3 Soil, Energy and Ecology—Patterns in Nature

B11CH3

Learning Objectives

Upon completion of topics, learners will:

- Define soil and state the composition of soil
- State the effect of erosion and overuse of soil on soil fertility
- Explain the processes of soil conservation, maintenance, and renewal of soil fertility
- Explain advantages and disadvantages of slash and burn methods in farming
- Distinguish between habitat and niche
- Describe the concept of ecological succession
- Define and calculate (population growth, doubling time and percentage growth rate, death and birth rates and explain the concept of population diversity)
- Describe inter-specific and intra-specific interactions among organisms
- Discuss the ecosystem (food chains, food webs, pyramids of numbers, pyramid of energy)
- Define the productivity of an ecosystem and distinguish between gross primary productivity and net primary productivity
- Discuss energy flow through trophic levels, the water cycle, the carbon dioxide cycle, the nitrogen cycle, the phosphorous cycle and the sulphur cycle
- Distinguish between immigration and emigration

3.1 SOIL

Definition of soil: Soil is the upper layer of earth's crust in which plants grow. It is a black or dark brown material typically consisting of a mixture of organic matter, mineral salts, air, water and rock particles.

The soil is one of the most important natural resources. It provides anchorage for plants. Soil serves as a storehouse of water and mineral salts required for the growth of plant. The soil shelters many organisms like bacteria, fungi, protozoa and burrowing animals. Living organisms cannot exist without the soil. Thus, soil is very important for the survival of organisms. Soil is one of the most important edaphic factors that help in determination of the types and distribution of vegetation and animals in a habitat.

3.1.1 Composition of Soil

The basic components of soil are mineral salts, organic matter, water and air. The typical soil consists of approximately 45% mineral particles, 5% organic matter, 25% water, and 25% air. Soil also houses many micro-organisms and small insects.

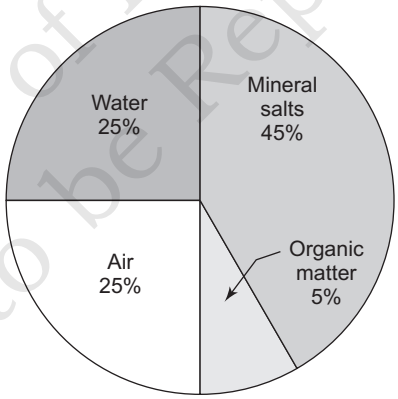


Fig. 3.1. Composition of average soil

Organic matter: Organic substance is found in very small amounts in the soil. Plants and animals are the main sources of organic matter. Depending upon the decomposition stage, the organic matter is of the following three types:

- Completely decomposed organic matter
- Partially decomposed organic matter
- Undecomposed organic matter

Minerals: Minerals are an important element of the soil. These are solid components composed of atoms. These occur naturally and have a fixed chemical composition. Olivine and feldspar are the main minerals present in the soil.

Air: The air-filled pores of the soil contain the gaseous components. Nitrogen and oxygen present in the pores is generally the atmospheric air fixed by the micro-organisms. However, the composition of carbon dioxide is higher due to the gas produced by microorganisms present in the soil.

Water: The soil dissolves the minerals and nutrients in the water and transports it to different parts of the plants. These are essential for the growth and development of the plant.

3.1.2 Importance of Soil

Soil is an important element essential for the survival of living organisms. The importance of soil is mentioned below:

1. The fertile soil helps in the growth and development of the plants. The plants thus produced are healthy and provide food, clothing, furniture, and medicines.
2. It supports many life forms including bacteria, fungi, algae, etc. These microbes, in turn, maintain environmental balance by retaining the moisture and decaying the dead organisms.
3. Soil is used for making cups, utensils, tiles, etc. The contents in the soil such as gravel, clay and sand are used in the construction of homes, roads, buildings, etc.
4. Useful mineral medicines such as calcium, iron, and other substances such as petroleum jelly for cosmetics are extracted from the soil.

3.1.3 Types of Soil

Soil is not the same in every place on earth. Differences in climate, the shape of the landscape, vegetation and the interval of time in which the soil has formed, affect the kind of soil found in an area. Different soil characteristics can be stated by colour, texture, and chemical properties. According to the size of particles, the soil is of three types:

1. **Sandy Soil:** It contains more than 60 per cent of sand with some particles of clay. The sand particles are mostly silica (SiO_2) having size of 0.02 mm to 2.0 mm in diameter. In sandy soil, percentage of sand is about 80% and that of clayey and silt is 20%.

- The particles of sandy soil are loosely arranged with large air spaces.
- The porosity of sandy soil is very high. As a result, it is very poor in water retention.
- It has very low capillarity due to high porosity.
- It contains very poor humus content.

Effect on vegetation: As sandy soil is light, well aerated and dry, with high level of leaching. This type of soil promotes the scanty vegetation or grassland because of low nutrient as a result of leaching.

2. **Clayey Soil:** In this type of soil, the percentage of clay particles is very high, *i.e.* about 60% and the percentage of sand is 40%. The relative size of clay particle is less than 0.002 mm in diameter.
   - The clayey soil is easily waterlogged so, it is difficult to till the soil.
   - The particles of clayey soil are tightly packed with no air spaces.
   - The porosity of clayey soil is very low, thus, it is very good in water retention.
   - Due to low porosity, it has a very high capillarity.

   Effect on vegetation: As the clay soil has variable content of humus, it can support vegetation like savanna and shrub land.
3. **Loamy Soil:** It consists of a good mixture of sand, clayey and silt. If the proportion of sand in the clayey soil is high, it is termed as **sandy loam**, whereas due to the high proportion of clay, it is known as **clayey loam**.
   - Loamy soil has water contents of about 50% which can be absorbed by the roots of plants.
   - The air spaces between the soil particles are intermediate between sandy soil and clayey soil.
   - Loamy soil has moderate porosity.

   Effect on vegetation: The humus content of loamy soil is between 5% to 10%, hence it is best suited for plant growth. It is suitable for cultivation. It contains sufficient nutrients for the growth of plants and it grows well in loamy soil. It also supports luxuriant vegetation.

The differences between sandy, clayey and loamy soil are represented in Table 3.1.

Table 3.1. Differences between sandy, clayey and loamy soil

Property	*Sandy soil*	*Clayey soil*	*Loamy soil*
Main constituent	Large-sized sand particles	S inaller-sized clay partcles	Clay, sand and silt present in right proportions
Space between particles	Quite large	Quite less	Sufficient
Presence of air	Well-aerated	Not well-aerated	Can hold sufficient air
Water-holding capacity	Cannot hold much water	Can hold much water	Adequate water-holding capacity
Nutrients	Cannot hold little nutrients	Can hold little nutrients	Veiy inch in nutrients
Ploughing	Easy to plough	Difficult to plough	Easy to plough

Activity 3.1 (Lab Work)

Collect samples of clayey, loamy and sandy soils. In the lab, take a fistful of soil from one of the samples. Remove any pebbles, rocks or grass blades from it. Now add water drop by drop and knead the soil. Add just enough water so that a ball can be made from it, but at the same time it should not be sticky. Try to make a ball from this soil. On a flat surface, roll this ball into a cylinder. Try to make a ring from this cylinder. Repeat this activity with other samples also. Does the extent to which a soil can be shaped indicate its type?

3.1.4 Formation of Soil

Soil is formed by weathering of rocks. Solid rock can weather away in one of the three ways into the soil, namely:

Physical Weathering: Physical weathering of rocks is caused by some physical factors, such as alteration in temperature range, force of flowing water and wind. The factors included in physical weathering are as follows:

1. **Force of Flowing Water:** When water is fast flowing in a river or stream, it carries small rocks, stones, boulder and other particles along with the downstream. These particles rub against each other, result in wearing and tearing of rock particles and form the particles of fine soil.

2. **Glaciations:** Rocks are split by the movement of huge blocks of ice ending up knocking each other and splitting into small particles of soil.
3. **Freezing of Water:** The rainwater seeps into the cracks developed in the rocks. When the water freezes, it expands thereby causing the rocks to break.
4. **Wind:** When strong wind blows, it carries small rock particles with them. When these rock particles rub against each other, they break further into smaller particles and thus the soil is formed.
5. **Temperature:** The sun heats up the rocks during the day. This causes the rock to expand. However, at night, these rocks cool down and contract. The regular expansion and contraction of rocks occur at different parts of the rocks at different rates. This results in the formation of cracks in the rocks. Finally, huge rocks break up into smaller pieces. These smaller pieces from over a span of time form the soil.

Fig. 3.2. Physical weathering of rocks by the force of flowing water

Chemical Weathering: Chemical weathering involves a change in the chemical composition of the original rock. It is caused when the rainwater reacts with the minerals present in rocks and formed some soluble salts. These reactions occur particularly when the water is slightly acidic. The processes involved in chemical weathering are as follows:

1. **Solution:** The water seeps into the rocks dissolves soluble minerals of the rocks and form a solution. This solution weakens the structure of rock thus, the rock will be easily crumbled.
2. **Hydrolysis:** When weak acids such as sulphur dioxide and nitric acid react with minerals found in the rocks, they form new substances that dissolve out and weaken the structure of rocks.

3. **Oxidation:** When oxygen from air reacts with minerals like iron and aluminium present in the rocks, some new compounds are formed. These compounds weaken the structure of rocks and thus cause weathering.
4. **Carbonation:** Carbon dioxide reacts with metals found in the rocks and forms carbonates that weaken the structure of rocks.

Fig. 3.3. Chemical weathering of rocks

Biological Weathering: Biological weathering is caused by various biological activities of living organisms. The processes involved in biological weathering of rocks are as follows:

1. Movement of heavy animals like elephants and rhinos over the rocks causes vibrations on the earth's crust. These vibrations weaken the structure of rocks.
2. When animals like birds forage for seeds, they create holes and erode the upper surface of the rocks, thus contribute in weathering of rocks.
3. Roots of plants weathered the rocks by growing into the cracks and fractures of the rocks.
4. Some fungi present on the rocks release chemicals which break down the rock minerals and the rocks become more prone to disintegration.

Factors Influencing Formation of Soil

The soil is formed by the weathering of rocks. The process of soil formation takes place by the following five factors:

1. Parent material
2. Climate

3. Living organisms
4. Topography
5. Time

Activity 3.2 (Presentation)

In a group, prepare a presentation for explaining of soil formation and present in the class. For this, you may consider the types of weathering of rocks and the factors that influence the formation of soil.

3.1.5 Soil Profile

Soil profile is defined as a vertical section of soil from the ground surface downwards to where the soil meets the underlying rocks. This is the vertical cross-section of earth's crust through the soil showing different horizontal layers called **horizons**. Each horizon differs in thickness, colour, depth, texture, consistency, porosity and composition. The soil horizons can easily be identified by the soil color and soil particles.

Importance of the Soil Profile

Soil with a thick top soil is more fertile as it contains humus. The roots of small plants are embedded in the top soil. Yet an area with a thin top soil layer will not have much fertility and will not produce large crops. Therefore, farmers need to use practices that keep the top soil from being lost.

A soil profile determines which crops or vegetation to grow normally in an area. Crops with long roots need deep soil with a sizeable thickness of top soil. This is because the deep soil has more nutrients and water to support the plant life.

Highly eroded areas will have thin layers of soil horizons and thus become less fertile. Such areas do not support the healthy growth of vegetation. Plants grown in such areas are generally pale in appearance.

Moisture Content of the Soil

The moisture content of the soil refers to the amount of water present in the soil. The moisture content of the soil affects the vegetation of an area. The plants cannot grow in dry soil. A good moisture content of soil helps the plants to grow well in the soil.

Activity 3.3 (Lab Work)

Take a boiling tube. Put two spoonfuls of a soil sample in it. Heat it on a flame and observe it. Let us find out what happens upon heating. Do you see water drops any where? If yes, where did you find them?

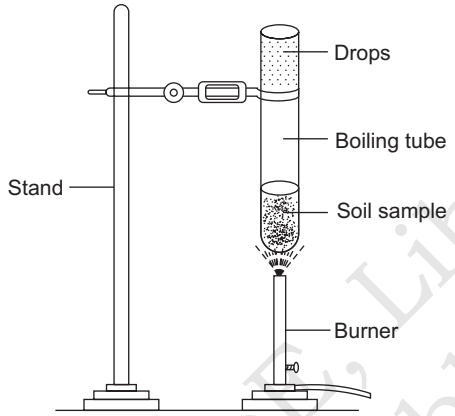


Fig. 3.4. Removing moisture from the soil

On heating, water in the soil evaporates, moves up and condenses on the cooler inner walls of the upper part of the boiling tube. After heating the soil, take it out of the tube. Compare it with the soil which has not been heated. Note the difference between the two.

3.1.6 Soil Fertility

Soil fertility refers to the ability of the soil to sustain plant growth. Fertile soil results in high yield and better quality of plants. Fertile soil is rich in fundamental elements and minerals, has good aeration, water holding capacity, and good texture.

The following factors affect the soil fertility:

- **Soil texture:** It refers to the composition of the soil in terms of the size of its particles. These particles make up the solid phase of the soil.
- **Soil crumb structure:** It refers to the arrangement of soil particles to form the crumbs. In a good crumb structure, the soil can retain water well. Also, the soil is well aerated.
- **Mineral composition:** The mineral composition of the soil helps to predict the ability of the soil to retain plant nutrients. Application of proper fertilizers and manures helps in enhancing the quality of the soil.

- **Soil pH:** Soil pH helps in maintaining the nutrient availability of the soil. A pH range of 5.5-7 is optimum for soil fertility.
- **Soil texture:** The minerals of different sizes are responsible for maintaining the structure of the soil. Clayey soil can retain more nutrients and hence acts as a nutrient reservoir.
- **Organic matter:** Organic matter is a source of nitrogen and phosphorus. These can be mineralized and made available to the plants. The soil formed by decomposing of organic matter is thoroughly mixed with mineral matter by the activities of burrowing animals such as earthworms, centipedes and rodents. This mixture is called **humus**.

3.1.7 Maintenance of Soil

The soil can be maintained by the following ways:

1. **Adding manures and fertilizers:** Fertilizers such as nitrogen, potassium and phosphorus are added to the soil to make it fertile. These are also added to the potted plants in gardens to enhance plant growth. NPK and urea are the most common fertilizers required by the soil. Urea adds nitrogen to the soil. Whereas, NPK adds nitrogen, potassium and phosphorus to the soil.
2. **Leguminous crops:** Leguminous plants contain nitrogen-fixing bacteria such as *Rhizobium* in the root nodules. These bacteria trap atmospheric nitrogen and make it available to the plants in the form of nitrogen compounds. The remaining nitrogen compounds are mixed with the soil to increase its fertility.
3. **Minimum tillage:** Minimum tillage increase the amount of water in the soil since continuous tillage exposes moist soil that will undergo evaporation thus reducing water amounts in the soil.

3.1.8 Disposal of Non-Biodegradable Wastes

Waste, which cannot be decomposed by biological processes, is called **non-biodegradable waste**. These are of two types:

1. **Recyclable:** Waste having economic values but destined for disposal can be recovered and reused along with their energy value. e.g. Plastic, paper, old cloth etc.
2. **Non-recyclable:** Waste which do not have economic value of recovery. e.g. Carbon paper, thermo coal, tetra packs, etc.

Disposal of non-biodegradable waste is a major concern, not just plastic, a variety of waste being accumulated. There are a few ways to help non-biodegradable waste management such as:

- Reducing the waste
- Reusing the waste
- Recycling the waste

Many types of plastics can be remolded. Such plastic items are segregated from the waste and sent to specific industries. Here they are melted and then remolded. These are reused. Recycling the waste reduces the burden on the environment.

Activity 3.4 (Group Activity)

Arrange campaign for the proper disposal of non-biodegradable substances such as plastics. Find out how plastics are recycled. Does the recycling process have any impact on the environment?

3.1.9 Soil Erosion

The removal and transportation of top layer of soil from its original position to another place with the help of certain agents such as strong winds and fast running rain water is called **soil erosion**. Following are the key points related to soil erosion:

- It is the natural process of wearing away topsoil, but human activities have accelerated the process.
- It is usually caused due to the removal of vegetation, or any activity that renders the ground dry.
- Farming, grazing, mining, construction and recreational activities are some of the causes of soil erosion.
- The effects of soil erosion are not just land degradation. It has led to a drastic increase in pollution and sedimentation in rivers that clogs the water bodies resulting in a decline in the population of aquatic organisms.
- Degraded lands lose the water holding capacity resulting in floods.

Causes of Soil Erosion

Soil erosion is caused both by **natural causes** as well as **human actions**.

Soil erosion due to natural causes

- **Strong winds:** During dry weather or in the semi-arid regions, the minute soil particles are carried away by the wind to faraway lands. This degrades the soil and results in desertification.

- **Heavy rain:** Higher intensity of rainstorms is the main cause of soil erosion. Heavy rain washes down the top layer of the soil and carries along with it into rivers. The raindrops disperse the soil, which is then washed away into the nearby streams and rivers. Regions with very heavy and frequent rainfall face a large amount of soil loss. The flowing water during floods also erodes a lot of soil by creating potholes, rock-cut basins, etc.
- **Frequent floods by rivers:** Frequent floods remove the topsoil of the fields, especially the soil present near the banks. It carries the soil with it and deposits it somewhere else. The flowing rivers and streams carry away the soil particles leading to a V-shaped erosion activity.

Soil erosion caused by human actions

- **Agriculture:** The farming practices are the major cause of soil erosion. The agricultural activities disturb the ground. The trees are cleared and the land is ploughed to sow new seeds. Since most of the crops are grown during the spring season, the land lies fallow during winters. Most of the soil is eroded during winters. Also, the tyres of tractors make grooves on the land, making a natural pathway for water. Fine soil particles are eroded by wind.
- **Construction:** The construction of roads and buildings exposes the soil to erosion. The forests and grasslands are cleared for construction purposes, which exposes the soil making it vulnerable to erosion.
- **Deforestation:** Human activities like deforestation have further exposed the barren land to the winds and rain. A large number of trees are cut down to carry out the logging process. Trees hold the soil firmly. The canopy of the trees protects the soil from heavy rainfall. The leaf litter that protects the soil from erosion is also lost during logging.

(a) (b)

Fig. 3.5. Natural and man-made causes of soil erosion

Prevention of Soil Erosion

Soil erosion is a serious environmental issue. Steps should be taken to curb this problem. Following are some of the methods of soil erosion prevention:

- Plant trees on barren lands to limit erosion of soil.
- Add mulch and rocks to prevent the plants and grass underneath to prevent soil erosion.
- Mulch matting can be used to reduce erosion on slopes.
- Put a series of fibre logs to prevent any water or soil from washing away.
- A wall at the base of the slope can help in preventing the soil from eroding.
- Every household should have a proper drainage system so that water flows down into proper water collecting systems.

Activity 3.5 (Field Trip)

- Arrange a field trip to observe the effect of erosion on the fertility of soil and discuss about them in the class. For this, you may plant in the eroded soil and then observe that the plant will grow or not in the soil.
- Digging in the school yard or any other dump site to observe non-biodegradable substances made up of plastics and metallic materials. You may observed that they are not degrade and remain persist in the environment.

3.2 LIBERIA FOOD AND CASH CROPS PRODUCTION

Cereals, pulses, fruits and vegetables are important types of crops because they provide all the necessary nutrients required by our body.

On the basis of trade and commercial aspects, the crops are classified into following three categories:

- **Food crops:** Crops that are grown for human consumption called **food crops**. Wheat, cereals, pulses, groundnut are the examples of food crop.
- **Fodder crops:** Crops that are exclusively grown for feeding the animals called fodder crops.
- **Cash crops:** Crops that are grown in large scale with the intension of generating profit called **cash crops**. Cotton, jute, sugarcane, tobacco are some examples of such type of crops.

The main **cash crops** and foreign exchange earners in Liberia are rubber, oil palm, cocoa, and timber.

- **Rubber:** Rubber is a dominant revenue generator, accounting for 12.5 percent of total export receipts in 2021. The Firestone Natural Rubber concession, covering almost 200 square miles, is the largest contiguous natural rubber operation in the world and the biggest private sector employer in Liberia.
- **Palm oil:** Palm oil is another significant cash crop. Traditionally it is domestically consumed but there has been some export development with smallholders and large investors expressing interest in expanding cash crop production. Stakeholders in the palm oil sector include smallholder farmer cooperatives, individual farmers, large multinational-owned corporations, and concessionaires such as Golden Veroleum Limited. The Ministry of Agriculture is the government ministry responsible for the governance, management, and promotion of the agriculture sector in Liberia.
- **Cocoa:** Liberia has a favorable climate and fertile soil for cocoa production. The country's international partners, such as the International Fund for Agricultural Development (IFAD), continue to invest in cocoa smallholder producers to improve livelihoods and raise incomes by modernizing cocoa farming, increasing production, and developing market access. Small scale cocoa production will likely increase as farmers continues to reclaim and rehabilitate their farms. As with the agriculture sector in general, smallholder cocoa farmers and local cooperatives suffer inadequate farm-to-market roads, lack of familiarity with measurement and quality standards, lack of storage facilities, and limited access to updated price and market information.

In addition to current cash crops listed above, market opportunities and potential for agribusiness investment and value chain investment are also present for vegetables, fruit, poultry, and fish. Liberia has a suitable climate for horticulture such as the production of peppers, okra, onions, tomatoes, and squash, which are in high demand throughout the country all year. Lowland cultivation and low-cost irrigation would provide opportunities to increase productivity and expand market share of these valuable crops. Liberia has an Atlantic coastline spanning 580 kilometers endowed with abundant fish. The coastline and freshwater bodies are breeding grounds for marine species including crab, lobster, shrimp, tilapia, tuna, shark, croaker, barracuda, grouper, and cassava

fish. Liberia lacks a commercial fishing sector, however, with no real domestic fish processing and most fish sold informally in local markets.

Activity 3.6 (Field Trip)

Arrange a field trip and list out various food crops and cash crops grown in Liberian Fields. Also consider the type of soil in which they are grown.

3.3 EFFECTS OF AGRICULTURAL ACTIVITES ON ECOLOGICAL SYSTEMS

Biology and Agriculture are the two main aspects of science that are closely related to each other. Biology is the study of life while Agriculture is the cultivating of plants as crops and livestock for food. We have learnt that in an ecosystem, population of plants, animals and decomposers (biotic components) are interacting with each other and also with their abiotic components to maintain a balance in nature. A farmland is an existing stable ecosystem occupied by the population of plants and animals. Farmers who grow crops employ some agricultural activities that affect ecosystem. In this section, we shall outline the effects of various agricultural activities on the environment.

The various agricultural activities and their effects on ecological systems include the following:

3.3.1 Bush Clearing

Bush clearing is the removal of plants to increase the size of crop-producing land. Bush clearing helps the farmer to get rid of weeds and make the field clear and safer. Although bush clearing is good for growing of crops, it has some adverse effects on the ecosystem.

- It leads to soil erosion. This is because by removing the vegetation cover, soil is directly exposed to wind. The strong wind removes the top soil.
- Bush clearing leads to evaporation of soil water due to which soil becomes dry and powdery.
- Animals that live in vegetation can migrate or die.
- Bush clearing encourages desert encroachment.
- Due to bush clearing, natural environment of the organisms change. It will introduce new pests and diseases in that environment.
- Bush clearing increases the soil temperature which leads to killing of some useful soil micro-organisms.

3.3.2 Slash and Burn Method

The **slash and burn method** is the clearing of forests, weeds and grass by setting them on fire. It is a common practice among the farmers in West Africa. In Liberia, farmers burn their harvested fields to prepare their farms for the next planting season.

Fig. 3.6. Slash and burn method of agriculture in Liberia

Advantages

The slash and burn method has some positive effects on ecological systems.

1. It releases potassium and phosphorous in the form of ash into the soil and makes the soil slightly alkaline.
2. It breaks the dormancy of some seeds.
3. It encourages sprouting of some grasses.

Disadvantages

The slash and burn method adversely affects the ecological system in the following ways:

1. Slash and burn method releases lots of smoke into the environment and causes air pollution.
2. Due to burning process, soil organisms are killed which disturb the ecological balance of that area.
3. Organic matter present in the soil can burn during bush burning.
4. Slash and burn method exposes the soil to erosion.

3.3.3 Tillage

Tillage is the preparation of land for growing crops. In this practice, large soil pieces can be broken into loose particles to make the soil ready for planting of crops. Tillage is done manually by using hoe or spade. Mechanically, it can be done with the help of a tractor.

Fig. 3.7. Tillage using tractor

Advantages

Beneficial effects of tillage are as follow:

1. The main advantage of tillage is soil aeration. Soil aeration helps the growth of useful worms and micro-organisms in the soil, and aids in mixing of humus and nutrients.
2. It helps in removal of weeds and other non-useful plants so that the main crop gets proper nutrition.
3. Tillage helps in improving the percolation of water by the soil.
4. In tillage, soil is turned before the seeds are sown so that the roots of young plants can penetrate the soil easily.

Disadvantages

Adverse effects of tillage are as follows:

1. Due to excessive tillage, soil can lose its fertility.
2. Tillage causes change in texture and structure of soil.

3.4 CONSERVATION OF NATURE

Conservation in Biology is the management of nature and Earth's biodiversity with the aim of protecting species, their habitats, and

ecosystems from excessive rates of extinction and the erosion of biotic interactions.

Natural resources that are judiciously conserved include the following:

3.4.1 Conservation of Soil

Soil conservation means the prevention of soil from erosion or reduced fertility caused by over usage, acidification, Stalinization or other chemical soil contamination. Soil is the basic resource for agricultural activities in most parts of the world. Due to various human activities, soil loses its organic reserves and water holding capacity. Natural disaster such as flood leads to soil erosion, due to which top, fertile soil has been removed. It enhances the desertification of soil. In the tropics, rapid deforestation damages the thin layer of soil which is quickly washed away when exposed to heavy tropical rains.

Methods for conserving soil resources

Soil resources can be conserved by the following ways:

1. Reducing deforestation which leads to soil erosion.
2. Avoiding overgrazing of animals.
3. Adapting agricultural practices such as crop rotation and mixed cropping for growing crops.
4. Avoiding bush burning which expose the soil to erosion.
5. Growing legumes to increase the nitrogen content in the soil.

3.4.2 Conservation of Forests

Forests have a lot of natural resources that are very important for human use. Besides these, forests play an important role in checking air pollution and soil erosion. They provide much oxygen for respiration hence, called **breathing cover**. They regulate water cycle in the environment and are responsible for rainfall pattern of a particular region. In many developing countries, due to increase in population, the demand for land has drastically increased for inhabitation and hence, the forest cover has been depleted. The demand for wood and timber has also increased for human settlements. For this, large areas of rich forests in Africa have been cleared.

(a) Deforestation (b) Afforestation

Fig. 3.8. Two extreme conditions of forests

Methods for conserving forest resources

Forest resources can be conserved through the following ways:

1. Cutting tree if needed should be done without destroying the roots of trees.
2. Practice afforestation should be encouraged.
3. Slash and burning method of agriculture must be avoided.
4. Forest reserves should be established to conserve their aesthetic values.

Liberian forests represent over half of the remaining rainforests in West Africa, and they are dominated by moist evergreen forests and semi-deciduous forests.

There are three types of forest ownership in Liberia:

1. State forest (which by extension would entails public ownership)
2. Community forest, and
3. Private forest

The Republic **holds all forest resources** in trust for the benefit of the People except for forest resources located in Communal Forests and forest resources that have been developed on private or deeded land through artificial regeneration.

3.4.3 Conservation of Wildlife

Wildlife traditionally refers to undomesticated wild animals, which include all organisms that grow or live wild in an area without being introduced by humans. Wildlife can be found in all ecosystems. **Deforestation** is the main cause of destruction of wildlife because it displaces the habitats of wild animals. Wildlife is also affected by human

incursion. For example, **poaching** which includes illegal killing, trapping or hunting animals for trading and commercial purposes. In Liberia and other African countries, due to poaching, many species of wild animals such as elephants, buffaloes, lions, hippopotamus and tropical pangolins are now either completely or locally extinct or endangered.

Methods for conserving wildlife resources

Wildlife resources can be conserved through the following ways:

1. Establishment of forest reserves to conserve various wild species of plants.
2. Establishment of zoological gardens to conserve various wild species of animals (Ex-situ).
3. Establishment of National Parks or protected areas.
4. Hunting and poaching of wild animals must be prohibited to prevent extinction of some wild animals.
5. Practice of slash and burn method is strictly prohibited as it leads to displacement of many wild animals.

3.4.4 Conservation of Oil

Oil conservation is an action taken to protect the oil resources of the Earth, as well as the wise management and use of these resources. Together with coal and natural gas, oil is an energy-giving substance called fossil fuel that was formed from plant and animal remains buried millions of years ago. The main aim of conservation or preservation is to provide protection to the ecosystem from degradation and therefore the consumption of resources must be reduced. The conservation of the organism is also essential for proper maintenance of the ecosystem balance.

Methods for conserving oil resources

Simple lifestyle changes can make a huge difference in our energy consumption levels. A few suggestions are listed below:

1. Try to cycle to places nearby instead of using fuelled vehicles.
2. Use public transport whenever possible.
3. Think about taking a bus or car-pooling while commuting.
4. Use energy-efficient lighting systems in your homes.
5. Switch off electrical appliances when not in use.

Activity 3.7 (Assignment)

Petroleum products like petrol and diesel are used in means of transport like motor vehicles, ships and airplanes. We cannot really imagine life without a number of electrical appliances and constant use of transportation. So can you think of ways in which our consumption of petroleum products can be reduced?

3.4.5 Conservation of Minerals

A naturally occurring substance that has a definite chemical composition is a mineral. Minerals are not evenly distributed over space. They are concentrated in a particular area or rock formations. Some minerals are found in areas which are not easily accessible such as the Arctic ocean bed and Antarctica. Minerals are a non-renewable resource. The rate of formation is much smaller than the rate at which the humans consume these minerals. It is necessary to reduce wastage in the process of mining. Recycling of metals is another way in which the mineral resources can be conserved.

Methods for conserving mineral resources

1. **Recycling:** It means using discarded materials once again. Many metals like Iron, Gold, Copper and Aluminium become reusable through recycling.
2. **Avoid wastage:** Minerals can be conserved by using efficient methods of extraction and processing and by avoiding wastage. Saving can be done at consumption level also.
3. **Substitutes:** In recent years biodegradable plastics and other substitutes have been used to conserve mineral resources.

Activity 3.8 (Individual Work)

List two organizations that you are aware of which, work towards protecting the environment. State any two laws that have been implemented by the government to preserve the natural resources.

3.5 ISOLATION MECHANISMS OF SPECIES

Meaning of isolation: The first step in the development of a new species is isolation. A population should split up into two or more separate demes each with its own gene pool. These demes must be isolated from one another. If genes are exchanged between them they will effectively

behave as one population. If they are isolated, mutation and selection can operate independently in the two populations and each can develop into a distinct species.

Mechanism of Isolation

There are three isolating mechanisms important that can lead to the origin of new species:

1. **Geographical Isolation:** Frequently isolation is geographic. The population may be widely separated geographically or divided by impenetrable barriers such as mountain ranges and rivers. Even if they occupy the same locality they may be separated by having a preference for slightly different habitats. This is also called as ecological isolation.
2. **Reproductive Isolation:** Even though two populations may not be ecologically separated, they may be effectively isolated by reproductive isolation i.e. they cannot interbreed. This might be caused by lack of attraction between males and females or by physical non-correspondence of genetalia. In case of flowering plants it may be due to the fact that pollination is impossible between the two populations. In animals with elaborate behaviour patterns, it may be because the courtship behaviour of one fails to stimulate the other. This is also called as behavioural isolation.
3. **Genetic Isolation:** Sometimes mating may be possible, but reproduction is not possible because of fundamental differences in genetic constitution. Thus, the gametes may be prevented from fusing. For example, the pollen grain of one population of plants, may fail to germinate on the stigmas of the other. Even if fertilization does occur, the zygote may be inferior in some way and fail to develop properly. Sometimes offspring are produced but the hybrids may be adaptively inferior, living only for a short time.

3.6 INTER-SPECIFIC INTERACTIONS (BIOLOGICAL ASSOCIATIONS)

In an environment, members of different species associate in various ways. Their associations are based on the following factors:

1. Nature of food and the method used to obtain it
2. Type of space used for their shelter
3. Habits such as breeding, aggregation and securing of mate

In a community, members of different species associate either positively or negatively. Based on this, there are three types of association. They are:

- **Positive association:** In positive association, one or both participating species benefit. Scavenging, commensalism, mutualism and interdependence of plants and animals are examples of positive association.
- **Negative association:** In negative association, one species benefits while the other is harmed. Amensalism, parasitism and predation are the examples of negative association.
- **Neutral association:** In neutral association species neither benefits nor lose.

3.6.1 Mutualism (Beneficial to both independent living organisms)

Mutualism is an association of organisms of two different species in which both species get benefited but cannot live separately under natural conditions. The species participating in such association are called **mutualists**.

Examples of Mutualism

1. **Sea anemone and hermit crab:** In this association, the anemone protects the hermit crab from enemies with its **nematocysts**. In return, the anemone receives pieces of food dropped by the crab and is carried to new places by it. Interestingly, the hermit crab is known to recognise its particular anemone, chiefly by touch.
2. **Termites and protozoa:** Termites do not digest wood cellulose but still feed on wood. Protozoa that live in the intestine of termite secretes enzyme. This enzyme converts wood cellulose into a form of simple sugar which is used by both organisms.
3. **Ruminant and bacteria:** Bacteria which live in ruminants such as sheep and cattle help the animal to digest cellulose. For this, they secrete an enzyme called **cellulase** which converts the cellulose into sugars while the ruminants provide food and shelter to the bacteria.

3.6.2 Commensalism (Host unaffected while the commensal benefits)

Commensalism is an association of the members of two species in which one benefits while the other is almost unaffected. The species that gets benefits is called the **commensal** while the other species is called the

host. In such association, the host neither benefits nor get affected. The commensal gets food, ride or shelter from the host.

Examples of Commensalism

1. **Man and intestinal bacteria:** *E. coli* bacteria live as a commensal in the large intestine of humans. Here, they feed on proteins of chyle and break them into amino acids which are absorbed by the blood. These bacteria also synthesise vitamins B and K which are absorbed by the blood. On the other hand, man neither benefits nor get affected.
2. **Shrimp and fish:** It is an interesting example of commensalism. The shrimp stands on the coral reef and waves its brightly coloured antennae. This behaviour of shrimp attracts fish while the shrimp eat up the parasites attached to them.
3. **Epiphytes and large flowering plants:** Epiphytes are the green, nutritionally independent plants that grow on large plantsin tropical rainforests and only utilises the space. They do not harm the host plant.

3.6.3 Predation (One species gets benefited and the other gets harmed)

Predation is a type of association between two different species, where an individual species captures, kills and eats up the individual of another species. The species that capture and feed on the other is called **predator** and the one that is caught and fed upon is called **prey**. The predator cannot survive without the prey.

In a predator-prey relationship, both are animals. Predator is equipped with structures that enable it to capture, kill and eat the prey.

Adaptations for predation: The adaptations in predators include their physical strength, presence of claws, venom, stinging cells (in cnidarians) and their speed.

Examples of Predatory Animals: They mainly include all carnivorous animals and scavengers such as Paramecium, Obelia, Praying mantis, Wall lizard, Snake, owl, Tiger and Lion.

3.6.4 Parasitism (Harmful to host)

Parasitism is an association of two different size organisms. The smaller one benefits and is called the **parasite** while the larger one suffers and is

called the **host**. Parasites get nourishment and shelter from their hosts. The hosts can live without parasites but parasites cannot live without their hosts.

Parasites which live inside the body of their hosts are called **endoparasites**. When they live outside the body of a host, they are called **ectoparasites**. Malaria parasite (*Plasmodium vivex*), Tapeworm and Guinea worm are examples of endoparasites. Leech, Bedbug, Mosquito and Tick are examples of ectoparasites.

Adaptation for Parasitism: Parasites have the following adaptations for their survival:

- They have clinging structures through which they can properly attach to the host body to get nutrition.
- They have boring organs like **haustoria** used to absorb nutrients from the host's body, e.g. Dodder plant.
- They are able to secrete enzymes which dissolve the host tissue for proper penetration into the host body. In the case of endoparasites, these enzymes prevent them from digestion of its tissues from the digestive enzymes secreted by the host body.

3.6.5 Competition (Harmful to both species)

Competition is an interaction between two or more organisms when the resources are limited for their survival. Examples of these resources are food, space and so on. Competition among organisms is of two types:

1. **Intraspecific competition:** This occurs when competition occurs between the organisms of same species. It is also called **intraspecific competition**. This type of competition among the organisms is severe because the organisms are competing for similar requirements of food, mate and shelter.
2. **Interspecies competition:** This occurs when there is competition between organisms of different species. It is also called **interspecific competition**. For example, grassland is the common feeding area for grasshoppers, rats, rabbits and deers. When the grasses available are plenty, there is a little competition between the organisms for food. But during drought, little grasses are available and competition of life and death occurs among the consumers.

Examples of competition

1. Tigers and lions compete for their prey.
2. Trees, shrubs and herbs compete for sunlight in forest habitat.

Activity 3.9 (Field Trip)

Organize a field trip to see different interspecific interaction that can be seen in your vicinity. Discuss about them in the class.

Table 3.2. Differences between intraspecific and interspecific competition

Intraspecific competition	*Interspecific competition*
1. The competition which takes place between the members of the same species is called intraspecific competition.	1. The competition which takes place between the members of different species is called interspecific competition.
2. The effect of this competition is it improves the adaptation power of the species.	2. The effect of this competition is one or both species can become extinct or more adaptable.
3. The intraspecific competition takes place when a population is more crowded.	3. It usually takes place when there is any limiting force like food, prey etc is present.
4. The intraspecific competition is more in the presence of a limiting factor.	4. The interspecific competition is not much in case of limiting factors like mates.
5. The growth rate in case of intraspecific competition is less.	5. Interspecific competition promotes niche diversification and differentiation.

3.7 BASIC ECOLOGICAL CONCEPTS

Some important commonly used concepts for the study of ecology are as follows:

Environment: An **environment** is the physical and biological world in which we live. It refers to the sum total of all external and internal factors which affect the life and development of organisms. In other words, anything that surrounds and affects the life of an organism is called its environment.

Biosphere: Biosphere or **ecosphere** refers to the earth zone where life can exist. It supports all life forms present on the earth's surface. It extends 11 km deep into the sea and 10 km up into the air from the earth's surface.

Habitat: Living things are found almost everywhere. They are found on land, air, water and underground.

The natural environment in which living organisms live is called **habitat**. It is defined as the place or environment where an organism lives naturally. Organisms can survive best in their own habitats as their bodies are well adapted for that particular habitat. For example, a camel is well adapted to live in the desert.

Niche: A **niche** can be defined as the interaction of a species with the other members of the same community. It is the specific part of a habitat which is occupied by a particular organism. In a niche, every organism is adapted to play a specific role in the community. No two organisms share the same role at the same time. For example, both the caterpillar and aphids are tree dwellers, but the caterpillar feeds on the leaves while the aphid sucks the sap of green stems. Although both organisms has its own habitat (tree) and sources of food, there is no competition between them. Thus, an **ecological niche** is not only the place where the organism lives; it also includes what the organism does in that niche. Sometimes the niche of an organism is restricted to the specific habitat. For example, the roundworm can only live in the human intestine and no other body parts. Rat is an animal that eats different kinds of food and is adapted to different kinds of habitats. Hence, the niche for the rat is not restricted.

Table 3.3. Differences between habitat and niche

Habitat	*Niche*
1. Habitat is an area or a place where an organism lives so that it can interact with the environmental factors.	1. Niche is related to the organism. It explains how an organism lives in any habitat. It also includes diet, shelter of organism, etc.
2. Habitat has many niches.	2. There are no such components here.
3. Temperature, rainfall, light and soil.	3. In niche, flow of energy is the major factor seen.
4. It has many species within it.	4. It consists of only one species.
5. It is nor species specific.	5. It is species specific.
6. It is a place.	6. It is an activity.
7. The habitats can be arboreal, aerial, terrestrial, aquatic etc.	7. It is spatial, trophic and multi-dimensional

3.8 COMPONENTS OF AN ECOSYSTEM (TROPICAL LEVELS)

There are two components of an ecosystem. These are **biotic component** and **abiotic component**.

3.8.1 Biotic Components of Ecosystem

All living organisms present in an ecosystem constitute the biotic component of that ecosystem. In the ecosystem, living organisms are interconnected through food. On the basis of the mode of obtaining food in an ecosystem, organisms can be divided into producers (plants), consumers (animals), and decomposers (microorganisms) according to their role in keeping the ecosystem operating as a stable unit.

1. **Producers:** Producers are also known as **autotrophs**. They are of two types:
   - **Phototrophs:** These are the green plants which synthesise their food by the process of photosynthesis.
   - **Chemoautotroph:** These are the microorganisms mainly bacteria that prepare their organic food by the process of chemosynthesis.
2. **Consumers:** Consumers are mainly animals. They are unable to synthesise their food and then utilize materials and energy stored in the producers. As they take food from other organisms (producers), they are also known as **heterotrophs**.

Decomposers: Microorganisms such as bacteria and fungi feed by the decomposition of the dead and decaying organic matter of living organisms. They are called **decomposers**. The decomposers secrete some chemicals that digest the complex organic matter and convert them into simpler inorganic nutrients. These nutrients get mixed with soil and are absorbed by the producers (plants). Plants are further eaten by animals, which on dying are decomposed by the micro-organisms. Thus, the decomposers help in recycling of nutrients in nature. On the basis of their sizes, they are grouped as:

1. **Micro-decomposers:** They include bacteria and unicellular fungi.
2. **Macro-decomposers:** They include Termite, Earthworm, Mushroom and Snail.

3.8.2 Abiotic Components of Ecosystem

The abiotic components of an ecosystem include the non-living physio-chemical factors of the environment. They are categorised as follows:

1. **Inorganic substances:** Carbon dioxide, oxygen, nitrogen, water, calcium and phosphorus are the inorganic components, which occur in the form of compounds dissolved in water in the soil or in their free state.
2. **Organic compounds:** Carbohydrates, proteins, fats, and nucleic acids are present in the organic matter. They are broken down into simpler inorganic substances by the action of microorganisms for their recycling.
3. **Edaphic factors:** The Edaphic factors include soil, topography, pH, rocks and so on.
4. **Climatic factors:** These include light, temperature, humidity, wind, and rainfall.

3.8.3 Interaction among the Biotic Components and Abiotic Components of Ecosystem

There is a unique interaction between biotic and abiotic components of an ecosystem. Plant (biotic components) needs carbon dioxide (abiotic component) for the preparation of food. This carbon dioxide is given out by the animals through respiration. In opposite of that, animals (biotic components) need oxygen (abiotic component) to respire, which is given out by the plant through the process of photosynthesis.

In any given ecosystem, all the living organisms (plants and animals) are interconnected in a systematic chain with respect to their mode of feeding.

3.8.4 Food Chain

A linear and sequential inter-linking of organisms involving the transfer of food energy from the producers to the consumers is referred to as **food chain**. A food chain shows the feeding relationship between different living organisms in a particular habitat. A food chain is always straight and proceeds in a progressive straight line. It always begins with green plants (producers) and end with an animal (consumer). A simple food chain is represented in Fig. 3.9.

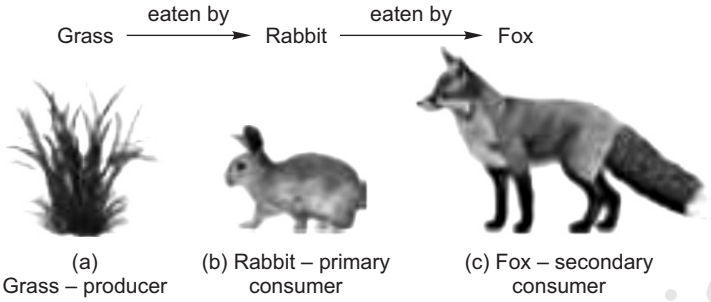


Fig. 3.9. A simple food chain

Characteristics of a Food Chain

1. In a food chain, there is a nutritive interaction between living organisms in the ecosystem.
2. A food chain proceeds in a progressive straight line.
3. In a food chain, a unidirectional flow of energy occurred from sun to producers and subsequently to the series of different organisms.

Examples of food chain in other terrestrial habitat:

1. Grass (Producer) ⟶ Grasshopper (Primary consumer) ⟶ Frog (Secondary consumer) ⟶ Snake (Teritary consumer)
2. Crop (Producer) ⟶ Aphids (Primary consumer) ⟶ Ladybird beetle (Secondary consumer) ⟶ Birds (Teritary consumer)

3.8.5 Food Web

Food web is an interconnected network of food chains which links various species in an ecosystem.

A food web is more complicated than a simple food chain. For example, in the food web shown in Fig. 3.10, the fox does not feed on rabbit only. It may feed on the field mouse as well as rat. So, the food web is surely not linear. It appears like a web. A food web is a set of interconnected food chains, for circulating energy in an ecosystem.

Characteristics of food web

1. A food web is never straight. Each food web displays the interlinking of various food chains.

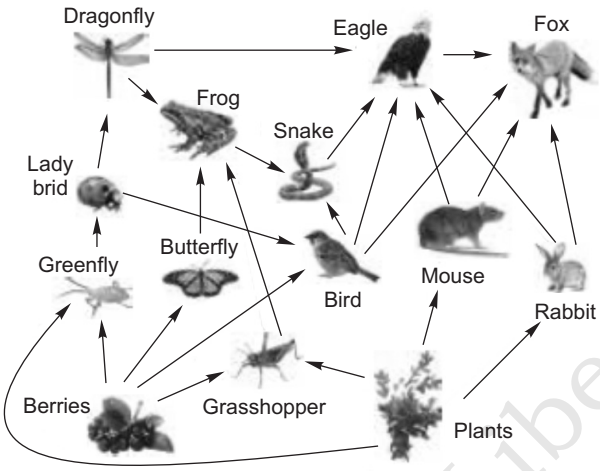


Fig. 3.10. A terrestrial food web

2. A food web shows that there are alternative pathways of food availability for various organisms.
3. Food web helps in the development of an ecosystem and provides stability to the ecosystem.

The differences between a food chain and a food web are represented in Table 3.4.

Table 3.4. Differences between a food chain and a food web

Food chain	*Food web*
The food chain is a feeding relationship between different organisms in which energy is transferred step-by-step from the producers to the consumers.	The food web is a complex pattern of feeding relationship formed by different food chains that are interlinked by organisms.

3.9 BIOCYCLES IN NATURE

Energy and inorganic nutrients play an important role. In an ecosystem, energy flow is a unidirectional process. The energy is constantly supplied by the sun in a functioning ecosystem.

The inorganic nutrients like carbon, oxygen, nitrogen and water cannot be supplied from the outside but they can be recycled within the ecosystem. Nutrients are recycled through **decomposition**. When primary producers or consumers die, fungi and other decomposers obtain energy by breaking down their remains and, in the process, they return key nutrients like nitrogen to the soil so that primary producers can use

them. The process of alternating these nutrients between the organisms and their physical environment is known as **nutrient movement** or **nutrient recycling**. The biocycles in nature are as follows:

3.9.1 Water Cycle

The **water cycle** is also known as the **hydrological cycle**. It can be described as the continuous flow of water on, above and below the surface of the earth. Water can exist in three states, such as solid (ice), liquid (water itself) and gas (water vapour). However, the balance of water on earth remains fairly constant over a period of time.

The process of water cycle in nature is described as follows:

1. The sun rays heat the water bodies. Due to this, the water gets evaporated and forms water vapours. The water vapour is lighter than air, so it rises and goes to the atmosphere.
2. Plants continuously absorb water from the soil with the help of their roots. However, they also lose some of this water by transpiration. So, the lost water gets converted into water vapours and then added to the atmosphere. The respiration of living beings, as well as decaying of dead plants and animals also produces water vapours, which also goes to the atmosphere.
3. As the water vapour rises, it gets cooled. On cooling, they condense to form tiny droplets of water. These tiny droplets keep floating in the sky and form clouds.

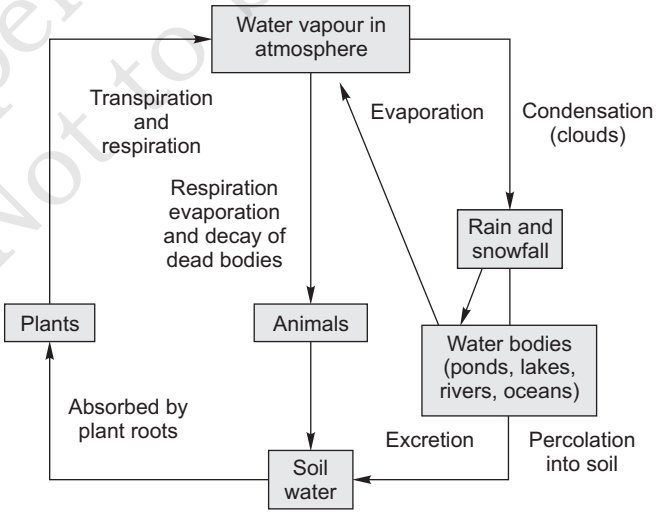


Fig. 3.11. Water cycle in nature

3.9.2 Carbon Cycle

The **carbon cycle** is the circulation and transformation of carbon in its various forms, between living organisms and the environment. Carbon is required by living organisms for their exoskeleton and endoskeleton. Besides proteins, carbohydrates, fats, nucleic acids, etc. all has carbon in their molecular structures.

Carbon is added to the biosphere by the following ways:

1. When human beings burn fossil fuels to power factories, power plants, cars and trucks, most of the carbon quickly enters the atmosphere as Carbon dioxide. The oceans and other water bodies soak up some carbon from the atmosphere.
2. During respiration, all living beings release carbon dioxide into the atmosphere.
3. When plants and animals die, their bodies, wood and leaves decay bringing the carbon into the ground. Some become buried miles underground and under right circumstances will become fossil fuels in millions of years.
4. Carbon dioxide can also be returned by the decomposition of organic wastes like urine and faeces.

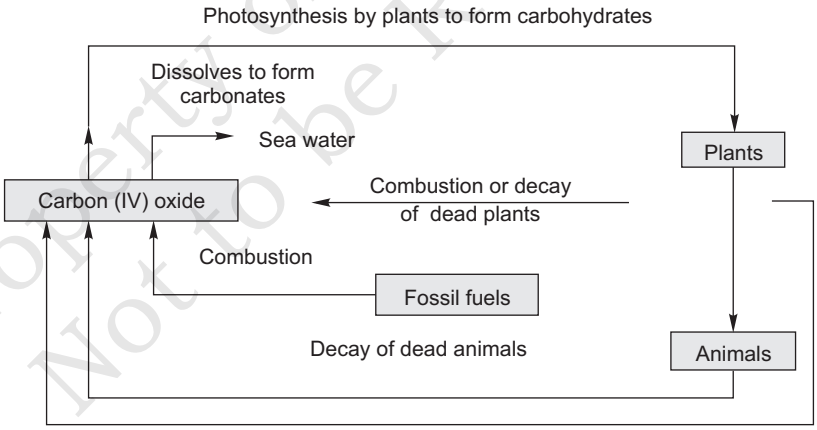


Fig. 3.12. The carbon cycle

3.9.3 Nitrogen Cycle

Nitrogen is required by plants and animals to synthesise proteins and nucleic acids. The atmosphere is very rich in nitrogen. However, organisms are unable to use this atmospheric nitrogen directly. Animals require nitrogen in the form of amino acid to form proteins. Whereas,

plants require nitrogen in the form of soluble salts and nitrates for the synthesis of amino acids and proteins. By nitrogen cycle, atmospheric nitrogen is converted into its various chemical forms. This transformation can be carried out by both biological and non-biological processes. Nitrogen fixation, ammonification, nitrification and denitrification are the important processes involved in nitrogen cycle.

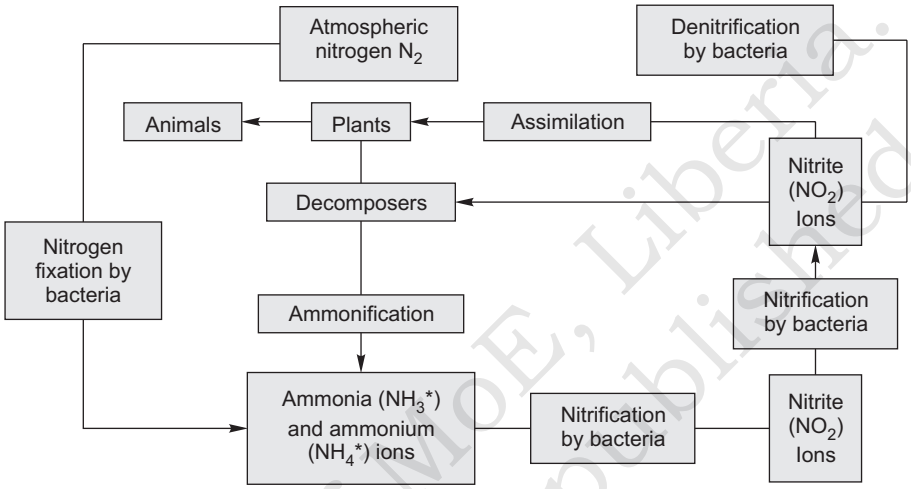


Fig. 3.13. The nitrogen cycle

3.9.4 Phosphorous Cycle

Phosphorous is very important for all organisms. It is a component of cell membrane, nucleic acids and Adenosine triphosphate (ATP), the major energy molecule. In animals, it is also a constituent of teeth. There is no atmospheric phase in the phosphorous cycle. Phosphorous is available in biosphere in the following ways:

- The major reservoir for phosphorous is in phosphorous rocks and fossil bone deposits lay down in the past geological ages. As rocks are eroded, small amounts of phosphorus dissolve, usually as phosphate that seep into the soil.
- Some amounts of phosphorous is washed into the sea by rain and floods. Seaweeds take phosphorous which finally passes into fish and sea birds. The sea birds deposit phosphorous rich feces called **guano** on land.
- Plants take up phosphorous from the soil. Animals get it from the plants directly or through other animals.
- Animals excrete phosphorous mainly as phosphate which the plant can use immediately.

- Phosphorous is also returning the soil and water through decay of excreta and dead bodies of organisms.

3.9.5 Sulfur Cycle

Sulfur is a component of certain proteins, vitamins and enzymes. Sulfur occurs in nature as an element and also as sulfate in soil, water and rocks. Plants absorb sulfates from soil and water and incorporate sulfur in proteins. The herbivores get organic sulfur from plant food and pass it into the carnivores. Some animals get sulfur from water also. Bacteria and fungi, under aerobic conditions, decompose the dead plants and animals and the excretory and fecal matter of animals. In this way, they change the organic sulfur to sulfates which are added to soil and water for the reuse of plants.

Activity 3.10 (Lab Work)

Diagramming different biocyles in nature such as water cycle, carbon cycle, nitrogen cycle, sulphur cycle and phosphorous cycle. Also discuss how these cycles show the intricate relationships existing between the various kinds of organisms.

3.10 POPULATION

Population is the total number of organisms of same kind living together in a particular geographical area at a given time with capability to freely interbreed. It is an ecological unit which plays a role in community of organisms in an ecosystem. The population of an area does not remain constant because the number of individuals varies at different times.

A species may have a single population or many populations in which organisms have the potential to freely interbreed and produce fertile offspring. For example, frogs live in a pond, marshy area, and lake, and from the different populations of same species. Human beings also make the different populations of same species as they inhabit plains, hills and ice lands.

This variation in population can be measured under following terms:

1. **Population size:** The **population size** refers to the total number of individuals of a species in a particular area at a specific time. For instance, in 2008, there were 40,000 Asiatic elephants and 625,000 African elephants present.

Population size is calculated by using the following formula:

Population size = Population density × Area of habitat

2. **Population density:** The **population density** refers to the number of organisms per unit area or volume at a given time. For instance, trees per acre in the forest, number of animals per square kilometres and number of planktonic organisms per cubic metre of water.

   Mathematically, population density can be expressed as follows:

$$D = \frac{N}{S}$$

   where, D is the population density; N is the total number of individuals and S is number of units of space.

3. **Population frequency:** This refers to the number of times a species appears in given area of a habitat.
4. **Percentage cover:** Percentage cover is a measure to estimate the amount of area occupied by a given species in its habitat.

3.10.1 Determination of Population Size and Density

The following procedure can be followed to determine the **population size** and **population density** of a particular species in a terrestrial habitat:

1. Select and locate the sample plot.
2. Identify the sample species in the plot.
3. By using a measuring tape, measure the area of the habitat of the species.
4. Throw the quadrat at least 10 times within that plot.
5. Each time, record the number of species present within the area of quadrat.
6. The density of species is calculated by dividing the number of times the species occur within the quadrat by the area of quadrat.

Calculation

Frequency of species = X

Number of quadrats = 10

Average number of species per quadrat = $\frac{X}{10}$

As the area of quadrat = 1 m^2

Then, $$\text{density} = \frac{X/10}{\text{Area of quadrant}}$$

Example: Estimate the population density and population size of a specific type of a grass plant (e.g. stubborn grass).

Given: Total area of habitat = 12 m^2

Frequency of the grasses is the total number of throwing of quadrat, say it is assumed as = 200 times, so

Number of tosses = 40

Average number of grasses per quadrat tossed = $\frac{200}{40} = 5$

Area of quadrat = 2.5 m^2

Density of grasses = $\frac{5}{2.5}$ = 2 grasses per m^2

Population size of grasses

= Density × Area of habitat

= $2/m^2 \times 12\ m^2$

= 24

Thus, we can say that the population size of grasses in the given habitat is equal to 24 grass plants.

3.10.2 Population Growth

Population growth refers to the increase in the number of individuals in a population. The size of a population keeps changing in time, depending on various factors including food availability, predation pressure and reduced weather.

1. **Immigration:** It is the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration. Immigration can occur due to unfavorable climatic changes that may result in decrease in population.
2. **Emigration:** It is the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration. It is the permanent departure of individuals out of their habitats due to scarcity of food or unfavorable breeding conditions.

3.10.3 Population Growth Rate

The birth and death rates are computed by dividing the annual total number of births and deaths by the total population multiplied by thousand. The difference between the birth rate and death rate is **growth rate** of a population. If the birth rate is more than the death rate, the growth rate becomes **positive**, meaning that the numbers of individuals are increasing in the population. If the birth rate is less than the death rate, the growth rate becomes **negative**, meaning that there is decrease in the population. There is **zero growth** when birth rate and death rate of individuals in a population is the same (equal).

3.10.4 Doubling Time

The **doubling time** is the time it takes for a population to double in size/value. It is applied to population growth, inflation, resource extraction, consumption of goods, compound interest, the volume of malignant tumours, and many other things that tend to grow over time. The Rule of 70 is a simplified way of determining the doubling time using the equation, **doubling time = 70/r**, where *r* is the rate of growth for a population in percent. For example, if a population of 10 species were growing by two individuals a year, the *r* value would be 20%.

3.10.5 Density-dependent and Density-independent Factors

A new environmental condition is favourable for the growth of a population in a habitat. It is not because of reproduction but simply due to survival of offspring in that environment. As the number of organisms increases, the environmental resistance begins to increase proportionately, competition between the members of same population for food, and a decrease in the supply of food per organism reduce the number of offspring that survive. The survived offspring are said to be at the **climax**, which means the number of offspring that survive is very close to the number of offspring that die. Now, the population has reached a **dynamic equilibrium**.

3.11 ECOLOGICAL SUCCESSION

Ecological succession is defined as a natural process by which the structure of a biological community is evolved over time in the same area, till a permanent climax community is established.

In an ecological succession, due to change in the physical condition of an area, existing plants and animals communities are sequentially replaced with new plants and animals. The first community to inhabit an area is community; the succeeding one is called **transitional community** and the last one is known as **climax community.**

3.11.1 Causes of Ecological Succession

Ecological succession is caused mainly by two types of factors:

1. **Biotic factors:** Organisms themselves direct succession. The action of each seral community makes the area less favourable for itself and more favourable for the next seral community in the succession, till the stable climax community is attained. Thus, each community drives itself out of its habitat.
2. **Abiotic factors:** These include climate and other physiological factors such as filling up of lakes, erosion of hills and so on. Human actions such as grazing cattle, farming and urbanization reverse the ecological succession.

3.11.2 Characteristics of Ecological Succession

Ecological succession shows the following characteristics:

1. It begins with a bare or virgin habitat.
2. The pioneers are short-lived, small, green plants (herbaceous plants) and progressively developed into the large, long-lived plants (trees).
3. It shows variation in diversities of life.
4. It tends to progress towards a complete adjustment with the environment.
5. It brings about gradual development of the soil and its humus structure.
6. In an ecological succession, initially the succession changes take place rapidly and gradually slow down until the climax community is reached.
7. After attaining the climax community, death of pioneer and previous seral communities add organic matter to the soil which enhances and leads to the establishment of some new species.

3.11.3 Types of Succession

Regarding the condition of an area where it occurs, ecological succession is of two types:

1. Primary succession
2. Secondary succession

Primary Succession

The **primary succession** occurs when a barren and uninhabited habitat is first colonized by the pioneer species. Life is usually very challenging for the pioneer community and takes a very long time, usually 1000 years or more.

Factors that can lead to the formation of bare surfaces include:

1. Retreating glacier or lake
2. Depositing rocks
3. Sand dunes
4. Volcanic eruptions
5. Deposition of silt and mud at river estuaries
6. Mining
7. Drought conditions

Process of Primary Succession

Primary succession is an **autotrophic succession** which is completed in the following sequential steps:

1. **Nudation:** It is the first step in which a bare area is created by the action of abiotic components such as wind, heat, flood an storm.
2. **Invasion:** The first settler species such as spores and seed invade the bare area by the process of invasion.
3. **Establishment:** The invading species of a bare area germinate, grow, establish and reproduces for successful succession. Species that are adjusted to the environmental situation can be well established on the bare area.
4. **Aggregation:** After establishment, the individuals of the species reproduce and get close to each other. This process is called **aggregation**.
5. **Competition:** Establishment of species results in **interspecific** and **intraspecific** competition among species. The species which are unable to compete ultimately die while the other species survive.

6. **Reaction:** The living organisms reciprocally get influenced by the environment. This is known as **reaction**. As a result of reaction, changes take place in abiotic conditions such as light, heat, soil, water and so on.
7. **Climax:** Climax is the terminal stage of primary succession in which the established final community can maintain itself in perfect equilibrium with climatic and edaphic conditions of the area. This final community is called **climax community** and the stage is called **climax stage**.

Primary Succession in an Aquatic Habitat

An open lake is an appropriate example of primary succession in an aquatic habitat. A lake has clear water with sandy bottom. Surrounding streams bring soil to the lake hence its sandy bottom is replaced by the mud and the manure. Vegetation grows up along the sides of lake and gradually progresses into the lake, making it a marsh and finally a dry land. There are four types of communities that are involved in primary succession in the lake habitat:

1. **Pioneer communities:** Phytoplankton such as diatoms, unicellular or filamentous algae and cynobacteria constitute the pioneer community of the lake. They multiply and increased rapidly. Some serve as food for the zooplanktons while some other died. The dead planktons mix with the deposited soil at the bottom and make it more fertile. This fertile layer helps in the growth of next succession serial stages.
2. **Transitional communities:** It comprises five types of plants that occur successively:
   - **Submerged plants:** Elodea and Ceratophyllum are the examples of submerged plants. They anchor in the bottom mud. Silts and decaying organic matter are deposited under these plants and raise the bottom of the lake. Decaying organic matter makes the mud fertile hence increasing the fertility in submerged plants.
   - **Rooted plants with floating leaves:** Such plants are grown in deeper water of the lake. *Nymphia* and *Nelumbium* are the examples of such plants. These plants have underground stem. Their growth makes the water rich in mineral and organic matter which is suitable for the growth of free-floating plants.
   - **Free-floating plants:** Free-floating plants such as *Pistia* and *Nymphia* grow and add more dead organic matter at the bottom

of the lake hence raises it further. As a result, the shallow water at the periphery almost turns into a marsh.

- **Amphibious plants:** In the marsh, plants such as *Typha* and *Polygonum* are rooted in the lake soil but their shoots are extended well into the air. As they grow both in land and water hence they are called amphibious plants. These plants loose water by the transpiration and add organic matter by their death at the bottom of the lake. This helps in raising the bottom of the lake the more. The marsh due to their growth ultimately changes into the soil which helps in increasing the growth of shrubs.
- **Shrubs:** The shrubs invade the peripheral area of the lake and replace the marshes by shading them. As they photosynthesize and grow well, they can add more soil for the growth of trees.

3. **Climax communities:** The shrubs are finally replaced by the trees which constitute the climax community. The type of climax community is determined by the climate of the region, e.g. rain forests grow in the moist and warm tropical zones.
4. **Animal communities:** A lake may originally have fish which spawn on its sandy bottom. As the bottom of lake acquires mud and other debris, the fish is replaced by the other organisms which can spawn in the aquatic habitat. In this way, fishes are replaced by the other aquatic organisms like insects, snails, prawns and aquatic birds in swamp community and finally the land animals come to occupy forests.

Differences between pioneer community and climax community are presented in Table 3.5.

Table 3.5. Differences between pioneer community and climax community

Pioneer community	*Climax community*
1. It is a primary biotic community which develops in an area.	1. It is a final biotic community which develops on the bare area.
2. It establishes over a previously bare area.	2. It develops over an area which is previously occupied by several communities.
3. It consists of small organisms.	3. It consists of numerous organisms large and small sized organisms.

4. In this community growth is fast.	4. In this community growth is slow.
5. Lifespan of organisms is short.	5. Lifespan of organisms is long.
6. It is soon replaced by the next developing community.	6. It is stable and not replaced by any other communities.

Secondary Succession

This is the ecological succession of recolonised plants and animals communities in previously inhabited areas which have been naturally or artificially disturbed such as devastating flood, wildfire, landslide or human activity such as farming and construction work.

The main concept in secondary succession is that, life was previously present in the soil, eliminating the need for deposition of new seeds or soil. Secondary succession is a much more rapid process than primary succession because the soil and nutrients are already available.

Examples of Secondary Succession

Examples of secondary succession include the following:

1. **Renewal of forest after forest fire:** The forest fire destroys the majority of different types of trees and plants. But the seeds, roots and other parts of trees are remains in and on the soil which gradually grow and return to their original states. In this way, a forest can be renewed after the naturally occurring forest fire.
2. **Renewal of crops after harvesting:** The ripened crop is completely harvested, but some seeds remained in the soil. Such seeds under favourable conditions regenerate the crop in the following year without planting new seeds.
3. **Renewal of forest after logging:** A large number of trees were chopped down by loggers in order to create building materials. Over time, trees regenerate and the area returns to its previous state.

Table 3.6. Differences between primary succession and secondary succession

Primary succession	*Secondary succession*
1. The primary succession occurs in an area which has been bare from the beginning.	1. The secondary succession occurs in an area which has been denuded recently.
2. In the beginning, soil is absent.	2. Soil is already present.

3. Humus is not found in the beginning stage of primary succession.	3. Humus is present before the beginning of secondary succession.
4. Regions of primary succession lack soil and organic matter.	4. Regions of secondary succession have the ability to retain the soil and organic matter.
5. The primary biotic succession is very challenging for the pioneer community.	5. In the secondary biotic succession, surviving plants can easily grow to form the pioneer community.
6. It takes very long time; over 1000 years for completion.	6. It takes very short time, over 50-200 years for completion.

Activity 3.11 (Group Activity)

To study the succession on a (unplastered or plastered) fence, Select the area of (unplastered or plastered) fence and observe it for several months. Now record and identify the plants that grow on it. Study the pattern of growth of the plants by using sketch maps. Make sure that in the sketch map, recording of plants is in a sequential manner so that the succession can be studied appropriately.

KEY GLOSSARY

- **Agriculture:** A practice of cultivating plants and live stock.
- **Bush clearing:** The removal of plants to increase the size of crop-producing land.
- **Cash crops:** Crops that are grown in large scale with the intension of generating profit.
- **Clayey loam:** Loamy soil in which the clayey proportion is high.
- **Climax community:** A stable community which maintains a balanced relationship with its environment is developed.
- **Commensalism:** An association of the members of two species in which one benefits while the other is almost unaffected.
- **Competition:** An interaction between two or more organisms when the resources are limited for their survival.
- **Doubling time:** The time taking for a population to double in size.
- **Ecosystem:** A biotic community and its environment constitute a system called an ecosystem.

- **Emigration:** the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration.
- **Famine:** An extreme scarcity of food.
- **Food chain:** A linear and sequential inter-linking of organisms involving the transfer of food energy from the producers to the consumers.
- **Food web:** An interconnected network of food chains which links various species in an ecosystem.
- **Habitat:** The natural environment in which living organisms live.
- **Humus:** A dark organic matter in soil that is formed by the decomposition of plant and animal matter.
- **Immigration:** the number of individuals of the same species that have come into the habitat from elsewhere during the time period under consideration.
- **Interspecific competition:** It occurs when there is competition between organisms of different species.
- **Intraspecific competition:** A competition occurs between the organisms of same species.
- **Mutualism:** An association of organisms of two different species in which both species get benefited but cannot live separately under natural conditions.
- **Niche:** It is the interaction of a species with the other members of the same community. It is the specific part of a habitat which is occupied by a particular organism.
- **Nitrogenase:** An enzyme present in nitrifying bacteria and help them in converting atmospheric nitrogen into ammonia.
- **Sandy loam:** Loamy in which the proportion of sand in the clayey soil is high.
- **Slash and burn method:** The clearing of forests, weeds and grass by setting them on fire.
- **Soil erosion:** The removal and transportation of top layer of soil.
- **Soil:** The uppermost layer of the earth's crust in which plants can grow.
- **Tillage:** Preparation of land for growing crops.
- **Topography:** The study of the form and features of a land surface.

- **Trophic level:** A level of consumption in a food chain.
- **Weathering:** Breaking down of rocks on the earth's surface.

SUMMARY

- Soil is an edaphic factor that helps in determination of the types and distribution of vegetation and animals in a habitat.
- According to the size of particles, there are three types of soil. These are—Sandy soil, Clayey soil and Loamy soil.
- The moisture content of the soil refers to the amount of water present in the soil.
- Bush clearing is the removal of plants to increase the size of crop-producing land whereas the slash and burn method is the clearing of forests, weeds and grass by setting them on fire.
- Natural resources that are judiciously conserved include soil, forest, wildlife, oil and minerals.
- Isolating mechanisms are intrinsic characteristics of species that reduce or prevent successful reproduction with members of other species.
- Commensalism and mutualism are positive s whereas amensalism, parasitism, predation and competition are negative associations.
- Environment, biosphere, habitat, niche, population, biotic community of biome and ecosystem are some basic ecological concepts.
- Producers, consumers and decomposers are the abiotic component of an ecosystem. The abiotic components of an ecosystem include the non-living physio-chemical factors of the environment.
- The distinct sequential steps in the food chains are referred to as trophic levels**.**
- Population is the total number of organisms of same kind living together in a particular geographical area at a given time with capability to freely interbreed. It is an ecological unit which plays a role in community of organisms in an ecosystem.
- Ecological succession is defined as a natural process by which the structure of a biological community is evolved over time in the same area, till a permanent climax community is established.
- Ecological succession is of two types—primary succession and secondary succession.

- Primary succession occurs in barren, uninhabitable areas whereas secondary succession takes place in previously inhabited but somehow disturbed areas.

A. Multiple Choice Questions

1. In addition to rock particles, the soil contains
(a) Air and water
(b) Mineral salts, organic matter, air and water
(c) Water and plants
(d) Water, air and plants

2. The soil particles are tightly packed in
(a) Clayey soil (b) Loamy soli
(c) Sandy soil (d) Silt

3. If 90 ants are found in a field with a total areaof 100 m2, what is the population density of the ants?
(a) 0.09 (b) 0.90
(c) 9.00 (d) 90.00

4. Which of the following statement is true about sandy soil?
(a) It has limited air space. (b) It is light and easy to dig.
(c) It drained slowly. (d) It is heavy and poorly aerated.

5. A process by which organisms synthesise their own food from simple inorganic substances is called
(a) Photosynthesis (b) Heterotrophy
(c) Decomposition (d) Scavenging

6. Snail, mosquito larva, and tadpole are the examples of
(a) Primary consumers (b) Secondary consumers
(c) Tertiary consumers (d) Decomposers

7. Which of the following organisms feed directly on green plants?
(a) Primary consumers (b) Secondary consumers
(c) Producers (d) Decomposers

8. Plants that have special devices for trapping and digesting insects are
(a) Carnivorous (b) Symbiotic
(c) Parasitic (d) Saprophytic

9. Rhizobium is a type of bacteria found in the
(a) Chloroplasts of green plants

(b) Root nodules of leguminous plants
(c) Leaves
(d) Stems

10. Carbon cycle is involved in
(a) Photosynthesis (b) Combustion
(c) Respiration (d) All of them

11. Which of the following statements is not associated with pyramid of energy?
(a) Efficiency of energy transfer between trophic levels can be studied
(b) Comparisons of pyramids for different ecosystems can be made
(c) More accurate comparisons of trophic levels
(d) Representation of numbers of organisms at different trophic levels

12. The removal of extra plants to increase the size of the crop producing land is called
(a) Bush clearing (b) Bush burning
(c) Tillage (d) Irrigation

13. Rhizobium bacteria are found in the
(a) Root nodules of plants (b) Chloroplasts of plants
(c) Leaves (d) Stems

14. Which of the following process is similar to decaying process?
(a) Ammonification (b) Nitrification
(c) Denitrification (d) Nitrogen fixation

15. The free nitrogen present in air can be converted into nitrites and nitrates by
(a) A biological process of nitrogen-fixing bacteria present in the soil
(b) A biological process of carbon-fixing factor present in the soil
(c) Any of the industries manufacturing nitrogenous compounds
(d) The plants used as cereal crops in field

16. Which step is not involved in the carbon cycle?
(a) Photosynthesis (b) Respiration
(c) Excretion (d) Burning of fossil fuels

17. In parasitism
(a) One organism is benefited
(b) Both the organisms are benefited
(c) One organism is benefited, other is unaffected
(d) One organism is benefited, other is affected

18. In positive association of organisms
(a) one species gets benefited and the other gets harmed
(b) both participating species are benefited
(c) no species get benefited or harmed
(d) both participating species are harmed

19. Association of sea anemone and hermit crab is the example of
(a) Parasitism (b) Commensalism
(c) Symbiosis (d) Mutualism

20. Association of Remora fish and shark is the example of
(a) Symbiosis (b) Commensalism
(c) Parasitism (d) Predation

21. The association between two organisms in which one of the organism gains and the other loses is referred to as
(a) Saprophytism (b) Commensalism
(c) Mutualism (d) Parasitism

22. Illegal hunting and killing of animals is referred to as
(a) Trapping (b) Poaching
(c) Torturing (d) Torching

23. Which of the following natural resources cannot be conserved?
(a) Soil (b) Water
(c) Wildlife (d) Air

24. A good site for secondary succession would be
(a) A sand dune
(b) A bare rock
(c) A land that has just had forest fire
(d) A stretch of barren land

25. The natural dwelling place of an organism is called its
(a) Ecological niche (b) Habitat
(c) Population (d) Environment

26. Climax community is in a state of
(a) Equilibrium (b) Non-equilibrium
(c) Constant change (d) Disorder

27. In a habitat, factors that are influenced by the population size are called
(a) Density-dependent factors
(b) Dynamic equilibrium

(c) Density-independent factors

(d) Population fluctuation

B. Fill in the blanks.

1. The soil consists of a mixture of _____ and _____ particles in various proportions.
2. The organic matter present in the soil increases the _____ of the soil.
3. The sandy soil is light, well aerated and dry, with high level of _____.
4. The regular _____ and _____ of rocks occur at different parts of the rocks at different rates.
5. The soil _____ can easily be identified by the soil color and soil particles.
6. The _____ content of the soil refers to the amount of water present in the soil.
7. Urea is an example of _____ fertilizer which mainly provides nitrogen.
8. In _____ the fertilizer is applied over the ground where the crop is growing.
9. The farming practices are the major cause of _____.
10. The spraying of herbicides on plants can cause _____ pollution.
11. The energy is constantly supplied by the _____ in a functioning ecosystem.

C. True or False.

1. Regions with very heavy and frequent rainfall face a small amount of soil loss.
2. If soil erosion is a continuous activity in a particular region, it may support only sparse vegetation.
3. The natural resources available are limited but the population across the world is decreasing rapidly.
4. Forests provide much oxygen for respiration hence, called breathing cover.
5. Liberian forests are dominated by moist evergreen forests and semi-deciduous forests.
6. Lowest amount of energy is available at the producer level in a pyramid of energy.
7. Carbon is required by living organisms for their exoskeleton and endoskeleton.
8. The population of an area is always remains constant because the number of individuals varies at different times.
9. The secondary succession occurs when a barren and uninhabited habitat is first colonized by the pioneer species.

10. Secondary succession is a much more rapid process than primary succession because the soil and nutrients are already available.

D. Answer the following questions.

1. What is soil? List three types of soil.

2. (a) What is an ecosystem?
(b) State two main factors of an ecosystem.
(c) Name two biotic factors that affect plants and animals of the terrestrial habitat.

3. What is the role of decomposers in an ecosystem?

4. Define (a) Producer (b) Consumer.

5. Which of the following is not a part of the carbon cycle?
(a) Organic carbon (b) Decomposition
(c) Nitrate formation (d) Photosynthesis

6. Describe the water cycle with the aid of labelled diagram.

7. What is meant by a food chain? How is it different from a food web?

8. What is the importance of decomposers in the ecosystem?

9. Describe the carbon cycle.

10. State the functions of:
(a) Nitrogen fixing bacteria (b) Nitrifying bacteria
(c) Denitrifying bacteria in nature.

11. Write short notes on the following:
(a) Parasitism (b) Commensalism
(c) Mutualism

12. Classify the following biological associations under the headings in the table below:
(a) Remora and shark (b) Lichen
(c) Cattle and white egret (d) Tapeworm in the gut of human
(e) Flowers and honeybees.

Parasitism	Mutalism	Commensalism

13. List four methods of conserving the following:
(a) Wildlife (b) Forest
(c) Oil

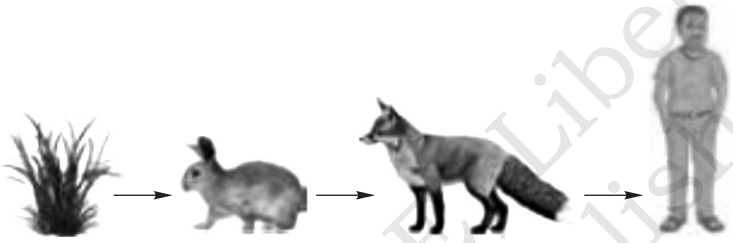
14. What is an ecological succession?

15. State two differences between primary succession and secondary succession.

16. List two biotic and two abiotic factors that affect the population growth.

17. State the differences between density-dependent and density-independent factors with examples.

18. (a) In the given diagram, what do the part (i), (ii) and (iii) depict?



(b) Which is the producer in the given diagram?

(c) Which one is the primary consumer?

(d) Which are the secondary and tertiary consumers?

19. Study the diagram of a food chain shown below and use it to answer the questions (a) and (b). P → Q → R → S → T

(a) The organism designated P in the food chain above is normally sustained by energy from

(i) Sunlight

(ii) Carbohydrates

(iii) Green plants

(iv) Mineral salts

(b) Which of the following statements best described the organisms designated R?

(i) It feeds on S

(ii) As a primary consumer

(iii) As a producer as well as a consumer

(iv) As a secondary consumer