CHAPTER 14: ECOSYSTEM

"It is an interaction between biotic and abiotic components in such a way that, there is a continuous flow of energy, so as to maintain dynamic equilibrium of a given geographical area at given time".

Hence ecosystem is a structural and functional unit of biosphere.

ECOSYSTEM – STUCTURE AND FUNCTION

- Interaction of biotic and abiotic components results in a physical structure that is characteristic of each type of ecosystem.
- Identification and description of plant and animal species of an ecosystem gives its **species composition**.
- Vertical distribution of different species occupying different levels is called **stratification.**
- The components of the ecosystem are seen to function as a unit.
  a) Productivity
  b) Decomposition
  c) Energy flow
  d) Nutrient cycle

Description of pond as an ecosystem

a) The abiotic components include all dissolved inorganic and organic substances and the rich soil deposit at the bottom of the pond.
b) The solar input, cycle of temperature, day length, regulates the rater of function of the entire pond.
c) The **producer** (autotrophic) includes phytoplankton, some algae and the floating, submerged and marginal plants found in edge of pond.
d) The **consumers** are represented by zooplankton, free swimming and bottom dwelling animals.
e) The decomposers are the fungi, bacteria especially abundant at the bottom of the pond.

Basic events (in terms of function) in an ecosystem

a) Conversion of inorganic into organic material (photosynthesis) by producers.
b) Consumption of the autotrophs by heterotrophs.
c) Decomposition and mineralization of the dead organic matter to release them back for reuse by the autotrophs.
d) There is unidirectional flow of energy from lower to higher trophic levels and its dissipation and loss as heat
to the environment.

PRODUCTIVITY

Primary productivity: 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-2) or energy (kcal m-2). The rate of biomass production is called **productivity.**

Gross primary productivity (GPP): It is the rate of production of organic matter (energy or biomass) during photosynthesis by producers.

Net primary productivity (NPP): A considerable amount of energy or biomass is utilized by plants for respiration, and remaining energy or biomass is transferred to the next trophic level.
Gross primary productivity minus respiration losses (R) is the net primary productivity.

$$\mathbf{NPP = GPP - R}$$

Net primary productivity is the available biomass for the consumption to heterotrophs (herbivore and decomposers.

Secondary productivity: It is defined as the rate of formation of new organic matter by the consumer.

DECOMPOSITION

- Earthworm belongs to Annelida that breakdown the complex organic matter into simpler molecules and loosening of the soil helps in aeration and entry of root. Hence earthworm is said to be 'friends' of farmer.
- The decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients, called **decomposition.**

Detritus: Parts of dead plants and animals including fecal matter constitute the **detritus.**

The process of decomposition completed in following steps

a) **Fragmentation**: Break down of detritus into smaller particles by detrivore (earthworm).
b) **Leaching:** Water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
c) **Catabolism :** Bacterial and fungal enzymes degrade detritus into simple inorganic substances.
d) **Humification**: Accumulation of dark coloured amorphous substances called humus**.**
e) **Mineralization**: The humus is further degraded by some microbes and release of inorganic nutrients occur.

Factor affects rate of decomposition:

1. Decomposition is largely an oxygen-requiring process hence it requires more oxygen.
2. Detritus rich in chitin and lignin has slow rate of decomposition.
3. Detritus rich in nitrogen and water-soluble substance like sugar has faster decomposition.
4. **Temperature** and **soil moisture** are most important climatic factor that regulate decomposition
5. **Warm** and **moist** environment favor decomposition.
6. **Low temperature**, **dryness** and **anerobiosis** inhibit decomposition.

ENERGY FLOW IN ECOSYSTEM

Energy flow refers to Food chain in an ecosystem.

Food chain: "*It is the transfer of energy from one trophic level to another trophic level with repeated eating and being eaten".*

- Except for deep sea hydrothermal ecosystem, sun is the only source of energy for all ecosystems on earth.
- Less than 50% of incident solar radiation is **photosynthetically active radiations. (PAR).**
- Plants capture 2-10 % of PAR and used in photosynthesis.
- All heterotrophic organisms depend on the producers, either directly or indirectly.
- **Energy flow in the ecosystem is unidirectional** i.e. energy transferred from producer to consumers.
- Energy transfer is not absolute, and spontaneous, unless energy is degraded it cannot be transfer. When energy transferred from one trophic level to another, lot of energy lost in the form of heat to the environment.
- Only 10% of energy transferred from one trophic level to other.

Types of food chains

1. **Grazing food chain:** It extends from producers through herbivore to carnivore.
2. **Detritus food chain**: Begins with dead organic matter **(detritus)** and pass through detritus feeding organism in

   soil to organisms feeding on detritus-feeders.

* In aquatic ecosystem **GFC** is the major conduit for energy flow.
* In terrestrial ecosystems a much larger fraction of energy flows through the **detritus food chain** than through GFC
* Different food chains are naturally interconnected e.g. a specific herbivore of one food chain may serve as food of carnivores of other food chains. Such interconnected matrix of food chains is called **food web.**

Trophic level: A group of organism irrespective of their size having same source of energy or similar food habit constitute a **trophic level.**

Standing crop: Each trophic level has a certain mass of living material (biomass) or the **number** in a unit area
at a particular time.

ECOLOGICAL PYRAMID

"It is a schematic representation of various trophic levels of a food chain for their number, biomass and energy".

- Base of the pyramid is broad and it narrows down at the apex. The similar shape is obtained when food or energy relationship between organisms at different trophic level.

- The relationship can be expressed in terms of number, energy or biomass.
- The base of the pyramid represented by producer and apex is the top consumer; other trophic levels are in between.
- In most ecosystems, all the pyramids, of number, of energy and biomass are upright.
- The pyramid of **number** in a tree ecosystem is **inverted.**
- The pyramid of **biomass** in sea also **inverted** because the biomass of fishes is far exceeds that of phytoplankton.
- Pyramid of **energy** is **always upright,** can never be inverted, because when energy flows from a particular trophic level to the next, some energy is always lost as heat at each step.

Limitations of ecological pyramids

- It does not take into account the same species belonging to two or more trophic levels.
- It assumes a simple food chain, it never exits in nature.
- It does not accommodate food web.
- Saprophytes are not given place in ecological pyramids.

ECOLOGICAL SUCCESSION: "The gradual and fairly predictable change in the species composition of a given area is called **ecological succession.**

1. Composition and structure of the community constantly change in response to changing environmental condition.
2. This change is orderly and sequential, parallel with the changes in the physical environment.

3. All the changes lead finally to a community that is in near equilibrium with the environment and that is called **climax community.**
4. During succession some species colonize in a given area and their populations become more numerous, whereas populations of other species decline and even disappear.
5. The entire sequences of communities that successively change in a given area are called **sere.**
6. The individual transitional communities are termed as **seral stages.**
7. In the successive seral stages there is a change in the diversity of species of organisms, increase in number of species and total biomass.

Primary succession: Succession that starts where no living organisms are there- these could be areas where no living organism ever existed may be a bare rock or new water body.

Secondary succession: Succession that starts in areas that somehow, lost all the living organisms that existed there.

Primary succession occurs in

1. Newly cooled lava,
2. Bare rock,
3. Newly created pond or reservoir.

Secondary succession begins in areas where natural biotic communities have been destroyed such as

1. In abandoned farm lands.
2. Burned or cut forest,
3. land that have been flooded
4. Since some soil or sediment is present, secondary succession is faster than primary succession.

Succession in plants

Based on the nature of habitat that is, whether it is water or dry areas, succession of plants is called **hydrarch** or **xerarch**.

a) **Hydrarch succession:** It takes place in water and the succession series progress from **hydric** to **mesic** condition.
b) **Xerarch succession:** It takes place in dry areas and the series progress from **xeric** to **mesic** conditions.

Both hydrarch and xerarch successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric).

Xerarch succession: Succession on bare rock

1. The species that invades bare area are called **pioneer species.**
2. In primary succession on bare rock the pioneer species is the **lichen.**
3. Lichen secretes acid to dissolve rock, helping in weathering and soil formation.
4. The little soil, leads to growth of **bryophytes (mosses).**
5. The mosses speed up the process of soil accumulation by trapping wind-blown particles.
6. Lichen and moss carpet provides suitable substratum for the germination of seeds of **herbaceous plants.**
7. Gradually more soil is accumulated and herbaceous species make way for the invasion of **shrubs** followed by **trees.**
8. The **climax community** is generally dominated by **trees.**

Hydrarch Succession: Succession in aquatic environment

1. In primary succession in water, the **pioneer species** are **phytoplankton.**
2. Zooplanktons.
3. Sub merged plant stage. (rooted hydrophytes)
4. Sub merged and free-floating plant stage.

5. Reed-swamp stage.
6. Marsh-meadow stage.
7. Shrub stage
8. Trees
9. The climax again would be the forest
10. All the succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

NUTRIENT CYCLE (Biogeochemical Cycle): "It is the cyclical movement of organic and inorganic chemicals between living organisms and the environment".

Organism needs constant supply of nutrients to grow, reproduce, and regulate various body functions.

Standing state: The amount of nutrients such as carbon, nitrogen, phosphorus, calcium etc. present in the soil at any given time.

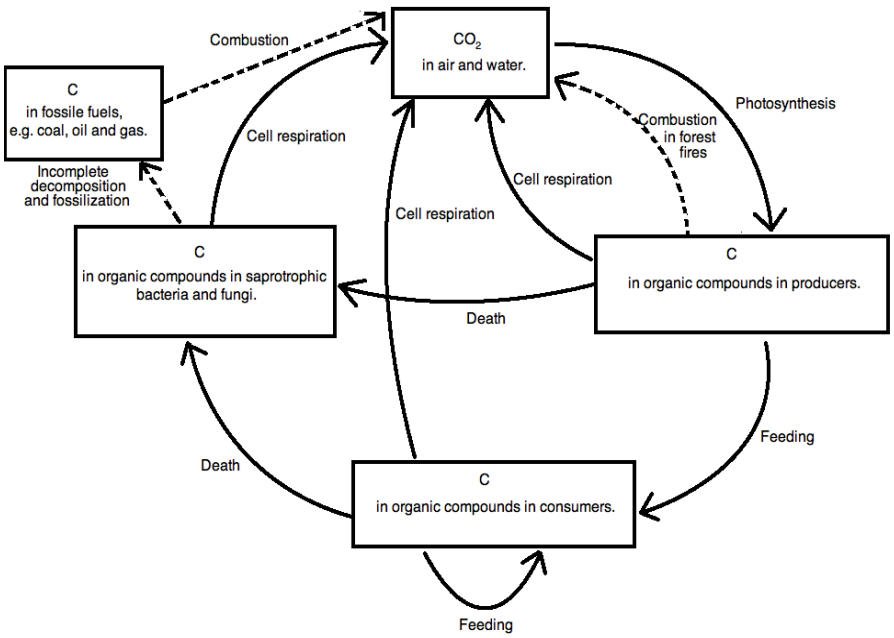
Nutrient cycle: The movement of nutrient elements through the various component of an ecosystem is called nutrient cycling.

Gaseous cycle: The reservoir for gaseous type of nutrient cycle (nitrogen, carbon) exists in the atmosphere.

Sedimentary cycle: The reservoir for sedimentary cycle (sulphur, phosphorus) is Earth's crust.

- Environmental factors like soil, moisture, pH temperature etc, regulate the rate of release of nutrient into the atmosphere.
- The function of the reservoir is to meet the deficit which occurs due to imbalance in the rate of influx and efflux of nutrients.

Carbon cycle: It is an example for gaseous cycle where the atmospheric air is the reservoir.



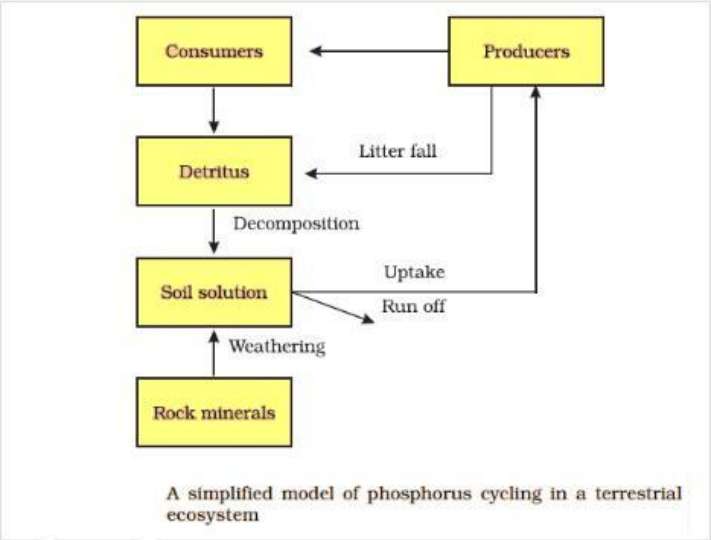
1. Carbon constitutes 49 percent of dry weight of organism.
2. Out of total global carbon, 71 percent carbon found dissolved in ocean and about 1 percent is in the atmosphere.
3. 4 X 10^{13} kg of carbon is fixed in the biosphere by photosynthesis, annually.
4. Large amount of carbon returned to the atmosphere as CO_2 through respiration of producers and consumers.
5. Decomposers also return CO_2 to reservoir during decomposition process.

6. Some amount of Carbon is lost to sediments and removed from circulation.
7. Burning wood, forest fire, combustion of organic matter, fossil fuel, volcanic activities are additional sources for releasing CO_2 to atmosphere.

Influence of human activity on Carbon cycle

* Rapid deforestation.
* Massive burning of fossil fuel for energy and transport
* Increased the rate of release of CO_2 into the atmosphere.

Phosphorus cycle: It is an example for sedimentary cycle, where sediments of rocks are the reservoir.



A simplified model of phosphorus cycling in a terrestrial ecosystem

1. Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer system(ATP)
2. Animals need phosphorus to make shell, bones and teeth.
3. Reservoir pool of phosphorus is the rock, which contain phosphorus in the form of **phosphates.**
4. During weathering of rock small amount of phosphates dissolved in soil solution and are absorbed by the roots of the plants.
5. Herbivore and other animals obtain organic form of phosphorus from plants.
6. The waste product and dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus.

How phosphorus cycle differs from carbon cycle?

* There is no respiratory release of phosphorus into atmosphere.
* Atmospheric inputs of phosphorus through rainfall are much smaller.
* Gaseous exchange of phosphorus between organism and environment are negligible.

ECOSYSTEM SERVICES

1. The products of ecosystem processes are named as **ecosystem services.**
2. Healthy forest ecosystems purify air and water.
3. Mitigate droughts and flood.
4. Cycle nutrients.
5. Generates fertile soil.
6. Provide wildlife habitat.
7. Maintain biodiversity.

8. Pollinate crops.
9. Provide storage site for carbon
10. Provides aesthetic, cultural and spiritual values