Introduction to Environment and Ecosystem

- The term "Ecology" was introduced by Ernst Haeckel (German scientist) in 1869 and involves the study of interactions as well as interrelationships amongst organisms and their environment. Environment made up of lithosphere, hydrosphere and atmosphere. Since, ecology involves the study of relations of living organisms with the environment, it is also known as environmental biology.

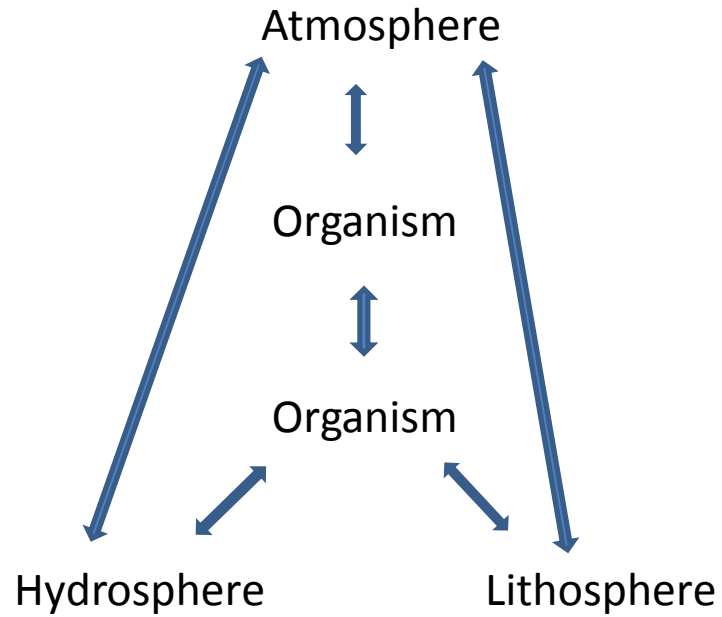

Fig. 1. Interaction between organisms as well as with other components of environment Bhatti (2015).

- **Ecology** has been differentiated into autecology and synecology, where Autecology deals with the study of relationships of a single species or population with the environment for different aspects like life history, adaptations, etc. On the other hand, Synecology involves the study of biotic communities with the environment for different aspects like structure, development, etc.

- **Ecosystem** is a functional unit of nature and contains both biotic (biological community like producer, consumer and decomposer) and abiotic (physical environment like water, soil, light, etc.) components. In ecosystem, relationships occur not only between the members of biological community but also amongst biotic and abiotic components.

- **Importance of ecosystem:** (1) Study of ecosystems provide information about amount of energy flowing into them, its harvesting and availability at various levels; (2) Density of ecosystem is governed by degree of biogeochemical cycling and the amount of inorganic nutrients entering the ecosystem from outside; (3) Each ecosystem has a number of food webs. The knowledge of food webs is helpful to restore a degraded ecosystem and prevent unscientific exploitation of different ecosystems; (4) It provides information about interrelationships between different types of organisms and amongst organisms with their abiotic environment; (5) By knowing the carrying capacity of an ecosystem, it can be known the number of producers and consumers that can be supported by that ecosystem; (6) The shortage of inputs can be known and corrected.

- **Biotic components** involve all the living organisms present in an ecosystem. These living organisms linked between themselves via food and web of other relations. Food is nutrient that provides energy for body functioning and materials for body building. Food is manufactured by autotrophs and are also known as producers. Other organisms that are unable to manufacture their own food are known as heterotrophs. They get their from outside. These are of two kinds namely consumers that feed on living organic matter and decomposer, which feed on organic remains. Thus, an ecosystem have three different kinds of biotic components based on the mode of obtaining food: (i) Producers, (ii) consumers and (iii) decomposers.

- **Producers/Autotrophs** are those organisms that are capable to prepare organic food from inorganic raw materials not only for themselves but also for the other biotic components of ecosystem. Green plants, yellow green algae, brown red algae, cyanobacteria, green and purple bacteria, etc., are the examples of producers. In terrestrial ecosystems, producers are rooted plants (herbs, shrubs and trees). In deep ecosystems, main producers are floating minute autotrophs termed as phytoplankton. Except chemosynthetic bacteria, all others get energy from sunlight and are known as photoautotrophs, which actually transform solar energy to chemical energy. Thus, these are also called transducers.

- **Consumers** are generally animals that feed on other organisms for obtaining nourishment. These are classified into herbivores and carnivores. Herbivores derive their food and energy straightforwardly from producers. They transform plant substance into animal matter and constitute primary or first order consumers, e.g., deer, goat, etc. Further, second order consumers are animals that prey on herbivores, e.g., frog, insectivorous birds, snake, etc. Third order consumers are also animals, which prey on second order consumers and tiger, lion, etc. are good examples.

- **Decomposers** are saprotrophic microbes that derive nourishment from organic remains. They do not ingest the organic material but secrete their digestive enzymes on the organic matter, which result in extracellular digestion. In this case, organic residues are fully disintegrated with the release of inorganic nutrients. Owing to this, decomposers are also called as mineralizers and the same process is important for biogeochemical cycling. Other heterotrophs involves: (1) **Scavengers/ Detrivores** feed on dead bodies and assist in rapid disposal of corpses, for example vulture, carrion, etc. Such scavengers also left small trashes for decomposers and (ii) **Parasites** derive their nourishment from a living host without capturing/ killing the host. Interestingly, they derive food from all types of organisms. Bacteria, fungi, etc. are good examples.
- **Abiotic Components** are factors as well as materials of the physical environment. The materials involve inorganic nutrients like carbon, nitrogen water, etc. and organic residues such as carbohydrates, lipids, proteins, etc. The abiotic substances present in all parts of biosphere, i.e., air, water and soil. Abiotic factors involve climatic factors, edaphic factors as well as topographic factors.
- The climate of an area is influenced by latitude, altitude duration, intensity of sunlight as well as movement of earth. The key climatic factors are light, temperature, humidity, precipitation, wind as well as water.
- Edaphic factors involve soil as well as soil containing substrata. In addition, they involve pH, topography, minerals, etc.
- Abiotic factors limit the distribution, behaviour as well as relationship with other organisms.

- **Trophic levels** are levels in which organisms derive their food. First trophic level (T1)) comprised of secondary carnivores that feed on primary carnivores; second trophic level (T2) made up of herbivores; Third trophic level (T3) composed of primary carnivores that prey on herbivores; Fourth trophic level (T4phic level (T5) composed of tertiary carnivores that prey upon secondary carnivores. In terrestrial habitats, carnivory does not go beyond T5 level, i.e., T5 level composed of top carnivores that are not eater by others. These may belong to the class of primary, secondary or tertiary carnivores. For instance, tiger, lion or panther fall in the class of primary carnivore if it preys deer/ antelope. Sixth trophic level (T6) represented by decomposers in terrestrial ecosystems.

Producers (T1) ⟶ **Herbivores(T2)** ⟶ **Primary carnivores(T3)** ⟶
Secondary carnivores (T4) ⟶ **Tertiary carnivores (T5)** ⟶ **Sixth trophic level (T6)**

Fig. 2. Trophic levels

- **Three most important functions of ecosystems are**: (1) Productivity, interrelations as well as energy flow; (2) Nutrient cycling and (3) Development and stabilization (Balance of nature).

- **Productivity** refer to the amount of energy bearing organic material fixed by ecosystem or its component per unit time. It is measured in terms of dry matter formed or energy captured per unit area per unit time, for example grams m^{-2} $year^{-1}$; kcal m^{-2} $year^{-1}$. The values are used in comparing the productivity of various ecosystems. Productivity is differentiated into primary and secondary.

- **Primary productivity** is the rate at which solar energy is captured as well as biomass formed by the producers as a result of photosynthesis. Magnitude of primary productivity reliant on the efficiency and photosynthetic ability of producers, solar radiations available, temperature and soil moisture. The most suitable conditions for photosynthesis take place in tropics. Here, the photosynthetic activity can be sustained at optimum rate throughout the year. Variations take place with the availability of moisture. It is further classified into gross primary productivity (GPP) as well as net primary productivity (NPP).
- **GPP** is the total amount of solar energy trapped as well as the total organic material/ biomass synthesized by the producers in their photosynthesis per unit time per unit area.
- **NPP** is the amount of energy/ biomass accumulated by the producers per unit area per unit time. NPP is less compared to GPP with respect to amount of energy/ organic material utilized by the producers in their own respiration per unit area per unit time.

NPP = GPP – Respiration

Where,

GPP= The amount of energy/biomass produced during photosynthesis.

NPP= The difference amongst the amount of photosynthetic yield and the utilization of organic material during respiration. NPP result in accumulation of biomass in the producers, which act as food for herbivores and decomposers. Mature tropical rain forests depict a NPP > tonnes/ha/year

- **Secondary productivity (SP)** is the rate at which organic matter is formed by consumers. Consumers depict heterotrophic mode of nutrition and they obtain ready made organic matter. But a part of organic material is wasted in this consumption. A part comes out as undigestable faecal material. Out of remaining material that has been digested and absorbed by the body, a part is consumed for obtaining energy in respiration. The rest is assimilated as well as utilized for growth and body building of consumers. Herbivores utilize a part of plant material for their feeding so that producers are not damaged. A good portion of ingested material is passed out as faeces that become accessible for decomposers. Herbivores utilize approximately 30% of the food energy in respiration and the remaining material is utilized for forming the body. Carnivores spoil a lot of organic matter in the course of preying and are more proficient in transforming food into biomass owing to easily digestion of meat. Carnivores utilize more organic material for respiration, which is about upto 60%.
- It must be noted that in SP, no new organic material is synthesized and thus, it is merely use of portion of food prepared by primary producers for the formation of consumer biomass.
- **Energy flow and energy flow model in ecosystem:** Energy flow in ecosystem is unidirectional or one way, where source of all energy is solar energy. Fifty percent of incident solar energy is photosynthetically active radition (PAR) in which a portion of it is captured by producers for their photosynthesis.

- Only a small portion of food energy, approximately 10% is stored as biomass (Lindeman, 1942). 1-5% of incident solar radiation or 2-10% of incident PAR is trapped by producers during their photosynthesis as gross primary productivity. The remaining bulk of incident radiation is dissipated, mostly as heat. About 20% of the captured energy in gross primary productivity is used by producers for their own respiration. The net primary productivity (NPP) is available to herbivores as well as human beings. Nevertheless, herbivory utilizes merely a portion of NP P. The remaining unused NPP is finally transformed into detritus, which is the energy source for decomposers.
- A good fraction of food energy remains unused by herbivores. They waste a lot of food energy during ingestion, where a fraction of ingested food is not digested and passed out as faecal matter that is utilized further by decomposers. Herbivores use 30% of assimilated food in respiration. The energy made available to herbivores by respiration is used for different metabolic activities and heat production. The remaining assimilation is transformed to herbivore biomass. It is about 10% of productivity of producers. The passage of about 10% of biomass energy from one trophic level to the next is **ten percent law.** This law was put farwarded by Lindeman, 1942.
- As energy available at higher carnivore level becomes small, an ecosystem does not have more than 3-5 trophic levels, for example:

Prodecer Biomass (1000 kcal) → Herbivore biomass (100 kcal) → carnivore I biomass (10 kcal) → Carnivore II biomass (1 kcal)

- **Food Chain** represents sequence of trophic levels by which food travels while passing from producers to ultimate consumers. The food chain involves the phenomenon of eat and be eaten operates, i.e., an organism that is predator at one trophic level turn out to be prey for organisms of higher trophic level.
- Food chains are of three types: (1) Predator-Prey or Grazing food chain (common food chain), where producers are eaten by herbivores, herbivores by carnivores and the latter by higher order carnivores; (2) Parasitic food chain that ends at the level of parasites, for instance, Grass $\longrightarrow$ cattle $\longrightarrow$ *Pneumococcus;* (3) Detritus food chain that initiate from dead bodies and organic remains.
- Food Web or food net is interlocking of two or more types of food chains at different trophic levels in such way that a particular food becomes available to two or more kinds of populations, while a consumer has a choice of two or more kinds of food.

All Resources for aforementioned notes:

1. Bhatti, K. (2015) Companion Biology, S. Dinesh & Co., India, pp. 1328-1345.