Chapter 14: Ecosystem

An ecosystem can be visualised as a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.Ecosystem is the interaction of living things among themselves and with their surrounding environment.

There are two basic ecosystems

Terrestrial

Forest, grassland and desert ecosystem

Aquatic

Pond, lake, wetland, river and estuary ecosystem

Ecosystem- Structure and Function

The interactions between the various biotic and abiotic factors of an ecosystem lead to the maintenance of the ecosystem.

Stratification : Vertical distribution of different species occupying different levels.

trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

The different aspects of the ecosystem

a. Productivity;
b. Decomposition;
c. Energy flow; and
d. Nutrient cycling

Example of pond ecosystem:

Abiotic component: the water with all the dissolved inorganic and organic substances and the rich soil deposit at the bottom of the pond.

Producers : autotrophic components that include the phytoplankton, some algae and the floating, submerged and marginal plants found at the edges.

Decomposers: the fungi, bacteria and flagellates especially abundant in the bottom of the pond.

The pond performs all the functions of any ecosystem and of the biosphere as a whole,i.e.,

Conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs;Consumption of the autotrophs by heterotrophs;

decomposition and mineralisation of the dead matter to release them back for reuse by the autotrophs.There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.

Productivity

A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.

Primary production: The amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. [Unit: weight (g – 2) or energy (kcal m – 2)].

Productivity: The rate of biomass production. [Unit: g –2 yr –1 or (kcal m – 2) yr –1]

Gross primary productivity (GPP): The rate of production of organic matter during photosynthesis.

Net primary productivity (NPP): Gross primary productivity minus respiration losses (R).

GPP – R = NPP

Secondary productivity: The rate of formation of new organic matter by consumers.

Primary productivity depends upon-

a. Type of plant species inhabiting a particular area
b. Photosynthetic capacity of plants
c. Nutrient availability

Decomposition

Decomposition: Break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients by the decomposers.

Detritus: Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter.Detritus acts as the raw materials for the decomposition.

The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.

Fragmentation: Break down of detritus into smaller particles by detrivores (earthworm)

Leaching: Water- soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

Catabolism: Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.

Humification: Accumulation of humus (a dark coloured amorphous substance).

Humus is highly resistant to microbial action.It undergoes decomposition at an extremely slow rate.It serves as a reservoir of nutrients.

Mineralisation: Degradation of humus to release inorganic nutrients.Decomposition is largely an

oxygen-requiring process.Rate of decomposition is controlled by:chemical composition of detritus. Decomposition rate is slower if detritus is rich in lignin and chitin.quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.
climatic factors:Warm and moist environment favour decomposition.
Low temperature and anaerobiosis inhibit decomposition.

Energy Flow

Photosynthetically active radiation (PAR) : Of the incident solar radiation less than 50 % of solar radiation; that can be used by autotrophs to make food from simple inorganic materials. Plants capture only 2-10 per cent of the PAR.

Producers: The green plant in the ecosystem that produces the food.

In terrestrial ecosystem: herbaceous and woody plants

In aquatic ecosystem: various species like phytoplankton, algae and higher plants.

Consumers: All animals depend on plants (directly or indirectly) for their food needs.

Food Chain:

Grazing food chain (GFC): A food chain that begins with producers.

Detritus food chain (DFC): A food chain that starts with dead organic matter.

It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria.

They meet their energy and nutrient requirements by degrading dead organic matter or detritus.

Secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them. (saprophytes)

Food Web:

Trophic level: Every organism occupies a specific level in their food chain known as the trophic level.

Producers - first trophic level

Herbivores (primary consumer) - second trophic level

Carnivores (secondary consumer) - third trophic level

Standing crop: The mass of living material (biomass) that is present in a trophic level at a particular time.

10% law: Only 10 per cent of the energy is transferred to each trophic level from the lower trophic level;

as a result of which the number of trophic levels in the grazing food chain is restricted.

Ecological pyramids:

An ecological pyramid is a graphical representation of the food or energy relationship between organisms at different trophic level.
The relationship is expressed in terms of number, biomass or energy.
The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer.

Pyramid of energy is always upright, can never be inverted-
Because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step.
A trophic level represents a functional level and not a single species as such. Also, a single species may become a part of more than one trophic level in the same ecosystem at the same time depending upon the role it plays in the ecosystem.

Limitations of ecological pyramids:

The ecological pyramids do not take into account the same species belonging to more than one trophic level.
It assumes a simple food chain that almost never exists in nature. It does not explain food webs.
Saprophytes are not given a place in ecological pyramids even though they play a vital role in ecosystem.

Ecological Succession

The gradual and fairly predictable change in the species composition of a given area.
The composition and structure of a community constantly change in response to the changing environmental conditions.
These changes lead finally to a climax community.
Climax community: The community that is in near equilibrium with the environment.
Sere: The entire sequence of communities that successively change in a given area.
Seral stages / seral communities : The individual transitional communities.
Primary succession: The succession that happens in areas where no life forms ever existed as in bare rocks, cool lava, etc.It takes hundreds to thousands of years as developing soil on bare rocks is a slow process.
Secondary succession: The succession that happens in areas which have lost all life forms due to destructions and floods, etc.
Since some soil or sediment is present, succession is faster than primary succession.

Successions of plants

Hydrarch succession: It takes place in wetter areas and the successional series progress from

hydric to the mesic conditions.
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).
Pioneer species: The first species that invade a bare area.

Primary succession on rocks:
Lichens are the pioneer species.
They secrete acids to dissolve rock, helping in weathering and soil formation.
This later helps the plants like bryophytes to grow there.
The bryophytes with time gets succeeded by bigger plants.
After several more stages, ultimately a stable climax forest community is formed.
The xerophytic habitat gets converted into a mesophytic one.
The climax community remains stable as long as the environment remains unchanged.

Primary succession in water :
Pioneer species are the small phytoplanktons.
They are replaced with time by rooted-submerged plants.
Rooted-floating angiosperms are replaced by free-floating plants
The free-floating plants are replace by reed-swamp, marsh-meadow, scrub and finally the trees.
The climax community here is forest.
With time the water body is converted into land.

Secondary Succession:
The pioneer species depends on the following factors:
Condition of the soil
Availability of water
The environment
The seeds or other propagules present
As the soil is present at the beginning the climax community is reached much quickly.

Nutrient Cycling
The amount of nutrients present in the soil at a given time is known as the standing state.
Nutrients are never lost from the ecosystem. They are only recycled from one state to another.

The movement of nutrients through the various components of the ecosystem is called nutrient cycling or

biogeochemical cycles. They are of two types:

Gaseous − Reservoir for these types of cycles exist in the atmosphere.

Sedimentary − Reservoir for these types of cycles exist in the earth's crust.

Ecosystem-Carbon Cycle

About 49% of the dry weight of living organisms is made up of carbon.

The ocean reserves and fossil fuels regulate the amount of CO_2 in the atmosphere.

Plants absorb CO_2 from the atmosphere for photosynthesis, of which a certain amount is released back through respiratory activities.

A major amount of CO_2 is contributed by the decomposers who contribute to the CO_2 pool by processing dead and decaying matter.

The amount of CO_2 in the atmosphere has been increased considerably by human activities such as burning of fossil fuels, deforestation.