AECC- Environmental Studies

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Ecosystem: The ecosystem is a basic functional unit of an environment, where organisms interact with abiotic and biotic, both necessary for the maintenance of life on earth. The term 'ecosystem' was coined by A.G. Tansley, an English botanist, in 1935. An ecosystem is the structural and functional unit of ecology encompassing complex interaction between its biotic and abiotic components. The ecosystem approach has grown in importance in many areas. The United Nations Convention on Biodiversity (1992), promoted an ecosystem approach, including humans, for conserving biodiversity rather than the more species-based approaches that predominated previously. The ecosystem regulates the quantities and flows of materials and energy through ecological systems. These materials include carbon, water, nitrogen, and rock-derived elements such as phosphorus.

Structure of ecosystem: The differences in physical properties between water and air lead to fundamental structural differences between aquatic and terrestrial ecosystems. Due to its greater density, water offers greater physical support for photosynthetic organisms than does the air that bathes terrestrial ecosystems. The major two components are the following:

1) ***Abiotic components:*** The abiotic substances likewise, inorganic and organic compounds of the habitat of the organism. The inorganic components of an ecosystem such as carbon (C), water (H), nitrogen (N), sulphur (S), calcium (Ca), phosphate (P), etc. involved in biogeochemical cycles. The amount and distribution of organic components such as proteins, carbohydrates, lipids, and amino acids, all of which are synthesized by the biota (flora and fauna) of an ecosystem and are reached the ecosystem as their wastes, dead remains, etc. The climate, temperature, light, soil, minerals, etc., are other abiotic components of the ecosystem.

2) ***Biotic components:*** The biotic component refers to the plants, animals, and microorganisms that are living components of the ecosystem. 1) ***Autotrophic components:*** The autotrophs (producers) are capable of making nutritive organic molecules from inorganic materials**,** thus, heterotrophs have the capability of producing their own foods. The autotrophic organisms like

chemosynthetic and photosynthetic bacteria, blue-green algae, algae, and all other green plants build up organic matter. The primary producers of water in the pelagic zone of aquatic ecosystems are phytoplankton float near the water surface and vascular plants are primary producers of lakes, streams, rivers, oceans, and ponds. Terrestrial ecosystems have trees, shrubs, herbs, grasses, and mosses that contribute with varying importance as primary producers of the ecosystem, 2) ***Heterotrophic*** components are also known as consumers, that feed on other organisms to obtain energy to survive, that is they obtain their carbon from organic compounds. The heterotrophs (consumers) that are unable to synthesize their own organic carbon-based compounds from inorganic sources, hence, have to feed on organic matter produced by other organisms. The following are the four types of consumers in an ecosystem:

1) Primary consumers
2) Secondary consumers
3) Tertiary consumer
4) Decomposers

Functioning processes: The primary function of an ecosystem are transfers of energy following thermodynamic principles, which eventually runs in a circle and sustains the entire life of the planet. The enters of energy an ecosystem when light energy drives the reduction of carbon dioxide (CO_2) to form sugars during photosynthesis. The organic matter and energy are tightly linked as they move through ecosystems. The energy is lost from the ecosystem when organic matter is oxidized back to carbon dioxide (CO_2) by combustion or by the respiration of plants, animals, and microbes. The functioning of an ecosystem incorporates processes such as the decomposition of organic matter, fixation of carbon, nutrient and water cycling, and degradation of toxic compounds. The functioning of an ecosystem not only underpins biomass production but also depends on and regulates the stocks and fluxes of resources, energy, and biota, these functions, together with ecological processes and species to an ecosystem. The ecosystems gain energy from solar radiation with help of minerals taken from their areal environment, they are made of complex organic matter. The ecosystem function is abiotic and biotic processes within an ecosystem. The essential abiotic components of an ecosystem which supplies carbon, nitrogen, and soil, which provide support, storage, and other nutrients required by organisms. The essential biological components of ecosystems are plants, animals, and decomposers. The

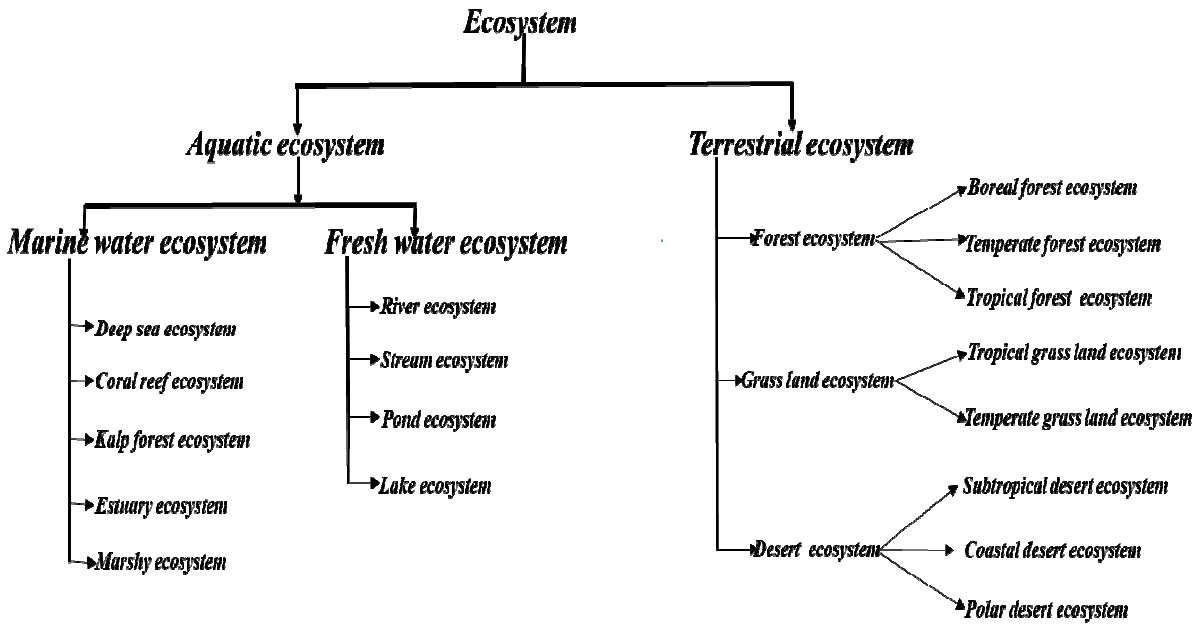
plants capture 2-10% solar energy in the process of bringing carbon into the ecosystem. The plants use solar energy to acquire nutrients and assemble organic material. A few ecosystems, such as deep-sea ecosystems have no plants but instead, have cyanobacteria that derive energy from the oxidation of hydrogen sulphide (H_2S) to produce organic matter. The microbes break down dead remains to release gases in the atmosphere, and nutrients in forms that are available to other microbes and plants.

Food chain: The food chain refers to the linear sequence of transfers of nutrients and energy in the form of food from organism to organism. The macro and microflora, which traps solar energy and convert this energy into chemical energy by the processes of photosynthesis, are primary sources of foods. The food chain is the movement of nutrients and energy from one creature to another at different trophic levels. The organisms of a food chain are classified into these levels on the basis of their feeding behaviour. The producers in the food chain are green plants. The primary consumer-eaten autotrophs are called herbivores. The secondary consumer-eaten herbivores are called carnivores. The tertiary consumer-eaten carnivores are called omnivores.

Grazing food chain: The grazing food chain starts from green plants and from autotrophs and it goes to herbivores (primary consumers) to primary carnivores (secondary consumers) and then to secondary carnivores (tertiary consumers) and so on. The consumers which start the food chain, utilizing the plant and plant parts as their food, constitute the grazing food chain.The gross production of a green plant in an ecosystem may have three fates – it may be oxidized in respiration, it may be eaten by herbivorous animals and after the death and decay of producers it may be utilized by decomposers and converters and finally released into the environment. In herbivores the assimilated food can be stored as carbohydrates, proteins and fats, and transformed into much more complex organic molecules. The energy for these transformations is supplied through respiration. As in autotrophs, the energy in herbivores also meets three routes respiration, decay of organic matter by microbes and consumption by the carnivores. Likewise, when the secondary carnivores or tertiary consumers eat primary carnivores, the total energy assimilated by primary carnivores or gross tertiary production follows the same course and its disposition into respiration, decay and further consumption by other carnivores is entirely similar to that of herbivores.

Detritus food chain: Detritus food chain refers to the dead organic remains including plants and animals bodies wastes. The decomposers consist of micro-organisms such as bacteria and fungi that break down dead organisms and waste materials. The decomposer secretes digestive enzymes that break down dead and waste materials into simpler substances into nutrients usable by the producers. Here, the detritus act as the source of energy for the primary consumers termed as detritus consumers. There are two major classes of detritus consumers, namely, detritus feeders and decomposers. Detritus feeders directly feed on dead plant and animal matter. For example, invertebrates such as termites, earthworms, millipedes, ants, etc. The detritus food chain plays an important role in the transfer of energy from organism to organism in ecosystems.

Energy flow in ecosystem: The energy is essential requirement for all living biota. The energy flow is the transfer of energy from one organism to another in an ecosystem. The energy conserving efficiency is 1.15% for grasslands, 0.9% for Savannah, 0.8% for mixed forests, 5% for modern crops and 10-20% for sugarcane field. . The energy flow models link the trophic levels with each other showing the inputs and losses of energy at each trophic level. Lindeman (1942) was the first to propose such model assuming that plants and animals can be arranged into trophic levels and the laws of thermodynamics hold for plants and animals. He emphasized that the amount of energy at trophic level is determined by the net primary production and the efficiency at which food energy is converted into biomass.



Aquatic Ecosystem: The aquatic ecosystem is defined as a water-based habitat of an ecosystem in which all living species interact with the environment's physical and chemical properties. The aquatic ecosystem plays a significant role in striking a balance between the atmosphere, lithosphere, and biosphere. For example, oceans, lakes, ponds, and rivers. The aquatic ecosystems support a wide range of organisms, including bacteria, fungi, algae, invertebrates, plants, and fish [Heinrichs et al., 2020]. The aquatic ecosystem is commonly categorized on the basis of water chemistry and also moving (lotic and lentic) of water. The marine ecosystem covers about 70% of the earth's surface and the freshwater ecosystem viz. lakes, ponds, rivers, and streams, which cover about 2% of the earth's surface (Kumar and Mishra, 2021). The marine ecosystem consists of two zones according to the light penetration and depth of water. The euphotic zone is the layer closer to the surface that receives enough light for photosynthesis to occur. In general, the euphotic zone can extend to depths of 80 to 100 metres, and the disphotic zone to depths of 80 to 700 metres.The marine ecosystem is the euphotic zone, extending down as far as 200 meters (656 feet) below the surfacesufficient light for regular photosynthetic activity. The aphotic zone does not receive any sunlight, which occupies the great bulk of the ocean. The temperature of water bodies also varies with water depth. The solar radiation transfer heat through the photic zone of an aquatic ecosystem. The density of water is also directly related to temperature.

Marine ecosystem: The marine (ocean) ecosystem contains a greater diversity of life forms than the terrestrial ecosystem, marine water possesses a higher concentration of salt. The marine organisms are frequently consumed worldwide because they constitute relatively cheap and accessible food items of high nutrient quality. The ocean ecosystems play an important role in climate regulation. The ocean's water covers more than 70% of the Earth's surface, accounts for more than 97% of the Earth's water supply, and occupies 90% of the Earth's habitable space. The oceans can be divided into numerous regions depending on the physical and biological conditions. The ocean environment is classified on the basis of penetration of light (euphotic, disphotic and aphotic), distance from shore, and depth of water. The open ocean is called the pelagic zone. The pelagic zone is also divided on the basis of light and depth of water: a) epipelagic zone (0 to 200-meter depth, b) mesopelagic zone (200 to 10000-meter depth), c) bathypelagic zone (1000 to 4000-meter of depth), d) abyssopelgic zone (about 6000 meters of depth) and e) hadalpelagic zone (more than 6000-meter depth). The benthic zone is found at the bottom of the ocean; it extends from the shoreline to the deep seafloor more than 6000 meters from the water surface. The marine environment provides many ecosystems that support biodiversity in coastal and open ocean habitats.

Freshwater ecosystems: The freshwater ecosystems cover 0.78% of the Earth's surface and inhabit 0.009% of its total water; they generate nearly 3% of their net primary production. The freshwater ecosystems enable the multidimensional dispersal of organisms and also play important roles in the cycling of matter and flow of energy.

Pond ecosystem: The pond ecosystem is a freshwater ecosystem on which living organisms rely for their survival and food they cover more earth's surface than lakes. The ponds are often identified by their small size and shallow depths of up to 12 to 15 feet, in which solar radiation can penetrate to the bottom. The pond ecosystem is temporary or permanent and consists of a wide variety of aquatic plants and animals interacting with each other and the surrounding aquatic conditions. The pond ecosystem consists of seven major categories: algae, floating and submerged hydrophytes, and amphibious. the United States classify a pond as a surface water body having surface area of less than 10 acres.

Littoral zone: The littoral zone closest to the shore and with enough sunlight to penetrate, it is high productivity and high biodiversity. They provide food, oxygen, and habitat to other aquatic organism.

Limnetic zone: The limnetic zone is the top layer of the pond water body; this zone covers much of the pond's surface with less sunlight to penetrate littoral zones. Photosynthesis occurs in this zone, and the primary producers are phytoplankton floats that float suspended in the water. The limnetic zone is generally lower in productivity and biodiversity than the littoral zone.

Profundal zone: The bottom and deep water area near the bottom, which is no sunlight penetration. This zone has low biodiversity.

Benthic zone: The benthic zone is the bottom of a pond. The organisms such as crayfish, snails, and insects also live in and around the plants near shore. The plants provide shelter from predatory fish as well as food and oxygen. In deeper water, where the bottom of the lake is completely dark, there are no producers. Most organisms that live here are decomposers.

Producers: The producers are autotrophs that trap solar energy with help of photo-synthesis and manufacture their own food viz. carbohydrates. These include species of rooted, submerged, floating plants, free-floating, and algae.

i) ***Phytoplankton****:* The phytoplankton is photosynthesizing microorganisms that inhabit the upper sunlit layer of freshwater pond bodies. Their species diversity phytoplankton such as *Cyanophyceae, Chlorophyceae, Bacillariophyceae* and *Euglenophyceae.* The phytoplankton primary producers obtain energy through photosynthesis; it plays a major bulk in food material for all aquatic organisms.

ii) ***Macrophytes****:* The macrophytes are important for aquatic food webs and affect the interaction between predatory, planktivorous, and benthivorous fish, as well as between fish and invertebrates, it is primary producers in a freshwater ecosystem. The some species of macrophytes grow in pond systems such as *Cladophoraspp, Chara spp. and Nitella spp, , Typha, Elodea spp., Wolffia spp.*.

Consumers: The consumers are heterotrophs which depend on producers (green plants) for their food. They are the following types:

i) ***Primary consumers:*** The zooplankton is primary consumers are usually herbivores, they feed upon phytoplankton. The zooplankton species such as Rotifera, Cladocera, Daphnia Copepoda and Ostracoda . Besides these, small herbivores such as snails, insects, small fishes, tadpoles, mites, and larvae of aquatic animals are the primary consumers often found in the pond.

ii) ***Secondary consumers****:* They are carnivores that feed on herbivores(zooplankton), these are chiefly insects and fish, most insects, and water beetles. These include large animal species such as frogs, big fishes, water snakes, crabs, etc. The consumers of the highest order might include mammals like water shrews, water voles, herons, ducks, kingfishers, etc.

iii) ***Tertiary Consumers****:* These are some large fish, game fish, and turtles, which feed on small fish and thus become tertiary consumers.

Decomposers: They are also known as micro-consumers. They break down the dead organic matterof both producers and consumers. Thus they play an important role in the return of minerals again into the pond ecosystem. The bacteria, Actinomycetes, and fungi constitute the decomposers of the pond ecosystem.The species of *Penicillium, Aspergillus, Rhizopus, Alternaria, Cephalosporium, Trichoderms,etc.* are the most common fungi (decomposers) present in the water and mud of the pond.

Terrestrial ecosystem: The terrestrial ecosystem is a land-based community of species and the interactions of abiotic components in a specific area. The terrestrial ecosystem covers 144,150,000 km2, which is about 25%-30% of the earth's surface. The terrestrial ecosystems are those that primarily live on land. The temperature range, average quantity of precipitation, soil type, and amount of light received help to determine the type of terrestrial ecosystem present in a particular location.

1). **Forest ecosystem**: Forest ecosystems, are dominated by trees and other woody vegetation, which cover approximately 30% of the global land area. The world's forests are mainly located in Asia (31% of the global forest area), South America (21%), North and Central America (17%), Africa (17%), Europe (9%), and Oceania (5%). The Earth's forests account for 80% of the planet's total plant biomass, and the amount of carbon they store in biomass and soil is more significant than the one currently present in the atmosphere. ***The boreal forests*** are the earth's second-largest ecosystem of land, it covers 40·106 km2 of the Earth, about 31% of global ice-

free land, it is also known as the Taiga forest. Theyare located in Northern Hemispheres at latitudes between 60° and 50° North, with an average of 20°F to 70°F and also annual rainfall is 18-38 inches. The climate of the boreal forest is characterized by strong seasonal variation with short, moderately warm, and moist summers and long, extremely cold, and dry winters. ***The tropical forest*** ecosystems are covering only 9% of the Earth's land. The tropical forest is mainly evergreen rainforests and moist forests. The tropical forest ecosystems occur between the tropics of Cancer and Capricorn (23.5° N and S of the Equator). The higher precipitation with annual rainfall exceeding 200 cm, and higher temperature between 20 to 25^0C.The temperate forest ecosystems are found in Northern Hemisphere and Southern Hemisphere, it covers 16% of the geographical area of the world forest, in India covers 6.74% of the geographical area and consists of 12.84% of the Himalayan region. ***The temperate forests*** ecosystem is mixed with deciduous, broad-leaved evergreen vascular plants. The function of ecosystem functions is defined as the fluxes of energy, matter, and information among the different compartments of an ecosystem.

Grasslands ecosystem: The grasslands are the most imperiled terrestrial ecosystem on the planet, vegetation is dominated by C_3 and C_4 grass other herbaceous plants. The grasslands provide feed resources for grazing animals that include livestock and wildlife. The grazing has a significant influence on the structure and composition of grassland communities and tends to maintain high species diversity. The grassland is the most widely distributed tropical and temperate grasslands. Tropical and subtropical savannas cover an eighth of the global terrestrial area (~1600 million ha) and represent the majority of savanna located in tropical and subtropical latitudes of Africa, Australia, South America, India, and South East Asia. The broad-leaved savanna species such as *Combretum* spp., *Lonchocarpus nelsii*, and *Terminalia* spp. always found in worm climate where the annual rainfall is between 30 to 50 cm annually. Temperate grasslands consist of *Bouteloua dactyloides*, *Lolium*, *Avena*, and *Nassella pulchra*, it has hot summers and cold winter and the annually rainfall about 25 to 75 cm annually.

The succession refers to the changes of pattern in the specific composition of the community after a radicaldisturbance or after the opening of a new patch in the physical environment occurring over time (Matthews, 1992; Walker et al., 2010), forthe colonization of plants and animals. If the physical environment remains constant eventually changes in the specific

composition of the communities become undetectably slow. The successional change results from the normal complex interactions between organisms and the environment, leading to changes in overall species composition. If succession is promoted by changing environmental factors or competitive interactions, species composition alters in response to the availability of niches.The succession term given by Hult (1885), the succession can encompass change in communities (often defined by their dominant species) and ecosystems (which drive or are driven by species change), structural and functional change (usually but not always driven by the biota), and abiotic environment change. Successional studies benefit restoration in six areas: site amelioration, development of community structure, nutrient dynamics, species life history traits, species interactions, and modeling of transitions and trajectories.

Hydrosere succession: The hydrosere is the primary succession sequence which develops in aquatic environments such as lakes and ponds..

1) ***Phytoplankton stage:*** It is an initial stage of hydrosere succession in the body of water. The unicellular organisms such as bacteria, blue green algae, and green algae As algal spores are introduced into the water and germinate and multiply, the water body is colonized by a large number of algal spores. The algal spores are brought into water in the initial stage of succession. The nutrients added in soil and water by death and decomposition of planktons to form a layer of muck. The subsequently a soft muddy bottom rich with silt form, the water depth becomes shallower and supported for rooted hydrophytes.
2) ***Submerged stage*****:** The submerged aquatic vegetation develops in the regions of ponds or lakes where water depth is about 10 feet or more, the complete penetration of light become easy. The hydrophytes begin to appear on the new substratum for growth of rooted submerges pioneers species. The hydrophytes die and decomposed by microorganisms and thus release nutrients. The nutrient rich muddy bottom helps to quickly flourish their population.
3) ***Floating stage*****:** they all are rotted hydrophytes floating on water surface. The depth of water reaches about 4 to 8 feet, the submerged vegetation starts the disappearing from its original place, and then the floating plants make their appearance gradually in that area. Their broad leaves of floating plants inhibit penetration of light to deeper layer of water, and this result submerged plants are completely disappearance.

4) ***Reed-swamp stages:*** This stage also called as amphibious stage. The water level very much reduced (water depth reduced one to three feet). The habitat is changed with increase the level of soil and silt, and this condition rotted floating plants cannot survive there. The soil becomes more fertile by death and decay of plant.

5) ***Sedge Marsh or Meadow stage:*** The water level further decreases and the filling process results in the formation of a marshy soil, which may be too dry for the plants of pre-existing community. Now the plants well adapted to new habitat begin to appear in the pre-existing community in mixed state. The rhizomes of these plants are well developed and they are interconnected to each other. They form mat-like vegetation over the top of soil. The luxurious growth of these plants will modify the current soil.

6) ***Woodland stage:*** In this stage some shrub and medium size tree will be starts to appear. These plants will prevent the light penetration to the bottom region and hence the marshy vegetation in the body gradually shrinks. The soil will stay dry in most of the time.

7) **Climax forest:** In this stage a very long time the hydrosere may lead to the development of climax vegetation. The climax community (herbs, shrubs, climbers, mosses, animals, decomposers etc.) are stable and self-sustainable. Trees are dominant and they have control over the entire vegetation. The bacteria, fungi, and other micro-organisms are more frequently found in the climax vegetation. At the climax stage, a complete harmony is developed between plant communities with the habitat.

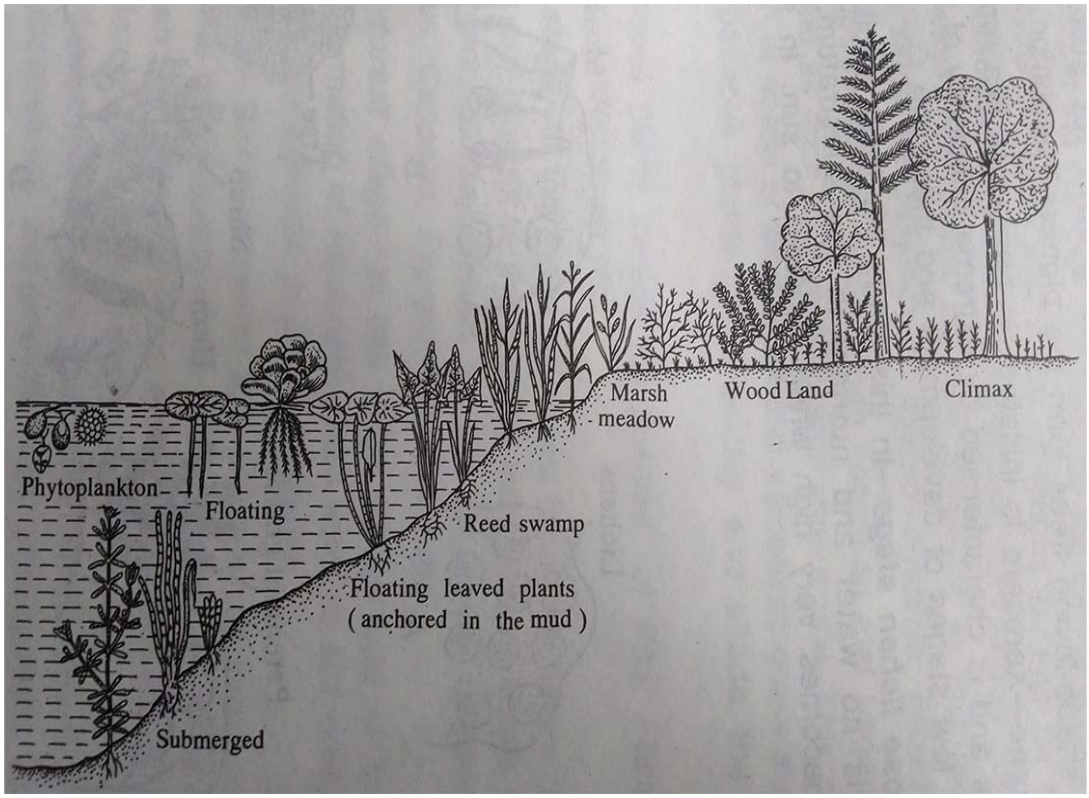


Fig. Illustrate the hydrosere succession.

Xerosere succession: This is a type of succession originating on bare rock surfaces. The rocky habitat shows many extreme xeric conditions like very high surface temperature, deficiency of water and absence of organic matter. The bare rocks are eroded by rain water and wind loaded with soil particles. The rain water combines with atmospheric carbon dioxide that corrodes the surface of the rocks and produce crevices. Water enters these crevices, freezes and expands to further increase the crevices. The wind loaded with soil particles deposit soil particles on the rock and its crevices. All these processes lead to formation of a little soil at the surface of these bare rocks. Algal and fungal spores reach these rocks by air from the surrounding areas. These spores grow and form symbiotic association, the lichen, which act as pioneer species of bare rocks.

1)Crustose lichen stage: The pioneer colonizers on the bare area are crustose lichens which occur on the bare rock surface in the form of membranous crusts.. The lichens produce lichenic acids which corrode the rock and their thalli collect windblown soil particles among them that help in formation of a thin layer of soil.

2) Foliage and fruticose lichen stage: After accumulation of little soil and humus, the rock surface now becomes covered with xeric foliose and fructicose lichens. They are attached by the substratum at one point only. The foliose lichens absorb and accumulate water and minerals and check evaporation of surface water.

3) Moss stage: The spores of xerophytic mosses are brought to the rock where they succeed lichens. They are rhizoids penetrate soil among the crevices, secrete acids and corrode the rocks. The bodies of mosses are rich in organic and inorganic compounds. When these die they add these compounds to the soil, increasing the fertility of the soil.

4) Herbaceous stage: The herbaceous weeds mostly annual such as asters, evening primroses and milk weed, with the increase of humus and mineral salt in soil. Their roots penetrate deep down, secrete acids and enhance the process of weathering. Leaf litter and death of herbs add humus to the soil.

5) Shrub stage: The soil conditions are now become favourable for shrub. The roots of shrub plant penetrate into soil, which develop wide crack of rock. The leaves, stems, roots of these plants are decomposed by bacteria and fungi, and the soil becomes rich in organic substances. The soil formation continues and its moisture content increases which initiates growth of vegetation.

6) Tree stage: Change in environment favours colonization of tree species. The trees begin to grow among the shrubs and establish themselves. The trees form canopy and shade the area. Shade-loving shrubs continue to grow as secondary vegetation.

7) Climax stage: The succession culminates in a climax community, the forest. Many intermediate tree stages develop prior to establishment of a climax community. The forest type depends upon climatic conditions.