Chapter 7

UNIT IX: Plant Ecology

Ecosystem

Learning Objectives

Learning objectives

The learner will be able to,

- Describe the Structure, functions and types of ecosystems
- Draw ecological pyramids by means of number, biomass and energy
- Interpret carbon and phosphorus cycle
- Recognise pond ecosystem as a self-sufficient and self-regulating system
- Analyse ecosystem services and its management
- Discuss about the importance and conservation of ecosystem
- Explain the types of plant succession

Chapter outline

SE62M

Have you seen lakes, ponds and pools in your surroundings? They are all called water bodies with many components in them. Can you list out the things which are found in water bodies? Mud, nutrients, clay, dissolved gases, planktons, microorganisms, plants like algae, *Hydrilla, Nelumbo, Nymphaea* and animals like snake, small fish, large fish, frog, tortoise and crane are the components of the water bodies which constitutes **ecosystem**. Further, we all know that plants and animals are prominent living components in the environment. They interact with space components such as air, water, soil, sunlight, etc. For example, you have studied in class XI, one of the life processes, photosynthesis which utilizes sunlight , water, carbondioxide, nutrients from the soil and release oxygen to the atmosphere. From this, we understand that the exchange of materials takes place between living and space components. Likewise, you can study the structure, function and types of ecosystem in this chapter. The term **'ecosystem'** was proposed by A.G. Tansley (1935), who defined it as '**the system resulting from the integration of all the living and nonliving factors of the environment'**. Whereas, Odum (1962) defined ecosystem **'as the structural and functional unit of ecology'.**

Parallel terms for ecosystem coined by various ecologists

- Biocoenosis – Karl Mobius
- Microcosm – S.A. Forbes
- Geobiocoenosis – V. V. Dokuchaev, G.F. Morozov
- Holocoen - Friederichs
- Biosystem – Thienemann
- Bioenert body – Vernadsky

7.1 Structure of ecosystem

Ecosystem comprises of two major components. They are:

i) **Abiotic (non-living) components**: It includes climatic factors (air, water, sunlight, rainfall, temperature and humidity), edaphic factors (soil air, soil water and pH of soil),topography (latitude, altitude), organic components (carbohydrates, proteins, lipids and humic substances) and inorganic substances (C, H, O, N and P). Abiotic components play vital role in any ecosystem and hence the total inorganic substances present in any ecosystem at a given time is called **standing quality** (or) **standing state**.

ii) **Biotic (living) components**: It includes all living organisms like plants, animals, fungi and bacteria. They form the trophic structures of any ecosystem. On the basis of nutritional relationships, trophic levels of an ecosystem have two components. (1) autotrophic components and (2) heterotrophic components.

(1) Autotrophic components: Autotrophs are organisms which can manufacture the organic compounds from simple inorganic components through a process called photosynthesis. In most of the ecosystems, green plants are the autotrophs and are also called **producers**.

(2) Heterotrophic components: Those organisms which consume the producers are called **consumers** and can be recognized into macro and micro consumers. **Macroconsumers** refer to herbivores, carnivores and omnivores (primary, secondary and tertiary consumers). **Microconsumers** are called decomposers. Decomposers are organisms that decompose the dead plants and animals to release organic and inorganic nutrients into the environment which are again reused by plants. Example: Bacteria, Actinomycetes and Fungi.

The amount of living materials present in a population at any given time is known as **standing crop**, which may be expressed in terms of number or biomass per unit area. **Biomass** can be measured as fresh weight or dry weight or carbon weight of organisms. Biotic components are essential to construct the food chain, food web and ecological pyramids.

7.2 Functions of ecosystem

The function of ecosystem include creation of energy creation, sharing of energy and cycling of materials between the living and nonliving components of an ecosystem.

Before studying the productivity in any ecosystem, we should understand the essential role of sunlight used by producers of the first trophic level. The quantity of sunlight is directly proportional to the production of energy by plants.

7.2.1 Photosynthetically Active Radiation (PAR)

The amount of light available for photosynthesis of plants is called **P**hotosynthetically **A**ctive **R**adiation (PAR) which is from of 400-700 nm in wave length. It is essential for photosynthesis and plant growth. PAR is not always constant because of clouds, tree shades, air, dust particles, seasons, latitudes and length of the daylight availability. Generally plants absorb more blue and red light for efficient photosynthesis.

Of the total sunlight, 34 percent that reaches the atmosphere is reflected back into the atmosphere, moreover 10% is held by ozone, water vapours and atmospheric gases and the remaining 56% reaches the earth's surface. Out of this 56%, only 2 – 10% of the solar energy is used by green plants for photosynthesis while the remaining portion is dissipated as heat.

PAR is generally expressed in millimoles / square meter / second by using silicon photo voltic detectors which detect only 400 – 700 nm wavelength of light. PAR values range from 0 to 3000 millimoles /square meter / second.

At night PAR is zero and during midday in the summer, PAR often reaches 2000 – 3000 millimoles /square meter/second.

Types of Carbon

Green carbon – carbon stored in the biosphere (by the process of photosynthesis).

Grey carbon – carbon stored in fossil fuel (coal, oil and biogas deposits in the lithosphere).

Blue carbon – carbon stored in the atmosphere and oceans.

Brown carbon – carbon stored in industrialized forests (wood used in making commercial articles)

Black carbon – carbon emitted from gas, diesel engine and coal fired power plants.

7.2.2 Productivity of an ecosystem

The rate of biomass production per unit area in a unit time is called productivity. It can be expressed in terms of gm /m^2/year or Kcal/m^2/year. It is classified as given bellow.

1. Primary productivity
2. Secondary productivity
3. Community productivity

1. Primary productivity:

The chemical energy or organic matter generated by autotrophs during the process of photosynthesis and chemosynthesis is called **primary productivity**. It is the source of energy for all organisms, from bacteria to human.

a. Gross Primary Productivity (GPP)

The total amount of food energy or organic matter or biomass produced in an ecosystem by autotrophs through the process of photosynthesis is called **gross primary productivity**

b. Net Primary Productivity (NPP)

The proportion of energy which remains after respiration loss in the plant is called **net primary productivity**. It is also called as apparent photosynthesis. Thus the difference between GPP and respiration is known as NPP.

$$NPP = GPP - Respiration$$

NPP of whole biosphere is estimated to be about 170 billion tons (dry weight) per year. Out of which NPP of oceanic producers is only 55 billion tons per year in unit time.

2. Secondary productivity

The amount of energy stored in the tissues of heterotrophs or consumers is called **secondary productivity**.

a. Gross secondary productivity

It is equivalent to the total amount of plant material is ingested by the herbivores minus the materials lost as faeces.

b. Net secondary productivity

Storage of energy or biomass by consumers per unit area per unit time, after respiratory loss is called **net secondary productivity**.

3. Community productivity

The rate of net synthesis of organic matter (biomass) by a group of plants per unit area per unit time is known as **community productivity**.

Factors affecting primary productivity

Primary productivity depends upon the plant species of an area, their photosynthetic capacity, availability of nutrients, solar radiation, precipitation, soil type, topographic factors (altitude, latitude, direction), and other environmental factors. It varies in different types of ecosystems.

7.2.3 Concept of trophic level in an ecosystem

(Greek word ' trophic' = to food or feeding)

A trophic level refers to the position of an organism in the food chain. The number of trophic levels is equal to the number of steps in the food chain. The green plants (producers) occupying the first trophic level (T_1) are called **producers**. The energy produced by

the producers is utilized by the plant eaters (herbivores) they are called **primary consumers** and occupy the second trophic level (T_2).

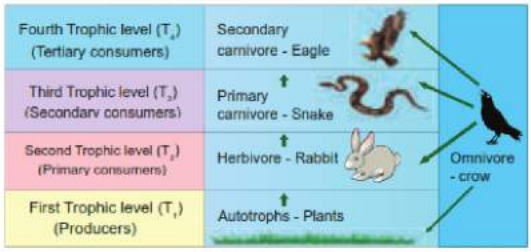


Figure 7.1: Diagrammatic representation of trophic levels

Herbivores are eaten by carnivores, which occupy the third trophic level (T_3). They are also called **secondary consumers** or **primary carnivores**. Carnivores are eaten by the other carnivores, which occupy the fourth trophic level (T_4). They are called the **tertiary consumers or secondary carnivores**. Some organisms which eat both plants and animals are called as **omnivores** (Crow). Such organisms may occupy more than one trophic level in the food chain.

7.2.4 Energy flow

The transfer of energy in an ecosystem between trophic levels can be termed as energy flow. It is the key function in an ecosystem. Part of the energy obtained from the sun by producers is transferred to consumers and decomposers through each trophic level, while some amount of energy is dissipated in the form of heat. Energy flow is always unidirectional in an ecosystem.

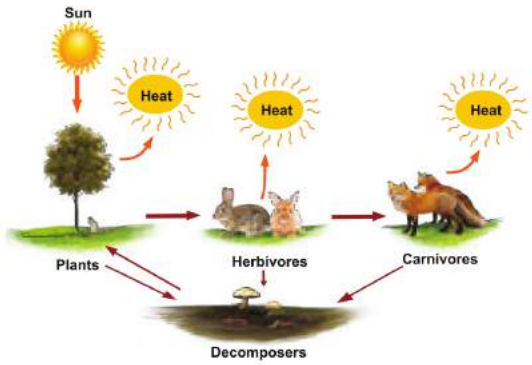


Figure 7.2: Diagrammatic representation of energy flow

Laws of thermodynamics

The storage and loss of energy in an ecosystem is based on two basic laws of thermo-dynamics.

i. First law of thermodynamics

It states that energy can be transmitted from one system to another in various forms. Energy cannot be destroyed or created. But it can be transformed from one form to another. As a result, the quantity of energy present in the universe is constant.

Example:

In photosynthesis, the product of starch (chemical energy) is formed by the combination of reactants (chlorophyll, H_2O, CO_2). The energy stored in starch is acquired from the external sources (light energy) and so there is no gain or loss in total energy. Here light energy is converted into chemical energy.

$$6\,CO_2 + 6\,H_20 \xrightarrow[\text{Chlorophyll}]{\text{light}} C_6H_{12}0_6 + 6\,O_2$$

Light energy $\longrightarrow$ chemical energy

ii. Second law of thermodynamics

It states that energy transformation results in the reduction of the free energy of the system. Usually energy transformation cannot be 100% efficient. As energy is transferred from one organism to another in the form of food, a portion of it is stored as energy in living tissue, whereas a large part of energy is dissipated as heat through respiration. The transfer of energy is irreversible natural process. Example: Ten percent law

Ten percent law

This law was proposed by Lindeman (1942). It states that during transfer of food energy from one trophic level to other, only about 10% stored at every level and rest of them (90%) is lost in respiration, decomposition and in the form of heat. Hence, the law is called **ten percent law.**

Example: It is shown that of the 1000 Joules of Solar energy trapped by producers. 100 Joules of energy is stored as chemical energy through

photosynthesis. The remaining 900 Joules would be lost in the environment. In the next trophic level herbivores, which feed on producers get only 10 Joules of energy and the remaining 90 Joules is lost in the environment. Likewise, in the next trophic level, carnivores, which eat herbivores store only 1 Joule of energy and the remaining 9 Joules is dissipated. Finally, the carnivores are eaten by tertiary consumers which store only 0.1 Joule of energy and the remaining 0.9 Joule is lost in the environment. Thus, at the successive trophic level, only ten percent energy is stored.

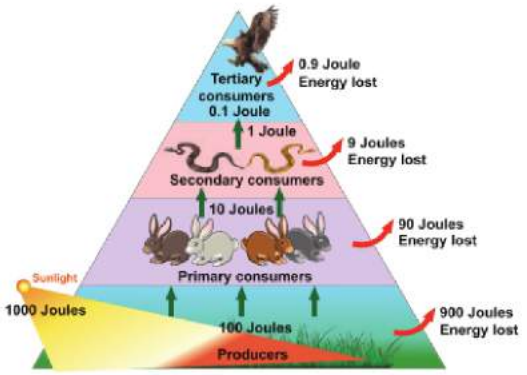


Figure 7.3: Ten percent law

7.2.5 Food chain

The movement of energy from producers upto top carnivores is known as **food chain**, i.e., in any food chain, energy flows from producers to primary consumers, then from primary consumers to secondary consumers, and finally secondary consumers to tertiary consumers. Hence, it shows linear network links. Generally, there are two types of food chain, (1) Grazing food chain and (2) Detritus food chain.

1. Grazing food chain

Main source of energy for the grazing food chain is the **Sun**. It begins with the first link, producers (plants). The second link in the food chain is primary consumers (mouse) which get their food from producers. The third link in the food chain is secondary consumers (snake) which get their food from primary consumers. Fourth link in the food chain is tertiary consumers (eagle) which get their food from secondary consumers.

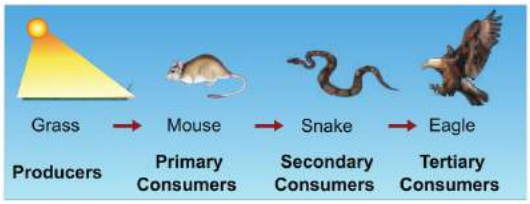


Figure 7.4: Diagrammatic representation of Grazing food chain

2. Detritus food chain:

This type of food chain begins with **dead organic matter** which is an important source of energy. A large amount of organic matter is derived from the dead plants, animals and their excreta. This type of food chain is present in all ecosystems.

The transfer of energy from the dead organic matter, is transferred through a series of organisms called detritus consumers (detritivores)- small carnivores - large (top) carnivores with repeated eating and being eaten respectively. This is called the detritus food chain.

Figure 7.5: Diagrammatic representation of Detritus food chain.

7.2.6 Food Web

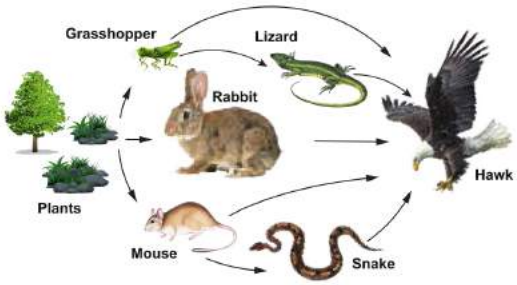


Figure 7.6: Diagrammatic representation of Food web in a grassland ecosystem

The inter-locking pattern of a number of food chain form a web like arrangement called **food**

web. It is the basic unit of an ecosystem, to maintain its stability in nature. Which is also called homeostasis.

Example: In a grazing food chain of a grass land, in the absence of a rabbit, a mouse may also eat food grains. The mouse in turn may be eaten directly by a hawk or by a snake and the snake may be directly eaten by hawks.

Hence, this interlocking pattern of food chains is the food web and the species of an ecosystem may remain balanced to each other by some sort of natural check.

Significance of food web

- Food web is constructed to describe species interaction called direct interaction.
- It can be used to illustrate indirect interactions among different species.
- It can be used to study bottom-up or top-down control of community structure.
- It can be used to reveal different patterns of energy transfer in terrestrial and aquatic ecosystems.

7.2.7 Ecological pyramids

Graphic representation of the trophic structure and function at successive trophic levels of an ecosystem is called **ecological pyramids**. The concept of ecological pyramids was introduced by **Charles Elton (1927)**. Thus they are also called as **Eltonian pyramids**.

There are three types: (1) pyramid of number (2) pyramid of biomass (3) pyramid of energy.

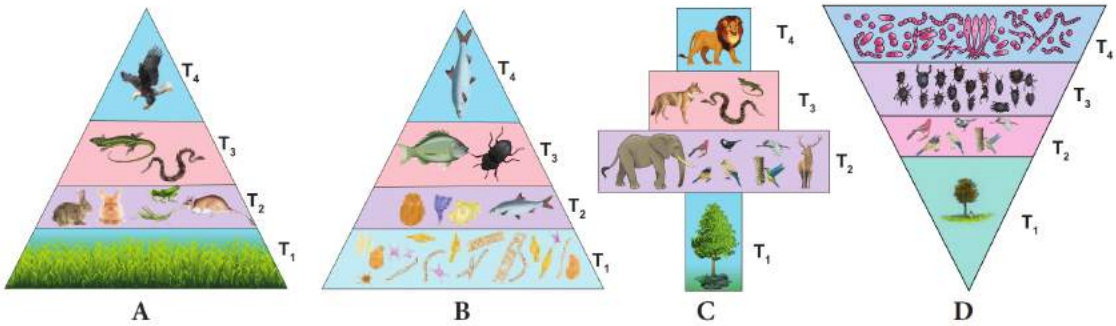
1. Pyramid of number

A graphical representation of the number of organisms present at each successive trophic level in an ecosystem is called **pyramids of number.** There are three different shapes of pyramids upright, spindle and inverted.

There is a gradual decrease in the number of organisms in each trophic level from producers to primary consumers and then to secondary consumers, and finally to tertiary consumers. Therefore, pyramids of number in **grassland** and **pond ecosystem** are always **upright**.

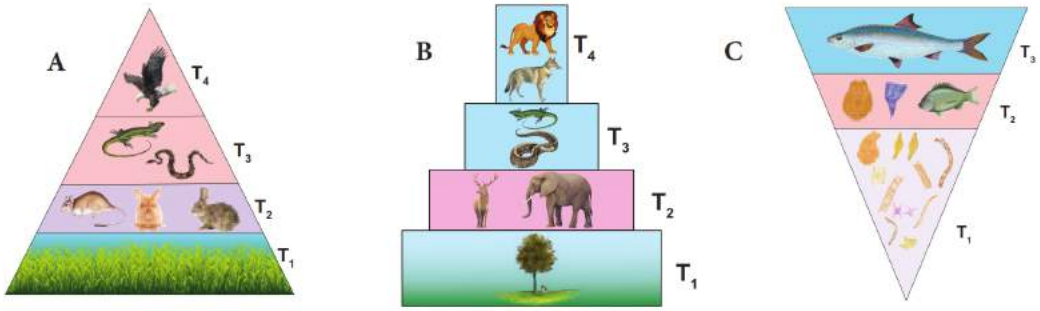
In a **forest ecosystem** the pyramid of number is somewhat different in shape, it is because the base (T_1) of the pyramid occupies large sized trees (Producer) which are lesser in number. Herbivores (T_2) (Fruit eating birds, elephant, deer) occupying second trophic level, are more in number than the producers. In final trophic level (T_4), tertiary consumers (lion) are lesser in number than the secondary consumer (T_3) (fox and snake). Therefore, the pyramid of number in forest ecosystem looks **spindle shaped**.

The pyramid of number in a **parasite ecosystem** is always **inverted**, because it starts with a single tree. Therefore there is



T_1 - Producers | T_2 - Herbivores | T_3 - Secondary consumers | T_4 - Tertiary consumers

Figure 7.7: Pyramids of numbers (individuals per unit area) in different types of ecosystems. **Upright**-A) Grassland ecosystem B) Pond ecosystem , **Spindle shaped** -C) Forest ecosystem, **Inverted**-D) Parasite ecosystem



T_1 - Producers | T_2 - Herbivores | T_3 - Secondary consumers | T_4 - Tertiary consumers

Figure 7.8: Pyramids of biomass (dry weight per unit area)in different types of ecosystems. **Upright**-A) Grassland ecosystem B) Forest ecosystem, **Inverted**- C)Pond ecosystem

gradual increase in the number of organisms in successive tropic levels from producer to tertiary consumers.

2 Pyramid of biomass

A graphical representation of the amount of organic material (biomass) present at each successive trophic level in an ecosystem is called **pyramid of biomass.**

In **grassland** and **forest ecosystems**, there is a gradual decrease in biomass of organisms at successive trophic levels from producers to top carnivores (Tertiary consumer). Therefore, these two ecosystems show pyramids as **upright** pyramids of biomass.

However, in **pond ecosystem**, the bottom of the pyramid is occupied by the producers, which comprise very small organisms possessing the least biomass and so, the value gradually increases towards the tip of the pyramid. Therefore, the pyramid of biomass is always **inverted** in shape.

3. Pyramid of energy

A graphical representation of energy flow at each successive trophic level in an ecosystem is called **pyramid of energy.** The bottom of the pyramid of energy is occupied by the producers. There is a gradual decrease in energy transfer at successive tropic levels from producers to the upper levels. Therefore, the pyramid of energy is **always upright**.

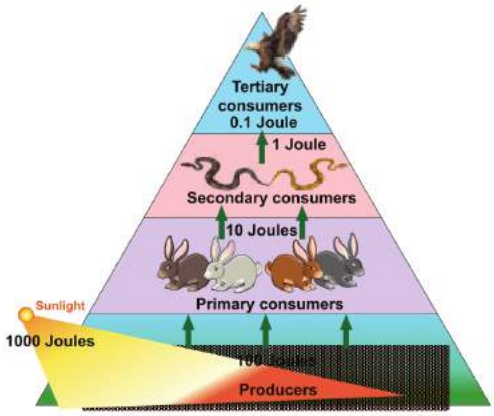


Figure 7.9: Pyramids of energy(Kcal/unit area/unit time) in any ecosystem

7.2.8 Decomposition:

Decomposition is a process in which the detritus (dead plants, animals and their excreta) are breaken down in to simple organic matter by the decomposers. It is an essential process for recycling and balancing the nutrient pool in an ecosystem.

Nature of decomposition

The process of decomposition varies based on the nature of the organic compounds, i.e., some of the compounds like carbohydrate, fat and protein are decomposed rapidly than the cellulose, lignin, chitin, hair and bone.

Mechanism of decomposition

Decomposition is a step wise process of degradation mediated by enzymatic reactions. Detritus acts as a raw material for decomposition. It occurs in the following steps.

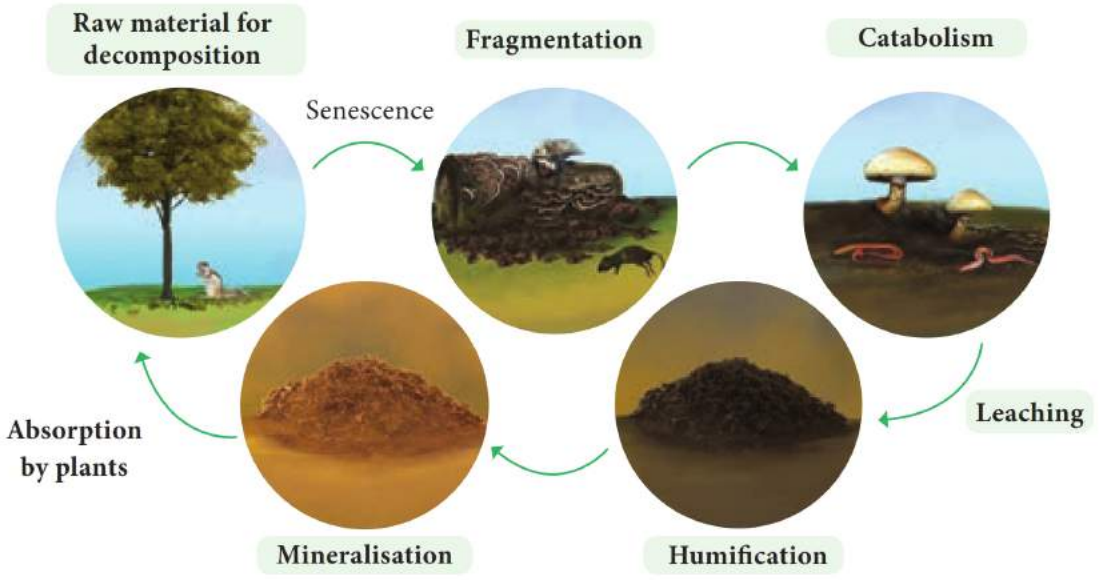


Figure 7.10: Diagrammatic representation – Process of decomposition and cycling of nutrients.

a. **Fragmentation** - The breaking down of detritus into smaller particles by detritivores like bacteria, fungi and earth worm is known as **fragmentation**. These detritivores secrete certain substances to enhance the fragmentation process and increase the surface area of detritus particles.

b. **Catabolism** - The decomposers produce some extracellular enzymes in their surroundings to break down complex organic and inorganic compounds in to simpler ones. This is called **catabolism**

c. **Leaching or Eluviation** - The movement of decomposed, water soluble organic and inorganic compounds from the surface to the lower layer of soil or the carrying away of the same by water is called **leaching** or **eluviation**.

d. **Humification** - It is a process by which simplified detritus is changed into dark coloured amorphous substance called **humus**. It is highly resistant to microbial action, therefore decomposition is very slow. It is the reservoir of nutrients.

e. **Mineralisation** - Some microbes are involved in the release of inorganic nutrients from the humus of the soil, such process is called **mineralisation**.

Factors affecting decomposition

Decomposition is affected by climatic factors like temperature, soil moisture, soil pH ,oxygen and also the chemical quality of detritus.

7.2.9 Biogeochemical cycles (Nutrient cycles)

Exchange of nutrients between organisms and their environment is one of the essential aspects of an ecosystem. All organisms require nutrients for their growth, development, maintenance and reproduction. Circulation of nutrients within the ecosystem or biosphere is known as **biogeochemical cycles** and also called as 'cycling of materials.' There are two basic types,

1. **Gaseous cycle** – It includes atmospheric Oxygen, Carbon and Nitrogen cycles.
2. **Sedimentary cycle** – It includes the cycles of Phosphorus, Sulphur and Calcium - Which are present as sediments of earth.

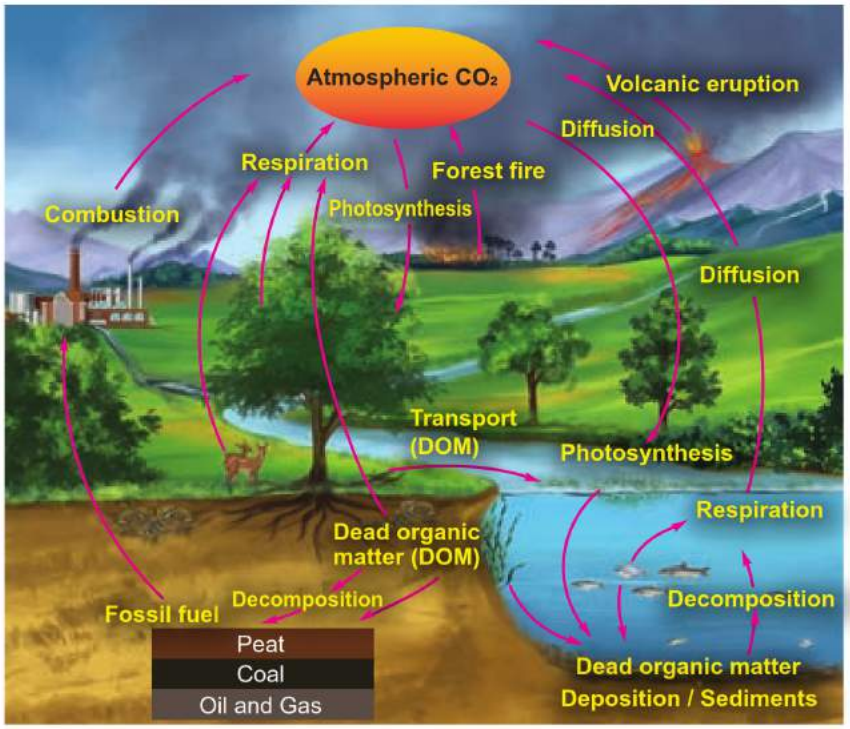


Figure 7.11: Diagrammatic Sketch showing Carbon cycle

Many of the cycles mentioned above are studied by you in previous classes. Therefore, in this chapter, only the carbon and phosphorous cycles are explained.

Carbon cycle

The circulation of carbon between organisms and environment is known as the **carbon cycle**. Carbon is an inevitable part of all biomolecules and is substantially impacted by the change in global climate. Cycling of carbon between organisms and atmosphere is a consequence of two reciprocal processes of photosynthesis and respiration. The releasing of carbon in the atmosphere increases due to burning of fossile fuels, deforestration, forest fire, volcanic eruption and decomposition of dead organic matters. The details of carbon cycle are given in the figure 7.11.

Phosphorus cycle

It is a type of sedimentary cycle. Already we know that phosphorus is found in the biomolecules like DNA, RNA, ATP, NADP and phospholipid molecules of living organisms. Phosphorus is not abundant in the biosphere, whereas a bulk quantity of phosphorus is present in rock deposits, marine sediments and guano.

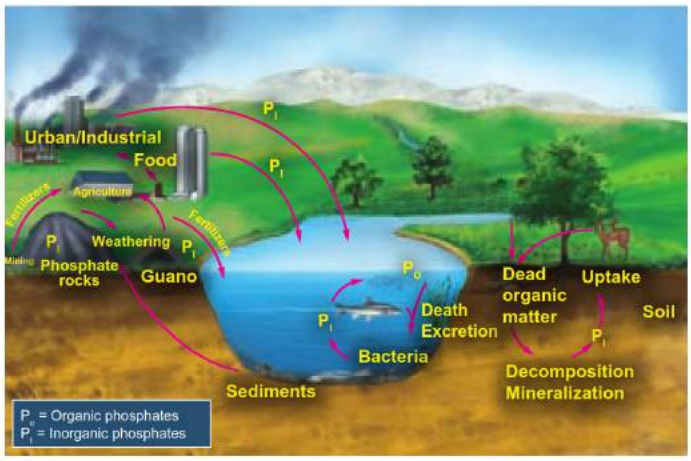


Figure 7.12: Diagrammatic sketch showing Phosphorous cycle

It is released from these deposits by weathering process. After that, it circulates in lithosphere as well as hydrosphere. The producers absorb phosphorus in the form of phosphate ions, and then it is transferred to each trophic level of food chain through food. Again death of the organisms and degradation by the action of decomposers, the phosphorus is released back into the lithosphere and hydrosphere to maintain phosphorus cycle.

7.2.10 Types of ecosystem

Biosphere consists of different types of ecosystems, which are as follows:

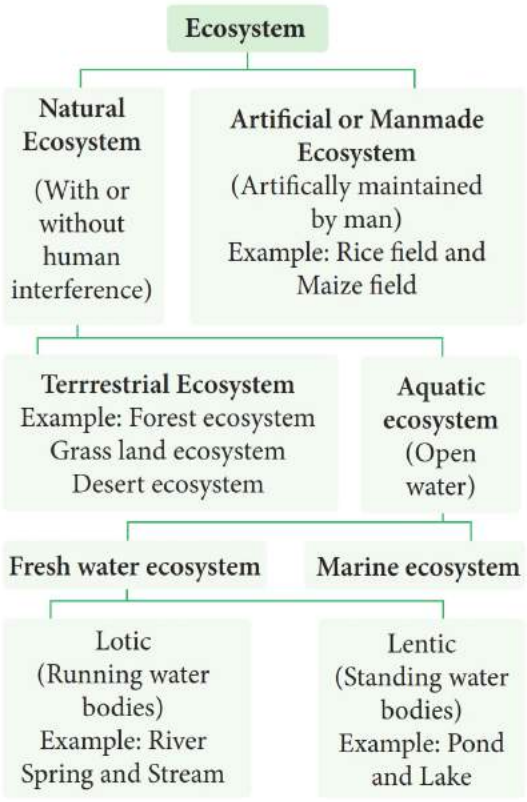


Figure 7.13: Types of Ecosystem

Though there are many types of ecosystems as charted above. Only the pond ecosystem is detailed below.

Structure of Pond ecosystem

It is a classical example for natural, aquatic, freshwater, lentic type of ecosystem. It helps us to understand the structure and function of an ecosystem. When rain water gathers in a shallow area, gradually over a period of time, different kinds of organisms (microbes, plants, animals) become part of this ecosystem. This pond ecosystem is a self sustaining and self regulatory fresh water ecosystem, which shows a complex interaction between the abiotic and biotic components in it.

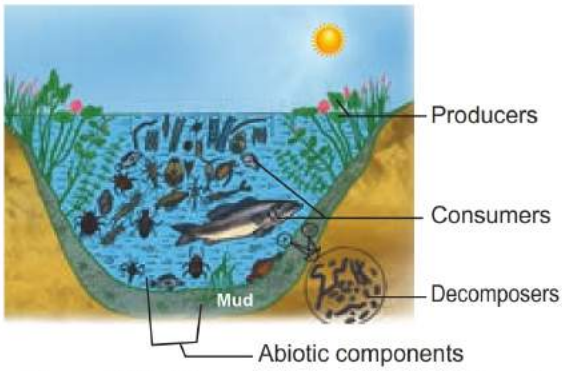


Figure 7.14: Diagram shows structure of pond ecosystem with abiotic and biotic components.

> **Activity**
>
> Collect few living and nonliving components from any water body found near by.

Abiotic components

A pond ecosystem consists of dissolved inorganic (CO_2, O_2, Ca, N, Phosphate) and organic substances (amino acids and humic acid) formed from the dead organic matter. The function of pond ecosystem is regulated by few factors like the amount of light, temperature, pH value of water and other climatic conditions.

Biotic components

They constitute the producers, variety of consumers and decomposers (microorganisms).

a. Producers

A variety of phytoplanktons like *Oscillatoria, Anabaena, Chlamydomonas, Pandorina, Eudorina, Volvox* and *Diatoms.* Filamentous

algae such as *Ulothrix, Spirogyra, Cladophora* and *Oedogonium;* floating plants *Azolla, Salvia, Pistia, Wolffia* and *Eichhornia*; submerged plants *Potamogeton* and *Phragmitis*; rooted floating plants *Nymphaea* and *Nelumbo*; macrophytes like *Typha* and *Ipomoea,* constitute the major producers of a pond ecosystem.

b. Consumers

The animals represent the consumers of a pond ecosystem which include zooplanktons like *Paramoecium* and *Daphnia* (primary consumers); benthos (bottom living animals) like mollusces and annelids; secondary consumers like water beetles and frogs; and tertiary consumers (carnivores) like duck , crane and some top carnivores which include large fish, hawk ,man, etc.

Sea grasses and mangroves of Estuarine and coastal ecosystems are the most efficient in carbon sequestration. Hence, these ecosystems are called as " **Blue carbon ecosystems**". They are not properly utilized and maintained all over the world although they have rich bioresources potential.

c. Decomposers

They are also called as microconsumers. They help to recycle the nutrients in the ecosystem. These are present in mud water and bottom of the ponds. Example: Bacteria and Fungi. Decomposers perform the process of decomposition in order to enrich the nutrients in the pond ecosystem.

The cycling of nutrients between abiotic and biotic components is evident in the pond ecosystem, making itself self sufficient and self regulating.

Limnology

It is the study of biological, chemical, physical and geological components of inland fresh water aquatic ecosystems (ponds, lakes, etc.).

Oceanography – It is the study of biological, chemical, physical and geological components of ocean.

Stratification of pond ecosystem

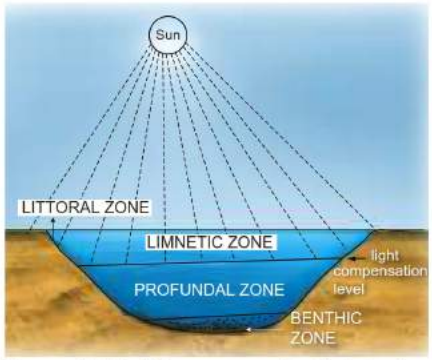


Figure 7.15: Diagrammatic sketch shows stratification of Pond ecosystem

Based on the factors like distance from the shore, penetration of light, depth of water, types of plants and animals, there may be three zones, littoral, limnetic and profundal. The littoral zone, which is closest to the shore with shallow water region, allows easy penetration of light. It is warm and occupied by rooted plant species. The limnetic zone refers the open water of the pond with an effective penetration of light and domination of planktons. The deeper region of a pond below the limnetic zone is called profundal zone with no effective light penetration and predominance of heterotrophs. The bottom zone of a pond is termed benthic and is occupied by a community of organisms called benthos (usually decomposers).The primary productivity through photosynthesis of littoral and limnetic zone is more due to greater penetration of light than the profundal zone.

7.2.11 Ecosystem services (Benefits)

Ecosystem services are defined as the benefits that people derive from nature. Robert Constanza et al (1927) stated "Ecosystem services are the benefits provided to human, through the transformation of resources (or Environmental assets including land, water, vegetation and atmosphere) into a flow of essential goods and services".

Study on ecosystem services acts as an effective tool for gaining knowledge on ecosystem benefits and their sustained use. Without such knowledge gain, the fate of any ecosystem will be at stake and the benefits they provide to us in future will become bleak.

Robert Constanza and his colleagues estimated the value of global ecosystem services based on various parameters. According to them in 1997, the average global value of ecosystems services estimated was US $ 33 trillion a year. The updated estimate for the total global ecosystem services in 2011 is US $ 125 trillion / year, indicating a four-fold increase in ecosystem services from 1997 to 2011.

Mangrove ecosystem services

- Offers habitat and act as nursery for aquatic plants and animals
- Provides medicine, fuel wood and timber.
- Act as bridge between sea and rivers by balancing sedimentation and soil erosion.
- Help to reduce water force during cyclones, tsunamis and high tide periods.
- Help in wind break, O_2 production, carbon sequestration and prevents salt spray from waves.

How do anthropogenic activities affect ecosystem services?

Now, we all exploit the ecosystem more than that of our needs. The **Millennium Ecosystem Assessment (2005)** found that "over the past 50 years, humans have changed the ecosystem more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, medicine, timber, fiber and fuel."

The varieties of benefits obtained from the ecosystem are generally categorized into the following four types

Ecosystem services

Provisoning services	Cultural services	Supporting services	Regulating services
• Food, fiber and fuel	• Spiritual and religious values	• Primary production	• Invasion resistance
• Genetic resources	• Knowledge system	• Provision of habitat	• Herbivory pollination
• Bio-chemicals	• Education and inspiration	• Nutrient cycling	• Seed dispersal
• Fresh water	• Recreation and aesthetic values	• Soil formation and retention	• Climate regulation
• Medicines	• Ecotourism	• Production of atmospheric oxygen	• Pest regulation
		• Water cycling	• Disease regulation
			• Erosion regulation
			• Water purification
			• Natural hazard protection

Figure 7.16: Types of Ecosystem services

Generally the following human activities disturb or re-engineer an ecosystem every day.

- Habitat destruction
- Deforestation and over grazing
- Erosion of soils
- Introduction of non-native species
- Over harvesting of plant material
- Pollution of land, water and air
- Run off pesticides, fertilizers and animal wastes

Ecosystem resilience

Ecosystem is damaged by disturbances from fire, flood, predation, infection, drought, etc., removing a great amount of biomasss. However, ecosystem is endowed with the ability to resist the damage and recover quickly. This ability of ecosystem is called ecosystem resilience or ecosystem robustness.

How to protect the ecosystem?

It is a practice of protecting ecosystem at individual, organisational and governmental levels for the benefits of both nature and humans. Threats to ecosystems are many, like adverse human activities, global warming, pollution, etc. Hence, if we change our everyday life style, we can help to protect the planet and its ecosystem.

"If we fail to protect environment, we will fail to save posterity".

Therefore, we have to practice the following in our day today life:

- Buy and use only ecofriendly products and recycle them.
- Grow more trees
- Choose sustained farm products (vegetables, fruits, greens, etc.)
- Reduce the use of natural resources.
- Recycle the waste and reduce the amount of waste you produce.
- Reduce consumption of water and electricity.
- Reduce or eliminate the use of house-hold chemicals and pesticides.
- Maintain your cars and vehicles properly. (In order to reduce carbon emission)
- Create awareness and educate about ecosystem protection among your friends and family members.

Go green

It refers to the changing of one's lifestyle for the safety and benefits of the environments (Reduce, Reuse, Recycle)

Way to go green and save green

- Close the tap when not in use.
- Switch off the electrical gadgets when not in use.
- Never use plastics and replace them with biodegradable products
- Always use ecofriendly technology and products.

"USE ECOSYSTEM BUT DON'T LOSE ECOSYSTEM; MAKE IT SUSTAINABLE"

7.2.12 Ecosystem Management

It is a process that integrates ecological, socio economic and institutional factors into a comprehensive strategy in order to sustain and enhance the quality of the ecosystem to meet current and future needs.

Ecosystem management emphasis on human role in judicious use of ecosystem

and for sustained benefits through minimal human impacts on ecosystems. Environmental degradation and biodiversity loss will result in depletion of natural resources, ultimately affecting the existence of human

"By 2025, at least 3.5 billion people, nearly 50% of the world's population are projected to face water scarcity." – IUCN.

"Forests house approximately 50% of global bio-diversity and at least 300 million people are dependent on forest's goods and services to sustain their livelihood." – IUCN

Strategy of ecosystem management

- It is used to maintain biodiversity of ecosystems.
- It helps in indicating the damaged ecosystem (Some species indicate the health of the ecosystem: such species are called a **flagship species**).
- It is used to recognize the inevitability of ecosystem change and plan accordingly.
- It is one of the tools used for achieving sustainability of ecosystem through sustainable development programme (or projects).
- It is also helpful in identifying ecosystems which are in need of rehabilitation.
- It involves collaborative management with government agencies, local population, communities and NGO's.
- It is used to build the capacity of local institutions and community groups to assume responsibility for long term implementation of ecosystem management activities even after the completion of the project.

Urban ecosystem restoration model

Adayar Poonga is located in Chennai and covers an area around a total of 358 acres of Adayar creek and estuary, of which 58 acres were taken up for eco restoration under the auspices of Government of Tamil Nadu. It is maintained by Chennai Rivers Restoration Trust (CRRT).This was a dumping site previously.

Presently it has 6 species of mangroves, about 170 species of littoral and tropical dry evergreen forests (TDF) which have successfully established as a sustainable ecosystem. Restoration of plants species has brought other associated fauna such as butterflies, birds, reptiles, amphibians and other mammals of the ecosystem.

Currently Adayar Poonga functions as an environmental education Centre for school and college students and the public. The entire area stands as one of the best examples for urban eco restoration in the state of Tamil Nadu.

Adayar Poonga

7.3 Plant Succession

We very often see that forests and lands in our areas are drastically affected by natural calamities (Flood, earthquake) and anthropogenic activities (Fire, over grazing, cutting of trees). Due to these reasons all plants of an area are destroyed and the areas become nude. When we observe this area, over a period of a time we can

see that it will be gradually covered by plant community again and become fertile. Such successive replacement of one type of plant community by the other of the same area/ place is known as plant **succession**. The first invaded plants in a barren area are called **pioneers**. On the other hand, a series of transitional developments of plant communities one after another in a given area are called **seral communities**. At the end a final stage and a final plant community gets established which are called as climax and climax community respectively.

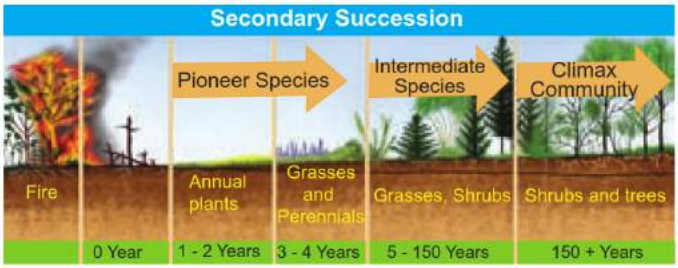


Figure 7.17: Diagrammatic representation of secondary succession

7.3.1 Characteristics of ecological succession

- It is a systematic process which causes changes in specific structure of plant community.
- It is resultant of changes of abiotic and biotic factors.
- It transforms unstable community into a stable community.
- Gradual progression in species diversity, total biomass, niche specialisation, and humus content of soil takes place.
- It progresses from simple food chain to complex food web.
- It modifies the lower and simple life form to the higher life forms.
- It creates inter-dependence of plants and animals.

7.3.2 Types of succession

The various types of succession have been classified in different ways on the basis of different aspects. These are as follows:

1. Primary succession - The development of plant community in a barren area where no community existed before is called primary succession. The plants which colonize first in a barren area is called **pioneer species** or **primary community** or **primary colonies**. Generally, Primary succession takes a very long time for the occurrence in any region.

Example: Microbes, Lichen, Mosses.

2. Secondary succession - The development of a plant community in an area where an already developed community has been destroyed by some natural disturbance (Fire, flood, human activity) is known as **secondary succession**. Generally, This succession takes less time than the time taken for primary succession.

	Primary succession	Secondary succession
1	Developing in an barren area	Developing in disturbed area
2	Initiated due to a biological or any other external factors	Starts due to external factors only
3	No soil, while primary succession starts	It starts where soil covers is already present
4	Pioneer species come from outside environment	Pioneer species develop from existing environment
5	It takes more time to complete	It takes comparatively less time to complete

Table 1: Differences between primary and secondary succession

Example: The forest destroyed by fire and excessive lumbering may be re-occupied by herbs over a period of times.

3. Allogenic succession

Allogeneic succession occurs as a result of

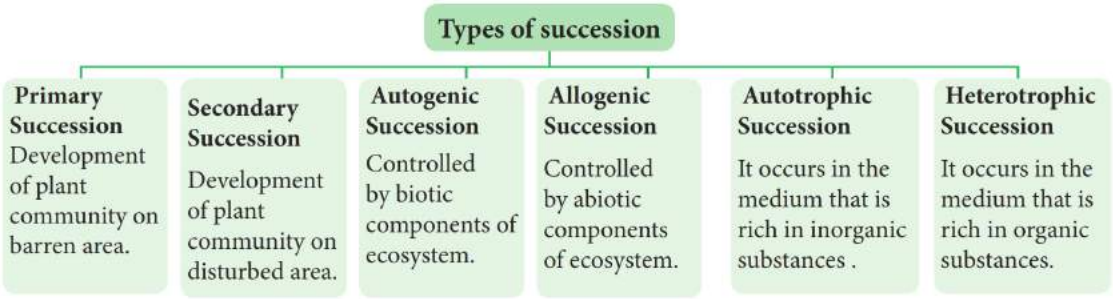


Figure 7.18: Types of succession

abiotic factors. The replacement of existing community is caused by other external factors (soil erosion, leaching, etc.,) and not by existing organisms.

Example: In a forest ecosystem soil erosion and leaching alter the nutrient value of the soil leading to the change of vegetation in that area.

7.3.3 Classification of plant succession

Detailed study of Hydrosere and Lithosere are discussed below:

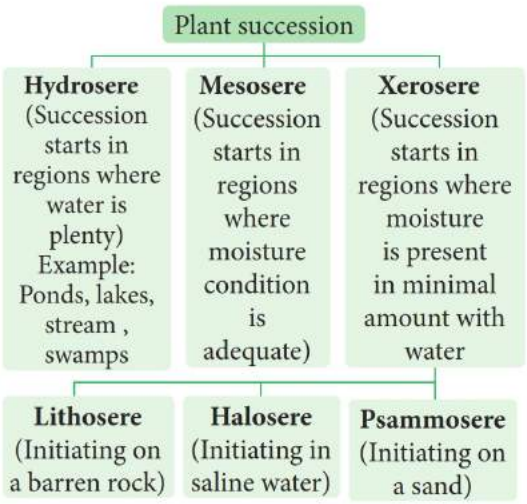


Figure 7.19: Classification of plant succession

Hydrosere

The succession in a freshwater ecosystem is also referred to as hydrosere. Succession in a pond, begins with colonization of the pioneers like phytoplankton and finally ends with the formation of climax community like forest stage. It includes the following stages Fig 7.20.

1. Phytoplankton stage - It is the first stage of succession consisting of the pioneer community like blue green algae, green algae, diatoms, bacteria, etc., The colonization of these organisms enrich the amount of organic matter and nutrients of pond due to their life activities and death. This favors the development of the next seral stages.

2. Submerged plant stage - As the result of death and decomposition of planktons, silt brought from land by rain water, lead to a loose mud formation at the bottom of the pond. Hence, the rooted submerged hydrophytes begin to appear on the new substratum. Example: *Chara, Utricularia, Vallisneria* and *Hydrilla* etc. The death and decay of these plants will build up the substratum of pond to become shallow. Therefore, this habitat now replaces another group of plants which are of floating type.

3. Submerged free floating stage - During this stage, the depth of the pond will become almost 2-5 feet. Hence, the rooted hydrophytic plants and with floating large leaves start colonising the pond. Example: Rooted floating plants like *Nelumbo, Nymphaea* and *Trapa*. Some free floating species like *Azolla, Lemna, Wolffia* and *Pistia* are also present in this stage. By death and decomposition of these plants, further the pond becomes more shallow. Due to this reason, floating plant species is gradually replaced by another species which

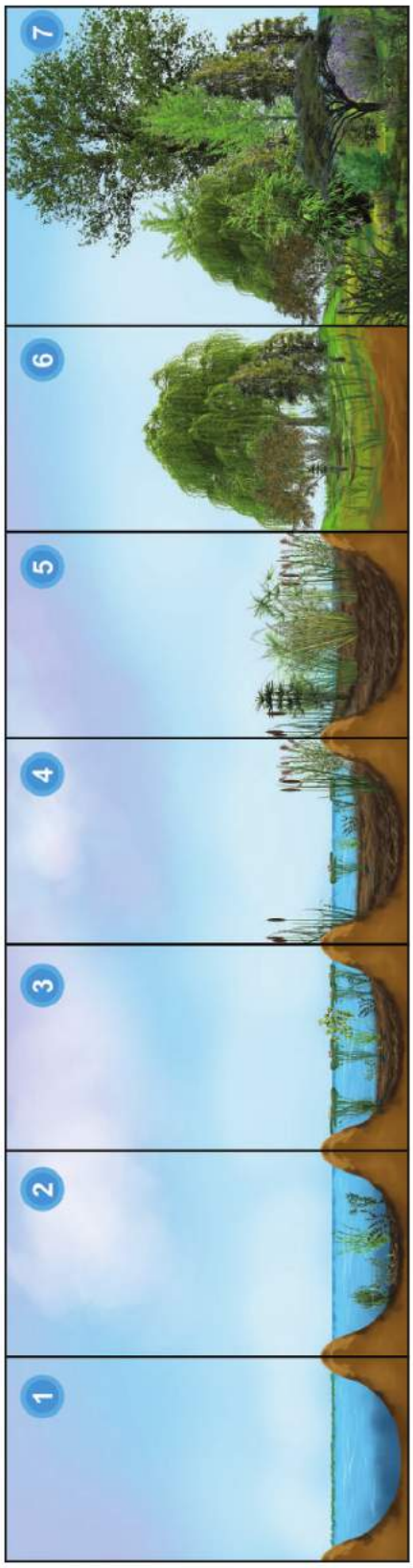


Figure 7.20: Diagrammatic representation shows different stages of hydrosere.

makes new seral stage.

4. Reed-swamp stage - It is also called an amphibious stage. During this stage, rooted floating plants are replaced by plants which can live successfully in aquatic as well as aerial environment. Example: *Typha, Phragmites, Sagittaria* and *Scirpus* etc. At the end of this stage, water level is very much reduced, making it unsuitable for the continuous growth of amphibious plants.

5. Marsh meadow stage - When the pond becomes swallowed due to decreasing water level, species of Cyperaceae and Poaceae such as *Carex, Juncus, Cyperus* and *Eleocharis* colonise the area. They form a mat-like vegetation with the help of their much branched root system. This leads to an absorption and loss of large quantity of water. At the end of this stage, the soil becomes dry and the marshy vegetation disappears gradually and leads to shurb stage.

6. Shrub stage - As the disappearance of marshy vegetation continues, soil becomes dry. Hence, these areas are now invaded by terrestrial plants like shrubs (*Salix* and *Cornus*) and trees (*Populus* and *Alnus*). These plants absorb large quantity of water and make the habitat dry. Further, the accumulation of humus with a rich flora of microorganisms produce minerals in the soil, ultimately favouring the arrival of new tree species in the area.

7. Forest stage - It is the climax community of hydrosere. A variety of trees invade the area and develop any one of the diverse type of vegetation. Example:Temperate mixed forest (*Ulmus,Acer* and *Quercus*), Tropical rain forest (*Artocarpus* and *Cinnamomum*) and Tropical deciduous forest (*Bamboo* and *Tectona*).

In the 7 stages of hydrosere succession, stage1 is occupied by pioneer community, while the stage 7 is occupied by the climax community. The stages 2 to 6 are occupied by seral communities.

7.3.4 Significance of Plant Succession

- Succession is a dynamic process. Hence an ecologist can access and study the seral stages of a plant community found in a particular area.
- The knowledge of ecological succession helps to understand the controlled growth of one or more species in a forest.
- Utilizing the knowledge of succession, even dams can be protected by preventing siltation.
- It gives information about the techniques to be used during reforestation and afforestation.
- It helps in the maintenance of pastures.
- Plant succession helps to maintain species diversity in an ecosystem.
- Patterns of diversity during succession are influenced by resource availability and disturbance by various factors.
- Primary succession involves the colonization of habitat of an area devoid of life.
- Secondary succession involves the reestablishment of a plant community in disturbed area or habitat.
- Forests and vegetation that we come across all over the world are the result of plant succession.

Summary

The interaction between biotic and abiotic components in an environment is called ecosystem. Autotrophs and heterotrophs are the producers and consumers respectively. The function of ecosystem refers to creation of energy, flow of energy and cycling of nutrients. The amount of light available for photosynthesis is called Photo synthetically Active Radiation . It is essential for increase in the productivity of ecosystem. The rate of biomass production per unit area /time is called productivity. It is classified as primary productivity, secondary productivity and community productivity. The transfer of energy in an ecosystem can be termed as energy flow. It is explained through the food chain, food web, ecological pyramids (pyramid of number, biomass and energy) and biogeochemical cycle. Cycling of nutrients between abiotic and biotic components is evident in the pond ecosystem, making itself self sufficient and self regulating Ecosystem protected for the welfare of posterity is called ecosystem management.

Successive replacement of one type of plant community by the other of the same area/ place is known as plant succession. The first invaded plants in a barren (nude) area are called pioneers (pioneers communities). On the other hand, a series of transitional developments of plant communities one after another in a given area are called seral communities. Succession is classified as primary succession, secondary succession, allogeneic succession and autotrophic succession. Plant succession is classified in to hydrosere (Initiating on a water bodies) ,Mesosere and xerosere. Further xerosere is subdivided in to Lithosere (Initiating on a barren rock), Halosere and Pasmmosere.

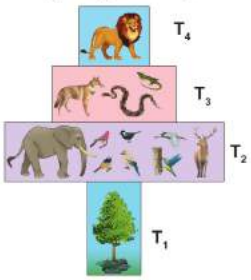
Evaluation

I Choose the most suitable answer from the given four alternatives and write the option code and the corresponding answer.

1. Which of the following is not a abiotic component of the ecosystem?
   a) Bacteria
   b) Humus
   c) Organic compounds
   d) Inorganic compounds
2. Which of the following is / are not a natural ecosystem?
   a) Forest ecosystem b) Rice field
   c) Grassland ecosystem d) Desert ecosystem
3. Pond is a type of
   a) forest ecosystem

b) grassland ecosystem
c) marine ecosystem
d) fresh water ecosystem

4. Pond ecosystem is
   a) not self sufficient and self regulating
   b) partially self sufficient and self regulating
   c) self sufficient and not self regulating
   d) self sufficient and self regulating
5. Profundal zone is predominated by heterotrophs in a pond ecosystem, because of
   a) with effective light penetration
   b) no effective light penetration
   c) complete absence of light
   d) a and b
6. Solar energy used by green plants for photosynthesis is only
   a) 2 – 8% b) 2 – 10%
   c) 3 – 10% d) 2 – 9%
7. Which of the following ecosystem has the highest primary productivity?
   a) Pond ecosystem
   b) Lake ecosystem
   c) Grassland ecosystem
   d) Forest ecosystem
8. Ecosystem consists of
   a) decomposers b) producers
   c) consumers d) all of the above
9. Which one is in descending order of a food chain
   a) Producers → Secondary consumers → Primary consumers → Tertiary consumers
   b) Tertiary consumers → Primary consumers → Secondary consumers → Producers
   c) Tertiary consumers → Secondary consumers → Primary consumers → Producers
   d) Tertiary consumers → Producers → Primary consumers → Secondary consumers
10. Significance of food web is / are
    a) it does not maintain stability in nature
    b) it shows patterns of energy transfer
    c) it explains species interaction
    d) b and c
11. The following diagram represents



    a) pyramid of number in a grassland ecosystem
    b) pyramid of number in a pond ecosystem
    c) pyramid of number in a forest ecosystem
    d) pyramid of biomass in a pond ecosystem
12. Which of the following is / are not the mechanism of decomposition
    a) Eluviation b) Catabolism
    c) Anabolism d) Fragmentation
13. Which of the following is not a sedimentary cycle
    a) Nitrogen cycle b) Phosphorous cycle
    c) Sulphur cycle d) Calcium cycle
14. Which of the following are not regulating services of ecosystem services
    i) Genetic resources
    ii) Recreation and aesthetic values
    iii) Invasion resistance
    iv) Climatic regulation
    a) i and iii b) ii and iv
    c) i and ii d) i and iv
15. Productivity of profundal zone will be low. Why?
16. Discuss the gross primary productivity is more efficient than net primary productivity.
17. Pyramid of energy is always upright. Give reasons
18. What will happen if all producers are removed from ecosystem?

19. Construct the food chain with the following data.

    Hawk, plants, frog, snake, grasshopper.

20. Name of the food chain which is generally present in all type of ecosystem. Explain and write their significance.

21. Shape of pyramid in a particular ecosystem is always different in shape. Explain with example.

22. Generally human activities are against to the ecosystem, where as you a student how will you help to protect ecosystem?

23. Generally in summer the forest are affected by natural fire. Over a period of time it recovers itself by the process of successions . Find out the types of succession and explain.

24. Draw a pyramid from following details and explain in brief.

    Quantities of organisms are given-Hawks-50, plants-1000.rabbit and mouse-250 +250, pythons and lizard- 100 + 50 respectively.

25. Various stages of succession are given bellow. From that rearrange them accordingly. Find out the type of succession and explain in detail.

    Reed-swamp stage, phytoplankton stage, shrub stage, submerged plant stage, forest stage, submerged free floating stage, marsh medow stage.

Glossary

Ecosystem: Study of interaction between living and non-living components

Standing quality: Total inorganic substances presents in any ecosystem at a given time and given area

Standing crops: Amount of living material present in a population at any time.

Biomass: Can be measured as fresh weight or dry weight of organisms

Benthic: Bottom zone of the pond

Trophic: Refers to the position of organisms in food chain

Omnivores: Those eats both plants and animals

Food chain: Refers movement of energy from producers up to top carnivores

Food web: Interlocking pattern of food chain

Pyramid of number: Refers number of organisms in a successive trophic level

Pyramid of biomass: Refers to quantitative relationship of the standing crops

Pyramid of energy: Refers transformation of energy at successive trophic levels

Ten per cent law: refers only 10 per cent of energy is stored in each successive trophic levels

Bio geo chemical cycle: Exchange of nutrients between organisms and environments

Carbon cycle: Circulation of carbon among organisms and environments

Guano: It is a accumulated excrement of sea birds and bats.

Phosphorus cycle: Circulation of Phosphorus among organisms and environments

Succession: Successive replacement of one type of plant communities by other on barren or disturbed area.

Pioneers: Invaded plants on barren area

Primary succession: Plants colonising on barren area

Secondary succession: Plants colonising on disturbed area.

Climax communities: Final establishment of plant communities which are not replaced by others.