quantity of this nitrate is absorbed by plants.



3. Nitrogen assimilation –

Plants absorb nitrate from the soil and form protein. When consumers eat these plants, these plant proteins are transferred into consumers.
After the death of plants and consumers, litter is formed in which protein is present.

4. Ammonification –

Protein present in litter, is converted into ammonia by some ammonifying bacteria. e.g. Bacillus vulgaris, Bacillus mycoides, Bacillus ramosus.

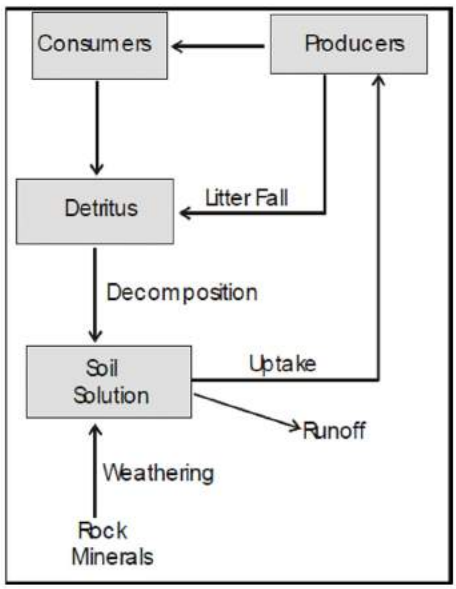
5. Denitrification –

Some quantity of nitrate which is not used by plants is converted into nitrogen by denitrifying bacteria. e.g. Thiobacillus denitrificans, Pseudomonas denitrificans

Note: Some nitrate washed out from the ecosystem through seepage.

3. Phosphorus Cycle

Phosphorus is the main constituent of protoplasm, plasma membrane, bones and teeth. Main source of phosphorus is rocks. It comes from the weathering of phosphorus containing rock in the soil. Plants absorb this phosphorous from the soil and transfer this phosphate to animals and after the death of animals it is released again into the lithosphere by the action of decomposers.



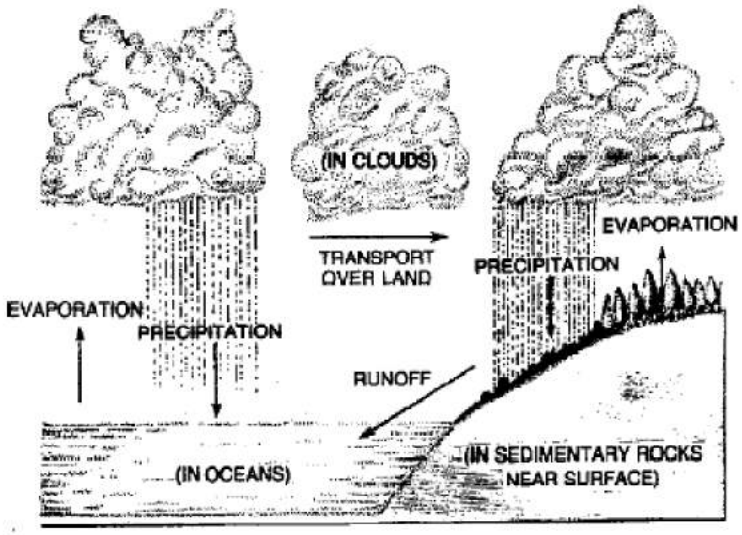
Sometimes some of the elements like phosphorus and calcium reach into the sea through water, from where they transform into rocks. They separate from the cycle for a long time so it is also known as sedimentary cycle.
But when these rocks break after sometime then this phosphorus is again made available to the sea plant or sea weeds, which pass into fish and sea birds. The excretory materials of birds on the rocks of sea shore is called Guano and it is a source of phosphorus.

Note: Plants absorb phosphate from the soil in the form of orthophosphate (Po_4^{3-}).
Difference between Carbon and Phosphorus cycle:

1. Atmospheric inputs of phosphorus through rainfall are much smaller than carbon.
2. Gaseous exchanges of phosphorus between organism and environment are negligible.

4. Water Cycle

Water is indispensable for life. Sea is the main source of water on earth, water is always present in the atmosphere in the form of water vapour. Water is also evaporated from other places from where it reaches into the atmosphere. These vapours form clouds in the atmosphere, condensation of water vapour forms clouds, mist, fog and ice at high altitudes. It comes again on the earth in above forms.



Water cycle plays a significant role on the earth. Plants and animals receive water or absorb water. Water participates in various metabolic activities of the body of organisms and again it is formed. Water is converted into food through the photosynthesis in plants. Water is also present in protoplasm of all organisms.This water again comes into the atmosphere through transpiration from the plants and evaporation and sweating from the animals. Thus, this cycle goes on continuously. The oxygen cycle and hydrogen cycle is also found in the ecosystem as above cycles.

Note:

1. Water cycle is directly operated by solar radiation and it is under the control of forests.
2. The term "Cycle" is used for the movement of matter and the term "Flow" is used for the movement of energy.

5. Oxygen Cycle

This biogeochemical cycle moves through the atmosphere, the lithosphere and the biosphere. Oxygen is an abundant element on our Earth. It is found in the elemental

form in the atmosphere to the extent of 21%.Oxygen is released by the plants during photosynthesis. Humans and other animals inhale the oxygen exhale carbon dioxide which the plants again take up. They utilise this carbon dioxide in photosynthesis to produce oxygen, and the cycle continues.

6. Sulphur Cycle

This biogeochemical cycle moves through the rocks, water bodies and living systems. Sulphur is released into the atmosphere by the weathering of rocks and is converted into sulphates. These sulphates are taken up by the microorganisms and plants and converted into organic forms. Organic sulphur is consumed by animals through food. When the animals die and decompose, sulphur is returned to the soil, which the plants and microbes again obtain, and the cycle continues.

Ecosystem Services

Introduction

- Ecological services are those humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems.
- These services include carbon fixation, pollination, oxygen release, cycle nutrients, mitigate droughts and floods etc.

Services can be subdivided into five categories–

1. Provisioning, such as the production of food and water
2. Regulating, such as the control by climate and disease
3. Supporting, such as nutrient cycle and crop pollination
4. Cultural, such as spiritual and recreational benefits
5. Preserving, which includes guarding against uncertainty through the maintenance of diversity

Ecosystem Services

- Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services.
- The products of ecosystem processes are named as ecosystem services, for example, healthy forest ecosystems purify air and water, mitigate droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.

- Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty price tag.
- Robert Costanza and his colleagues have very recently tried to put price tags on nature's life-support services.
- Researchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystems services, which are largely taken for granted because they are free.
- This is nearly twice the value of the global gross national product GNP which is (US $ 18 trillion).
- Out of the total cost of various ecosystem services, the soil formation accounts for about 50 per cent, and contributions of other services like recreation and nutrient cycling, are less than 10 per cent each.
- The cost of climate regulation and habitat for wildlife are about 6 per cent each.

Components: Producers & Consumers

Components of Ecosystem

Every ecosystem is composed of two components -

1. **Biotic component**
2. **Abiotic component**

Biotic Component

Formed by living things. e.g., plants, animals, microbes.

Types of Biotic Components

1. Producers -

All the autotrophs of ecosystem are called producers. They prepare their own food. The green plants are the main producers. In the process of photosynthesis, producers absorb solar energy and convert it into chemical energy so producers are also called transducers or converters.
Energy enters into the ecosystem through the producers. The solar energy is the only ultimate source of energy in ecosystem. This energy is available for the remaining living organisms.
Other e.g. of producers are -

- Chemotoautotrophs:(iron bacteria, sulphur bacteria, nitrifying bacteria)

- In aquatic ecosystem: Floating plants called phytoplanktons are the major autotrophs.

Phytoplankton may produce as much food as produced by the larger shrubs and trees in unit area.

2. Consumer -

All the heterotrophs of the ecosystem are known as consumers. They directly (herbivores) or indirectly (Carnivores) depend on the producers for food.

Types of consumers:

(i) Macroconsumers
(ii) Microconsumers

(i) Macro consumers (Phagotrophs or holozoic) –

They digest their food inside the body of organism i.e.first ingestion then digestion.

Macro consumers are of following type

(a) Primary consumer – Such living organisms which obtain food directly from producers or plants are known as primary consumers. e.g. herbivores of ecosystem, cow, grazing cattle, Rabbit.
They are also known as **secondary producers** as they synthesize complex materials in the cells, by the digestion of food which is obtained from the plant.

(b) Secondary consumers or primary carnivores – Animals which feed upon primary consumers and obtain food. The carnivores which kill and eat the herbivores, are called predators. **e.g.** Dog, cat, snake
Note:

- The organism which completely depends on dead animals are not example of predators but they all are the **scavangers** or detrivores. **e.g.** Vulture, crow, fox.
- All predators are carnivores but all carnivores are not predators.

(c) Top Consumers – Those animals which kill other animals and eat them, but they are not killed & eaten by other animals in the nature. **e.g.** Lion, man, hawk, peacock.

(ii) Micro Consumers/Decomposers or Saprotrophs/osmotrophs – Those living organisms which decompose the dead body of producers and consumers are known as decomposers or reducers or transformers or osmotrophs.

Note –

- The main decomposers in ecosystem are bacteria and fungi.
- Decomposers play a significant role in **mineral cycle.** Decomposers are responsible for converting complex organic material of dead animals or plants into simpler organic matter through the process of decomposition and release mineral substances into the soil where these are reused by the producers, So that soil is considered as the best resource of minerals.
- In Bacteria and fungi, process of decomposition completely takes place outside the body. They release enzymes from their body on dead remains and decompose it into simpler organic substances and then absorb it so these are called as **osmotrophs (absorptive).**

Special Point of Biotic factor

- **Nutrient Immobilisation-** In the process of decomposition, some nutrients get tied up with the biomass of microbes and become temporarily unavailable to other organisms. Such incorporation of nutrient in living microbes (bacteria & fungi) is called **nutrient immobilisation.**
- In aquatic system, **whale** is secondary consumer. It is an example of **filter feeder** because it feeds on plankton.
- **Vulture** is a scavenger not predator because it never kills any animal.Vulture is also a decomposer. In Vulture, the break down of the food material takes place inside the body and then released into the soil in the form of waste material and minerals.
- **Plant parasites** are known as primary consumers while animals parasites (E.coli bacteria, Entamoeba histolitica, liver fluke, tapeworm) are known as secondary consumers.
- **All the insectivorous** plants play the double role i.e. producer as well as secondary consumer because they synthesise their own food through photosynthesis and they eat insects simultaneously.
- **Man and peacock** are omnivores.
- Organisms which use milk or curd are known as secondary consumer.

  Note :

  Inorganic materials (CO_2 ,H_2O, Light), autotrophs (Producers) and decomposers are essential in ecosystem but, macro consumers are non-essential.

Abiotic Component

- Abiotic components include inorganic substances or minerals; organic substance and atmospheric factor.
- Inorganic substances are P, S, N, H, Mg, K, CO2, NO2 etc. These are raw materials for plants.
- Organic substances are proteins, carbohydrates, lipids in dead organic substances.
- Atmospheric factors are light, temperature, humidity, rain, water, gas etc.

Function of ecosystem

There are two basic functions of ecosystem.
(i) Biogeochemical cycle (mineral cycle)
(ii) Energy flow – The storage, expenditure, transformation of energy is based on two basic law of thermodynamics –

- Energy is neither created nor destroyed but only transformed from one state to another state.
- The law of entropy – The transfer of food energy from one to another organism leads to loss of energy as heat due to metabolic activity.

Food Chain

In ecosystem every organism depends on other organism for food material and all organism are (herbivores to carnivores) arranged in a series in which food energy is transferred through repeated eating and being eaten. It is called food chain. In food chain, energy flow is in the form of food.
In a food chain, food material or food energy transfer is from one tropic level to next tropic level.
Four tropic levels are present in the ecosystem, because level of energy decreases during the flow of energy from one tropic to the another tropic level.
First tropic level [T_1] = Producers
Second tropic level [T_2] = Primary consumers
Third tropic Level [T_3] = Secondary consumers
Fourth tropic level [T_4] = Top consumers

Note –

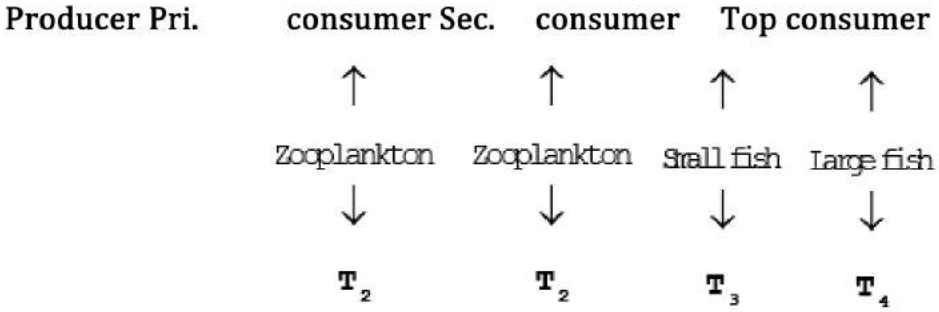
1. There are five tropic levels found in highly complex ecosystem in which tertiary consumer is present in between the secondary consumers and top consumer. Then the fifth tropic level(T5) is formed by the top consumer.

2. In food chain energy flow is unidirectional (producers to herbivores)
3. Shorter food chains will provide greater energy.
4. Generally the decomposers (Bacteria and Fungi) are not included in the food chain but when included then included as the last tropic level.

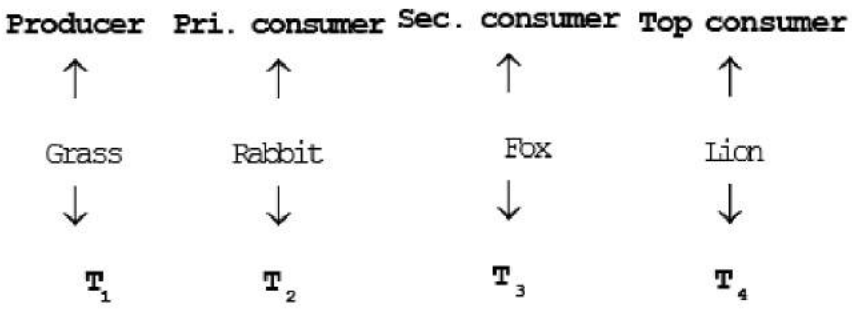
Types of Food Chain

In nature three types of food chains are present.
1. Grazing food chains or Predatory food chain – Most of food chain in nature are of this type. This food chain begins with producers (plants) and in successive order it goes from small organisms to big organisms.

Aquatic ecosystem:

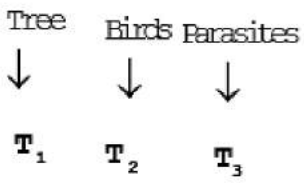


Grass land ecosystem:



2. Parasitic food chain – This food chain also starts from producers but in successive order it goes from big organism to the smaller organism. **e.g.**

Tree ecosystem –



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

3. Detritus food chain or Saprophytic food chain – This food chain begins with decomposition of dead organic matter by decomposers so it is also known as saprophytic food chain. In this food chain primary consumers are bacteria and fungi.
Dead organic matter → bacteria fungi
Note:

- In mangrove vegetation this food chain goes up to big organism.
- Dead mangroves leaves → Bacteria & fungi → Amphipds, molluscs, crabs, nematodes → small fishes → fish eating birds.
- In detritus food chain, energy flow is rather very slow yet magnitude of energy is great because vast no. of decomposers are involved.
- It indirectly depends on light.

Ecosystem/food chain – In an aquatic ecosystem, GFC (Grazing Food Chain) is the major conduit (source) of energy flow. As against this, in a terrestrial ecosystem, a much larger energy flows through the detritus food chain than through the grazing food chain.
In Sunderbans, Tigers feed on the fishes and crab in the absence of their natural prey.