



**Soil:** The top layer of the earth's surface, in which plants grow, is called soil. Soil is a natural resource made up of a complex mixture of several components. Rock particles make up a large part of soil. The following are the main constituents of soil.

**Constituents of soil:**

1. **Water:** in soil is present between and at the surface of soil particles.
2. **Air:** The spaces between the particles of soil are occupied by air. The amount of air in the soil varies from soil to soil. This air is required for the respiration of plants
3. **Organic matter:** Organic matter is added to the soil by the decomposition or decay of dead organisms such as plants, animals and micro-organisms. The excreta or organic matter are also added to the soil.
4. **Inorganic matter:** Inorganic nutrients come into the soil from the rock from which the soil is formed. The soil gets nutrients from time to time in the form of manure (organic matter) and fertilizers.
5. **Minerals:** the minerals present in the soil are called nutrients. All soils provide a number of nutrients to vegetation that grows on them. Some of the nutrients are required in larger amounts. These are called macronutrients. Hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur are examples of macronutrients. Some of the minerals are required by plants in very small amounts. These are called micronutrients. They are iron, manganese, copper, zinc, boron, molybdenum and chlorine.
6. **Humus:** is a black material formed by the decomposition of dead plants and animals. It gets deposited as a layer over the soil. Humus supplies nutrients such as nitrogen, phosphorus and sulphur to the soil.

Thus, soil is the most important source of plant nutrients.

The nutrients mentioned here are present in soil in the form of compounds like phosphates, nitrates, water, etc. Plants obtain these substances from the soil. These are used to prepare complex molecules which decay or degrade into simpler substances and return to the soil.

**Formation of soil:** The fine particles of soil are formed mainly by the breaking down of larger rocks by the action of wind, moving water (rain and river water), snow and sun. This process is called **weathering**. Dead animals and plants decompose and add valuable minerals to the soil. This makes the soil fertile. Microbes play an important role in maintaining the fertility of soil. The soil which we see today has been formed over thousands of years. So, we should conserve this valuable resource.

**Types of soil:** On the basis of particle size, soils are classified as sand, silt and clay. Sand contains particles of largest size, clay the smallest and silts the intermediate ones. Sand, being very porous, allows air and water to pass through it. So, it is not suitable for growing plants. Clay forms a sticky paste with water. It does not allow air to reach the roots of plants. So, it too is not suitable for the growth of plants.

**Loam** is a mixture of sand, silt and clay. It is just the right kind of soil for growing plants. The topmost layer of the soil which contains humus and living organisms is called the topsoil. The amount of humus and the depth of the soil determine the type of plan that can be grown in the topsoil. **Functions of soil**

1. Soil gives mechanical support or anchorage to plants. Had there been no soil bas the existence of plants would have been impossible.
2. The roots of plants get oxygen from the soil through the process of aeration. For this, the soil should be loose so that roots may penetrate it properly and hold firmly to it. There should not be excess water in the soil as this would adversely affect aeration.
3. Soil provides mineral nutrients for the growth of plants. Water trapped within the soil is available to the roots of plants.



4. Animals obtain their food directly or indirectly from plants. Thus, animal life too is dependent on soil.

**Fertility of soil:** The fertility of soil is determined by the capacity of the soil to sustain the life of plants by supplying the required nutrients. Soil rich in nutrients is said to be fertile, while soil deficient in nutrients is said to be infertile. The quality of soil is determined by the amounts of humus present in it. Humus makes the soil porous. So, water and air can easily go deep inside the soil.

**Soil erosion:** The removal of the top layer of the soil by wind and rainfall is called soil erosion. Air and water are the main agents of such erosion.

1. **Air:** Small particles of soil are easily blown away by strong winds. Bigger particles of soil stay on the ground. Due to continuous friction with other pieces, they are eventually transformed into smaller pieces and finally fly away with the wind. This process is called saltation.

2. **Water:** Strong currents of water cause more soil erosion than wind. This occurs in two forms. In the first, a stream of water carries with it the upper soft layer of the soil. As a result, runnels are formed on the soil. This is called gully erosion. This type of erosion makes the land unfit for cultivation. In the second form, sheets of soil formed on the surface of the land are washed away during rainfall, thereby reducing the fertility of the soil. Such erosion is called sheet erosion. **Causes of soil erosion**

**1. Uncontrolled grazing of grass by animals:** In our country, pastoral land is insufficient for the high population of farm animals. This leads to excessive grazing. The soil becomes unprotected and is washed away by wind and water.

**2. Deforestation:** The roots of plants and trees firmly bind the particles of soil together because of large-scale deforestation; the binding force between the soil particles becomes too weak to withstand the impact of storms or floods. As a result, the soil on the surface of the earth gets washed away easily.

**3. Low water-holding capacity** In some soils the water-holding capacity is high, whereas in others it is low. Soil with low water-holding capacity is swept away by air or water easily.

**Prevention of soil erosion** Learning With Innovation.....

1. Trees should be planted on a large scale. The roots of trees hold the particles of the soil together and prevent them from being carried away by flowing water. Thus, the trees act as soil binders.

2. Ploughed fields should not be allowed to remain unused for long as it would cause erosion due to storms.

3. Proper devices of irrigation and drainage should be used, particularly on slopes, to stop the washing away of soil by flowing water.

4. The soil should be properly levelled so that water may be drained out easily.

5. Bunds or earthen embankments should be built to check the flow of water.

**Improving soil fertility:** Soil has been used for agricultural purposes since ancient times. But, there are some agricultural practices which deprive the soil of its nutrients. For example, growing the same crop in the same soil repeatedly for years (known as monoculture) reduces soil fertility. This is because the crop draws nutrients from the soil, and growing it repeatedly makes the soil deficient in these nutrients. The infertility of soil caused by monoculture can be avoided by adopting the following methods.

1. **Crop rotation:** In this system, different crops requiring different nutrients are grown on the same soil during different seasons. This is called crop rotation. **Advantages of crop rotation:**

(a) The fertility of the soil is improved. This leads to an increase in food production.





(b) Use of a large amount of nitrogenous fertilizers is avoided. Leguminous plants like gram, pea, etc., grown during the rotation period can fix atmospheric nitrogen with the help of bacteria. These leguminous plants replenish the nutrients of the soil by a process known as nitrogen fixation.

2. **Keeping land fallow:** The agricultural land is left unused for one or two seasons. This helps the soil restore its lost nutrients and thereby regain its fertility.

3. **Mixed or multiple cropping:** The system of growing two or more crops together in the same soil is known as multiple or mixed cropping. For example, groundnut and cotton are grown in the same soil.

**Effects of manure and fertilizers on the soil:** We know that soil provides the most suitable base for agriculture. By the repeated growing of plants, the essential nutrients get depleted in the soil and hence the fertility of the soil is reduced considerably. The excessive use of chemical fertilizers degrades the quality of the soil in the long run. This also leads to water pollution. For example, excessive use of nitrogenous fertilizers makes the soil and water rich in nitrates. Such water becomes unsuitable for drinking. Besides, when this water flows into rivers, lakes and ponds nearby, it encourages the prolific growth of algae and thereby reduces the amount of oxygen dissolved in water. Such water then becomes unfit for the survival of aquatic life. This process is called **eutrophication**.

Inorganic fertilizers like  $\text{NaNO}_3$  and  $(\text{NH}_4)_2 \text{SO}_4$  also change the chemical behaviour of soil. For example, the use of  $\text{NaNO}_3$  as fertilizer provides  $\text{Na}^+$  and  $\text{NO}_3^-$  ions to the soil. Nitrate ions ( $\text{NO}_3^-$ ) are used by plants, but sodium ions ( $\text{Na}^+$ ) remain unused. The  $\text{Na}^+$  ions combine with hydroxide ions ( $\text{OH}^-$ ) of the water present in the soil and form sodium hydroxide ( $\text{NaOH}$ ). This makes the soil alkaline. Similarly, the use of ammonium sulphate as fertilizer makes the soil acidic due to the formation of sulphuric acid in the soil.

**Effects of pesticides:** Pesticides are normally used to prevent crop diseases. These pesticides produce many harmful effects too. Most of the pesticides are nonbiodegradable. They accumulate in the soil causing environmental pollution. They may cause irritation of the skin and also respiratory problems. Further, when these pesticides are sprayed on crop plants, they enter the soil and water bodies. Crop plants absorb these. And when animals or human beings eat these plants or their parts the pesticides enter their bodies, causing a number of diseases.

**Management and conservation of natural resources:** It is very necessary to treat our natural resources as wealth that we need to pass on to future generations. For this we need to use our natural resources in such a way that there is a balance between our needs and those of the future generations.

1. The use should be rational, i.e., reasonable. We should look for alternatives.
2. The use should be equitable, i.e., the use should be made in such a way that the society as a whole benefits from it and not just a few individuals.
3. The resource used should be replaceable, i.e., the resource should be consumed at the rate at which it is replenished in nature.
4. Inexhaustible resources, too, should be used judiciously, i.e., they should not be overexploited.

**Cycling of materials (nutrient cycles):** Of the more than hundred elements known to occur in nature, thirty to forty are required by living organisms. These elements not only provide the building blocks for the living, but are also needed for the operation of the living system. These elements which are essential for life are known as **biogenic nutrients**. Biogenic nutrients are absorbed by plants from the soil, water and air. They enter the living world at the producer level and get transferred to other trophic levels. They are ultimately returned to



the nonliving world by decomposers. This kind of exchange of nutrient elements between the living and the nonliving world is called cycling of materials.

## Biogeochemical Cycles

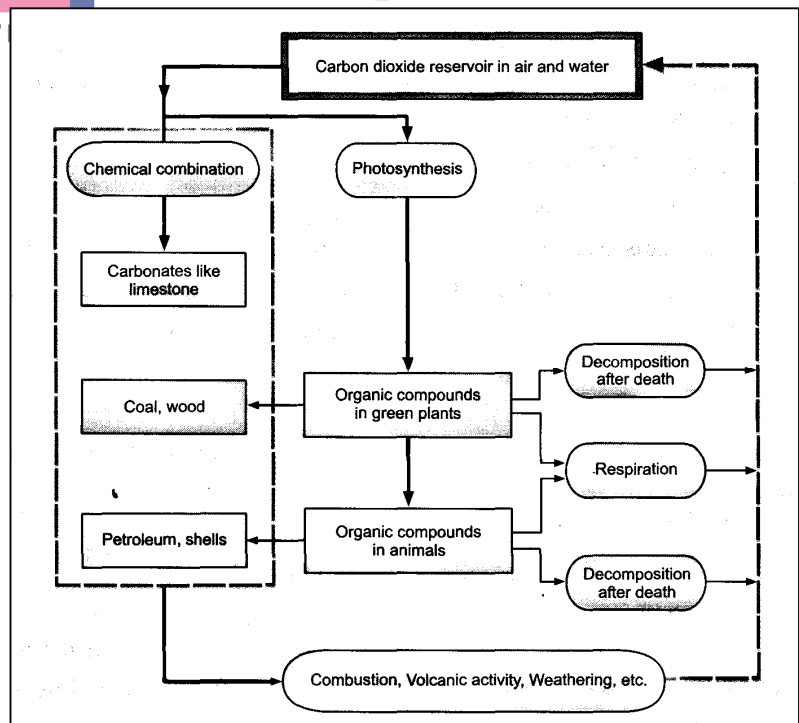
'Bio' refers to living organisms and 'geo' to the air, water and soil of the earth. Chemical elements tend to circulate in a characteristic path—from the environment to organisms and back to the environment. These more or less circular paths are known as biogeochemical cycles or nutrient cycles. Circulation of various nutrients between the living and nonliving components of ecosystems are called biogeochemical cycles. During these cycles, inorganic nutrients get converted into food. They are utilized by consumers and returned to the environment by decomposers. The four important biogeochemical cycles in nature are the carbon cycle, nitrogen cycle, oxygen cycle and water cycle. They help maintain a balance in our environment.

## Carbon Cycle

Carbon is the basic constituent of all living beings. Its organic compounds play a major role in our life as carbohydrates, fats, proteins and nucleic acids. Food, fibres (cotton, jute), medicines, fertilizers, fuels—all contain compounds of carbon. There are three main reservoirs of carbon: (a) atmosphere, (b) oceans, and (c) carbonate rock, coal and petroleum.

The atmosphere, in which carbon is present as carbon dioxide, serves as the main reservoir of carbon. Some carbon dioxide is also found dissolved in water. Carbon dioxide constitutes 0.03 per cent of the atmosphere. Most of the carbon dioxide enters the living world through the process of photosynthesis. The amount of carbon fixed by photosynthesis per year is  $4 \times 10^{13}$  to  $9 \times 10^{13}$  kg. The process of photosynthesis takes place on land as well as in water. Carbon dioxide enters the producers by diffusion and is then utilized for photosynthesis. During this process, producers use it to make carbohydrates. These are consumed by all living beings. The carbon in carbohydrate passes through different living beings as food. There is also a continuous exchange of carbon dioxide between the atmosphere and water bodies like oceans, through the plants present in them. Some of the dissolved carbon dioxide is also trapped to form limestone (calcium carbonate) and other carbonate rocks.

Carbon dioxide returns to the atmosphere through respiration in plants and animals, decomposition of dead plants and animals, volcanic eruptions and combustion of fossil fuels. Thus, a carbon cycle operates in our environment, as a result of which the proportion of carbon dioxide in the atmosphere remains almost the same.





### Nitrogen Cycle

Nitrogen comprises 78 to 79 per cent of the earth's atmosphere. It is an important constituent of plant and animal protein, which forms the structural and functional component of cells. Nitrogen is also present in DNA, RNA, vitamins, urea and alkaloids. Before studying the nitrogen cycle, you should understand the following processes.

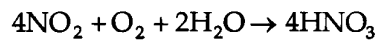
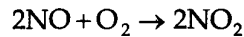
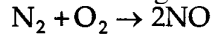
#### Nitrogen fixation

Nitrogen present in the atmosphere cannot be absorbed directly by most plants and animals. It can be used only by a few simple organisms. The rest can use nitrogen only when it is converted into nitrates and nitrites. Certain microorganisms do this.

The process of converting free nitrogen of the atmosphere into compounds of nitrogen is called nitrogen fixation.

This is the process by which nitrogen of the nonliving world enters the living system. Nitrogen fixation occurs in three ways.

(i) Atmospheric fixation the high temperatures and pressures produced during lightning allow nitrogen to combine with oxygen in the atmosphere to form oxides of nitrogen. These dissolve in rainwater and get soaked into the soil, and form nitrates.



Nitric acid is carried by rainwater to the soil where it forms nitrates. The nitrates get stored in the soil and the atmospheric nitrogen is fixed. The nitrates present in the soil are then absorbed by plants.

(ii) **Biological fixation** The fixation of nitrogen by some nitrogen-fixing bacteria is called biological nitrogen fixation. The root nodules of certain leguminous plants like peas and beans have nitrogen-fixing bacteria. These bacteria directly fix atmospheric nitrogen to nitrogen compounds. Some nonleguminous plants (Ginkgo) can also fix atmospheric nitrogen.

#### Learning With Innovation.....

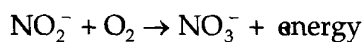
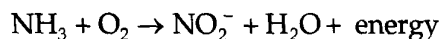
(iii) Industrial fixation In this artificial fixation, nitrogen of the atmosphere is made to combine with hydrogen to form ammonia (NH<sub>3</sub>). This ammonia can be oxidized to form nitrates or made to react with acids to form ammonium salts. These nitrates and ammonium salts are used as fertilizers.

(ii) Ammonification.

(iii) The process of conversion of complex organic compounds (plant and animal proteins) into ammonia is called ammonification. The proteins of dead plants and animals are broken down by bacteria present in the soil, which convert them into ammonium ions. A number of animals excrete urine, which contains urea. This urea gets converted into ammonia (along with carbon dioxide and water) in the soil by the process of ammonification. Some types of bacteria synthesize proteins from ammonia.

#### Nitrification

Nitrification is the process of conversion of ammonia into nitrites and nitrates Ammonia is acted upon by nitrifying bacteria and is changed to nitrates



(iv) In the first step, ammonia is oxidized to nitrites which are further oxidized to nitrates in the second step. The nitrates are available for recycling.

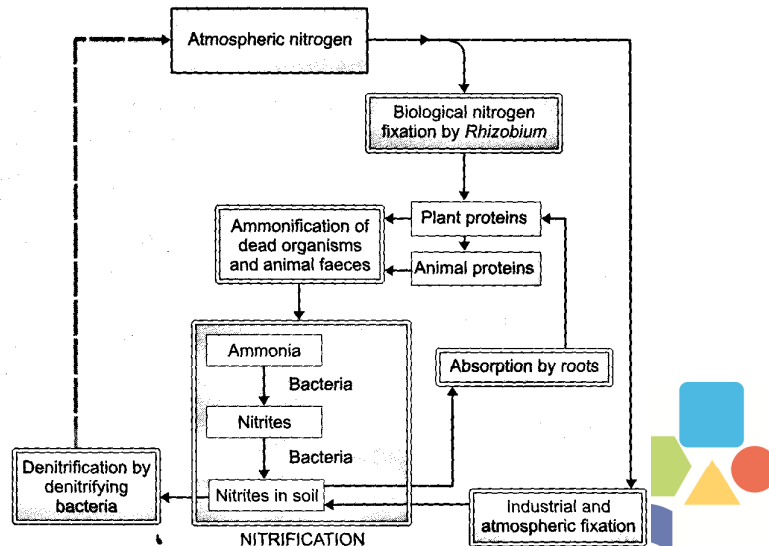




(v) Denitrification is the process of conversion of nitrate salts to free nitrogen. In this process nitrates of the soil come back to the atmosphere. It is carried out by free-living denitrifying bacteria present in the soil.

(vi) Nitrogen cycle in nature

Atmospheric nitrogen is used only by a few simple organisms. Nitrogen is converted to complex compounds in organisms. These are finally converted to nitrogen in the atmosphere. The cyclic pathway by which nitrogen is circulated continuously through the living and nonliving components of the biosphere is called the nitrogen cycle.



## Water cycle

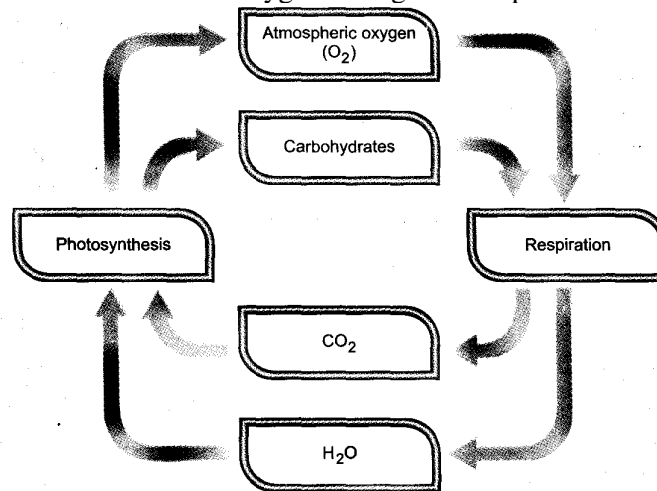
You know that three-fourth of the earth's surface is covered by water. Most of the water is cycled between the oceans and the atmosphere through evaporation and rainfall. Evaporation changes water from the surface of oceans, rivers, ponds and lakes into water vapour. As water vapour rises condensation changes it to clouds. Heavy drops of water in the clouds fall as rains. Thus, water is returned to the water bodies. Such circulation of water is called water cycle.

(vii) Water cycle Living beings also cycle water. For example, animals drink water and throw out water as urine and sweat. Plants lose water to the atmosphere through transpiration, and absorb water from the soil. Although only a very small proportion of the earth's water resides in living organisms, it is essential for them.

## Oxygen cycle

The concentration of oxygen in the atmosphere is about 21%. It is one of the constituents of water. Oxygen is cycled in the living world through respiration and photosynthesis. All living organisms take in oxygen for respiration. During this process food is oxidized, energy is produced and carbon dioxide is released into the atmosphere. Carbon dioxide is used by green plants to produce food materials during photosynthesis. Oxygen is released in this

process as a by-product. Some of the oxygen also gets incorporated into the food materials



(carbohydrates).

Oxygen cycle

Oxygen is also cycled during burning and combustion. Oxygen is consumed in the burning of materials and carbon dioxide is released during this process. Oxygen combines with nitrogen and forms nitrogen oxides, amino acids, proteins, etc. These compounds release oxygen in the atmosphere when they are broken down. Thus, the oxygen level is balanced in the environment.

Functions of various nutrient cycles

The following conclusions may be drawn after studying the various nutrient cycles.

- (i) Nutrient elements are circulated continuously between the living world and its nonliving surroundings.
- (ii) The amounts of various chemical materials cycling through the living and nonliving components remain almost constant.

Various human activities such as the excessive use of fossil fuels, mining and overuse of pesticides disturb the nutrient cycles. In order to maintain a balance in the biosphere, its components must be used judiciously.