# CHAPTER 6

## Nutrient Cycling in Nature

### PERFORMANCE OBJECTIVES

At the end of this chapter, students should be able to:

describe how carbon circulates in nature.
draw the carbon cycle in detail.
state why the carbon cycle is necessary for life.
recognise the delicate balance between carbon and oxygen. _

describethepartplayedbyplantsandanimalsinthewatercycle.

draw the water cycle in detail.
describe with the aid of diagram, the role of nitrogen.

### INTRODUCTION

A cell or organism is affected by different nutrients present in its environment. The cell requires a certain quantity of each particular nutrient to sustain itself. The availability of nutrients is important to the ecosystem. However, nutrients take various forms in nature and could be available to organisms either as gases or solids. Some materials such as carbon, nitrogen and oxygen form gases, which move through global atmospheric cycles.

Nutrients could be available in the form of ions, organic materials or inorganic materials. The organic materials include living or dead tissues of organisms, whereas the inorganic materials include rock and soil.

Producers acquire nutrients from the air, soils and water. Consumers acquire nutrients from the producers. These nutrients are not tied to the organisms that utilise them. In other words, nutri- ents that make up living organism are used over and over again, i.e., recycled between the living and non-living environments of the ecosystem.

Mineral elements in plants are passed on to animals in the process of animals feeding on plants. When plants and animals die, their remains decay and decompose, thus releasing the nutrients (minerals) back into the soil (envi- ronment )from where they can be re-utilised.

The continuous movement of nutrients between the living and non-living environment is known as nutrient cycling. Nutrient cycles do not function in isolation; they are interdepen- dent. For instance, oxygen combines freely with other nutrients and as such cuts across most cycles. Cycles are balanced in nature, but human activities upset this balance and often result

in ecological problems.

## CARBON CYCLE

Carbon atom is a major component of all living (organic substances) and most non-living substances in any environment. It provides the backbone for most biological molecules. The carbon cycle brings about the circulation of carbon in the environment. Sources of carbon include carbon (IV) oxide in the air or bicarbonate ions dissolved in water, also lime stone (CaCo3); dead remains of organisms contain carbon.

Carbon is taken up from the atmosphere as carbon (IV) oxide during photosynthesis and incorporated into the tissues of plants. This is passed to animals when plants are eaten. Carbon (IV) oxide makes up 0.03% of the atmospheric gases. This proportion remains constant because certain processes in nature produce carbon (IV) oxide, whereas some other processes utilise carbon (IV) oxide.

## SUGGESTED PRACTICALS

### *ACTIVITY 1*

Teacher should assemble materials from the environment (such as bottles, plastics, empty milk can, cartons, old tyres and charcoal).

(i) Students should be made to work in groups and sort the materials out into those that contain carbon and those that do not contain carbon.

(ii) Students should be asked to make a list of at least six materials in their environ- ment which contain carbon.

## THE PROCESS OF CARBON CYCLING

- Carbon cycling brings about the recycling of carbon between the biotic and abiotic components of the ecosystem through the processes of photosynthesis, respiration and decay.
- Through the process of photosynthesis, green plants (primary producers) remove carbon in the form of carbon (IV) oxide from the atmosphere and incorporate it into car- bohydrates and other organic compounds in plant tissues.
- The carbon is incorporated into the tissues of animals (primary consumers) as they eat and digest plant materials. Some of these carbon pass directly into the abiotic envi- ronment as wastes (faeces and urine) from animals. As plants and animals respire, they also release carbon (IV) oxide into the atmosphere.
- When living things die, decomposers feed on and break down their remains and in the process, they release carbon (IV) oxide back into the atmosphere.
- When fuels like coal, petroleum and natural gas are burnt, carbon (IV)

oxide is also pro- duced and released into the atmosphere.

## THE IMPORTANCE OF CARBON CYCLE FOR LIFE

- The carbon cycle is important in ecosystems because it moves carbon from the atmo- sphere into organisms and back again to the atmosphere.
- If the balance is upset, it affects the climate. Increased atmospheric heat content, human activities, such as burning of fossil fuels, and clearing of forests lead to increased carbon (IV) oxide levels in the atmosphere. Carbon (IV) oxide absorbs infrared rays in the atmosphere.
- The carbon cycle recycles carbon atoms in the ecosystem.
- All living organisms contain carbon, and the carbon cycle is important for the continuing synthesis of biomolecules.

## OXYGEN CYCLE

- The oxygen cycle is a cyclic movement of oxygen within the atmosphere, biosphere and lithosphere. The main driving factor of the oxygen cycle is photosynthesis.
- Oxygen is lost from the atmosphere through respiration and decay.
- Oxygen is also cycled between the biosphere and lithosphere. Marine organisms have shells of calcium carbonate (CaCo3), which is rich in oxygen.
- Oxygen cycles through the earthâ€™s environ- ment in several forms. It can be dissolved in air or water; plants and animals breathe in oxygen and release carbon (IV) oxide, which is used during photosynthesis to release oxygen.
- Burning requires oxygen and releases carbon (IV) oxide, which is necessary for photosynthesis. The lithosphere has the larg- est reservoir of oxygen. Most of this oxygen is found in silicates and oxides (99.5%).
- The atmosphere is the smallest source of oxygen on earth (0.36%), whereas free oxy- gen in biosphere is 0.01%.
- In the atmosphere, oxygen is freed by the process called photolysis. Oxygen makes up 21% of air in the atmosphere.

## IMPORTANCE OF OXYGEN TO LIVING ORGANISMS

- Oxygen is a structural component of all the major classes of molecules in living organ- isms. It is needed for respiration to release energy. All living cells need oxygen.
- The natural oxygen cycle is determined by the aerobic respiration of animals that consumes oxygen and produces carbon (IV) oxide and water, and plants consume carbon (IV) oxide and water to produce organic molecules and oxygen during photosynthesis.

## SUGGESTED PRACTICALS

***ACTIVITY 2***

To show that carbon (IV) oxide is absorbed, during photosynthesis, teacher should provide the fol- lowing materials: two potted green plants, two wide-mouth bottles that can accommodate the potted plants, alcohol, potassium hydroxide, calcium hydroxide Ca(OH)2 solution (lime water) iodine solution, test tubes, capillary tubes and rubber bungs or cork with hole.

**PROCEDURE:** The potted plants should be placed in a dark cupboard to de-starch them. Two experiments A and B should be set up. In A, air that has been passed through potassium hydroxide (KOH) is drawn through the bottle containing one of the potted plants, whereas in B, the natural air is drawn through the set-up (Figure 6.3A and B). Both plants should be placed in the sun for 4–6 hours after which leaves from both plants are tested for starch.

Teacher should guide the students to discuss the results.

**SUGGESTED PRACTICALS**

***ACTIVITY 3***

To show that oxygen is released during photosynthesis, teacher should set up an experiment using a water plant such as Elodea or Ceratophyllum, which is placed in a trough of water and covered with a funnel.

A test tube filled with water is inverted over the narrow end of the funnel (Figure 6.4). Sodium hydrogen carbonate is added to the water in the trough to increase the carbon (IV) oxide content.

The set-up is placed under the sun for about 4–6 hours. The gas collected in the test tube is confirmed to be oxygen by placing a glowing splint into it. The glowing splint is rekindled.

**CARBON–OXYGEN BALANCE**

Oxygen is used by living organisms in many forms. The role in the cycle begins with carbon (IV) oxide during photosynthesis and release oxygen.

Animals breathe in oxygen and release car- bon (IV) oxide. Plants and animals use oxygen for their respiration and metabolic activities, and in the process, they release carbon (IV) oxide. Then, the cycle starts all over again.

**WATER CYCLE**

- The water cycle is also known as the hydro- logic cycle. This describes the continuous movement of water in liquid or vapour form from rivers or oceans to the atmosphere and back to the source through processes such as evaporation, condensation, precipitation, runoff and subsurface

flow.

- Oceans supply about 90% of evaporated water that goes into the water cycle. Water in the atmosphere helps in modifying the cli- mate by reducing the temperature.
- Water evaporates from open water bodies, such as oceans, seas, rivers, lakes, ponds, into the atmosphere. Transpiration also adds to the water content of the atmosphere in the form of water vapour.
- Water vapour in the atmosphere condenses to form clouds and returns to the earth sur- face as precipitation (rainfall, Snow and hail). When it rains, some of the rain water runs off the ground to streams and rivers, and some sink into the ground until it reaches the rocky bed and cannot flow through it.
- Then, it moves sideways along the surface of the rock until it breaks out as a spring at a point of low resistance. The spring may flow into a river, and the river into an ocean.
- Some of the rainwater, which has sunk into the soil, is absorbed by plants. Plants release water into the atmosphere as water vapour during their respiration and transpiration.

## THE IMPORTANCE OF WATER TO LIVING ORGANISMS

- All living organisms need water. Water is needed to maintain good health. Human beings and most other animals must drink water to avoid dehydration. Plants need water for life.
- Most metabolic activities occur in solution in water. Water is called a universal solvent. It also provides an environment for those organisms that live in water.

## SUGGESTED PRACTICALS

### ***ACTIVITY 4***

To show the presence of water in expired air. Teacher should provide students with small mir- rors and ask students to breathe on the mirrors.

It will be observed that the mirrors become cloudy as a result of condensation of water vapour in their breath on the cold mirror surface.

A similar situation is observed when rid- ing in a car on a rainy day with the glasses closed up vapour in form of mist settles on the glasses and wind screen.

## NITROGEN CYCLE

- Nitrogen is a very important element required by living organisms in their synthesis of nucleic acids, proteins and other biological molecules. Nitrogen occurs in various forms such as organic nitrogen, ammonium nitrate and nitrogen gas.
- Nitrogen cycle is the process by which nitro- gen is converted into

various chemical forms. This could be done through nitrogen fixation, mineralisation, nitrification, denitrification and decay.

- The atmosphere contains about 79% nitro- gen. However, this atmospheric nitrogen is unavailable for biological use. Nitrogen fixation converts gaseous nitrogen into forms usable by living organisms.
- The nitrogen cycle depends on the activi- ties of many microorganisms, whereas some fixation also occurs during lightning strikes. Some plants especially legumes also contribute to nitrogen fixation. Microorganisms that fix nitrogen include cyanobacteria, Azotobacter and Rhizobia (Rhizobium).

**PROCESS OF NITROGEN CYCLING**

- The atmosphere has a large quantity of nitrogen in gaseous form, which constitutes about 79% of air by volume. This is, however, unavailable for biological use.
- Atmospheric nitrogen is transformed into nitrogen compounds through the process of nitrogen fixation by the following organisms:

  (i) Symbiotic nitrogen-fixing bacteria in root nodules of leguminous plants

  (ii) Free-living nitrogen-fixing bacteria in soil

  (iii) Some blue-green algae in aquatic habitats.

- Electrical discharge in the atmosphere during thunderstorms converts atmospheric nitro- gen into oxides of nitrogen.
- Plants absorb nitrates in solution from the soil and transform them into proteins and other nitrogen compounds in plants.
- Animals feed on plants and convert nitrogen into nitrogen compounds in animals.
- Plants and animals eventually die and decay. Their remains are decomposed by bacteria to release the nitrogen in their bodies in the form of ammonia and ammonium compounds.
- Plants and animals release nitrogen com- pounds into the soil.
- In the soil, ammonium compounds and ammonia are transformed into nitrites and then to nitrates by bacteria. This process is known as nitrification. Bacteria species like Nitrosomonas convert ammonium com- pounds to nitrites, whereas species such as Nitrobacter convert nitrites to nitrates.
- Nitrogen could also be added to the soil through fertilizers.
- Nitrates in the soil may be converted back to atmospheric nitrogen by denitrifying bacteria. The process is called denitrification. Examples of denitrifying bacteria are Pseudomonas spp., Bacillus spp. and Micrococcus.

**DECOMPOSITION IN NATURE**

Decomposition is the breakdown of organic matter into its components through chemical or biologi- cal processes. Decomposition could occur in the absence of oxygen. This is known as anaerobic decomposition or fermentation.

It could also occur in the presence of oxygen. This is known as aerobic decomposition. Organisms that obtain their energy through break- ing down dead organism (plant and animals) are called decomposers. These include bacteria. fungi, moulds, protozoa, mites, millipedes, cen- tipedes, beetles and earthworms. Decomposers are important in the ecosystem because they help in recycling the materials in the ecosystem.

## MICRO AND MACRO DECOMPOSERS

Micro decomposers are small sized organisms involved in the decomposition process. These include bacteria, protozoa and moulds, whereas the macro decomposers are large sized multi- cellular organism involved in the decomposition process. These include fungi, millipede, centi- pede, earthworm and mites.

## ROLE OF DECOMPOSERS

Decomposers play a vital role in the ecosystem by breaking down and recycling dead remains of plants and animals in the environment. Decomposers return nutrients to the ecosystem. They make use of a little quantity of the materials they break down, and the bulk of the materials are recycled.

## CHAPTER SUMMARY

â– Cells require certain quantities of nutrients for sustenance.

â– These nutrients are available in various forms, which may not be readily available to the organisms.

â– Nutrients could be made available in form of ions.

â– The activities of organisms such as producers, consumers and decomposers make these nutrients available to be used over and over again.

â– Producers acquire nutrients from the air, soil and water.

â– Consumers acquire nutrients from producers

â– Carbon is found in all living and most non-living substances.

â– Carbon is taken up from the atmosphere through photosynthesis.

â– Oxygen is lost from the atmosphere through respiration and decay.

â–  The continuous movement of nutrients between the living and non-living environment is known as nutrient cycling.

â–  All living things need water, which is important in maintaining good health.

â–  The water cycle or hydrologic cycle describes the continuous movement of water in an environment.

â–  The movement occurs in liquid or vapour form from rivers, oceans and the soil to the atmosphere and back to the source.

â–  The process involves evaporation, condensation, precipitation, runoff and subsurface flow

**REVISION QUESTIONS**

*OBJECTIVE QUESTIONS*

Choose the correct options to the following questions.

1. The continuous movement of nutrients in the ecosystem is known as
a. food web. b. atmospheric cycle. c. nutrient cycle. d. global cycle.

2. The organisms that remove carbon (IV) oxide from the atmosphere are called a. decomposers. b. producers. c. consumers. d. detritivores.

3. The least quantity of oxygen is found in
a. lithosphere. b. water. c. atmosphere. d. biosphere.

4. Nitrites in the soil are converted to atmospheric nitrogen through the process of
a. nitrification. b. denitrification. c. nitrogen fixation. d. decomposition.

5. One of the ways through which oxygen is lost from the atmosphere is
a. photosynthesis. b. water cycle. c. respiration. d. transpiration.

*ESSAY QUESTIONS*

1. Explain briefly how carbon atoms are recycled in the ecosystem.

2. Differentiate between aerobic and anaerobic respiration.
3. Explain the water cycle.
4. Discuss the importance of water to living organisms.

5. (a) List five importance of nitrogen to living organisms. (b) Explain the forms in which nitrogen occurs in nature