5. Maintaining the composition of the environment

At the end of this chapter, you will have the competencies to:

- Contribute to maintain the composition of air at a level, favourable for living organisms;
- Contribute to maintain the quality of water at a level, favourable for living organisms;
- Contribute to maintain the quality of soil at a level, favourable for living organisms;
- Use chemicals in a favourable manner in domestic affairs.

5.1 Maintaining the composition of air at a level favourable for living organisms

Composition of air

If you were asked to list out the things around you, most likely such a list would include such items as houses, trees , animals. What place in your list would air which is one of the most essential resources for the survival of living organisms occupy?

You already know that air is a mixture of many gases. Table 5.1 indicates the amounts in parts per million of all the gases present in air. This favourable composition of air is changing drastically due to various human activities such as the large scale combustion of fuel as a result of industrialization, increase in the amounts of natural and artificial waste being added to the environment and the unlimited destruction of forests. In addition to the above, natural phenomena such as volcanic eruptions too bring about changes to the environment, particularly by the addition of the following components to air.

Table 5.1

Gases present	Parts per million/ppm
N_2	780,840
O_2	209,460
Ar	9340
CO_2	332
Ne	18
He	5.2
CH_4	1.65
Kr	1.1
Xe	0.09
H_2	0.58
CO	0.05 - 0.2
O_3	10^{-2} - 10^{-1}
SO_2	10^{-5} - 10^{-4}
$NO + NO_2$	10^{-6} - 10^{-2}
H_2O	varies

- Oxides of carbon
- Hydrocarbons
- Oxides of sulphur
- Halogenated hydrocarbons
- Oxides of nitrogen
- Solid and liquid waste particles

Oxides of carbon

Combustion of large amounts of fossil fuels in factories, vehicles, thermal power plants and domestic use in addition to the burning of other waste has caused a rapid increase in the addition of carbon dioxide and carbon monoxide to the atmosphere. These are colourless and odourless gases. The main source of carbon monoxide is the combustion of fuel in automobile engines. Carbon monoxide is a poisonous gas.

Carbon dioxide is an essential gas to plant and animal life when present in optimum levels in air. The level of carbon dioxide in air is maintained at an optimum level naturally due to the carbon dioxide given out by plants and animals during respiration. This carbon dioxide is absorbed by plants for their photosynthetic activities. However, the activities mentioned earlier would affect this balance.

Oxides of sulphur

As a result the industrial revolution in the 19th century, the use of coal with a high percentage of sulphur has become popular. This caused an increases in the addition of sulphur dioxide to the atmosphere. Sulphur dioxide is also added to the atmosphere due to combustion of petroleum fuels, burning of vulcanized rubber,and natural activities around volcanoes. Sulphur dioxide is one of the oxides of sulphur. It is a colourless gas with a suffocating smell and causes a significant effect on the optimum composition of the gas in the atmosphere. The oxides of that is added to the atmosphere by various sources is given in the pie-chart in Fig. 5.1.

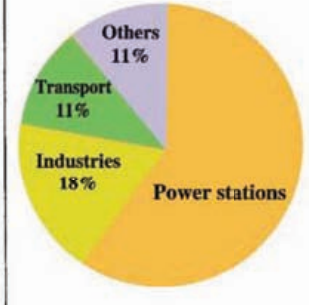


Fig.5.1
Sources of oxides of sulpher

Oxides of nitrogen

The combination of atmospheric nitrogen with oxygen and forming oxides of nitrogen during lightning is a natural occurrence in nature. A similar reaction occurs with nitrogen gas of air inside the internal combustion engines of vehicles.

$$N_2(g) + O_2(g) \xrightarrow{\text{electric arc}} 2NO(g)$$

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

Fig.5.2 Lightning

It has being found that 30% - 40% of nitrogen dioxide in the atmosphere is due to combustion of fuel by vehicles.

Hydrocarbons and halogenated hydrocarbons

Hydrocarbons are those compounds with carbon and hydrogen that are combined in various proportions. Some examples of hydrocarbons are petroleum gas, petrol, diesel etc., obtained by fractional distillation of mineral oils. These get added directly to the atmosphere due to being used as fuel, organic solvents and lubricants. Methane (CH_4) is the simplest of the hydrocarbons that is added in large quantities due to bacterial action on dead plant and animal tissues, carbonic waste in areas such as garbage dumps and agricultural lands and marshy areas.

Halogenated hydrocarbons are those compounds where one or more hydrogen atoms in the hydrocarbon molecule has been replaced by some halogen such as fluorine, chlorine or bromine. Some examples are chloroform ($CHCl_3$), carbon tetrachloride (CCl_4),chloroflouro carbons (CCl_2F_2)and halons ($CBrClF_2$,$C_2Br_2F_4$). Chlorofluoro carbons (CFCs) get added to the atmosphere from coolants in refrigerators and air conditioners, aerosols in spray paints and perfumes. Another instance where halogenated hydrocarbons get added to the atmosphere is in the production of polymers such as polyvinyl chloride (PVC), and the use of halons as a fire extinguisher.

Particle waste

Solid particle waste - Carbon particles, heavy metal particles, ash, dust, asbestos
Liquid particle waste – Water vapour, liquid carbonic particles, mercury vapour.

Effects on the environment due to the changes in the composition of air

The changes in the optimum composition of air due to the addition of the above components and the resulting effects have given rise to many problems in the world today. Some such problems are detailed out below.

Global warming

Scientists have revealed that the increases in the proportion of certain gases in the atmosphere causes an increase in the temperature of the atmosphere.

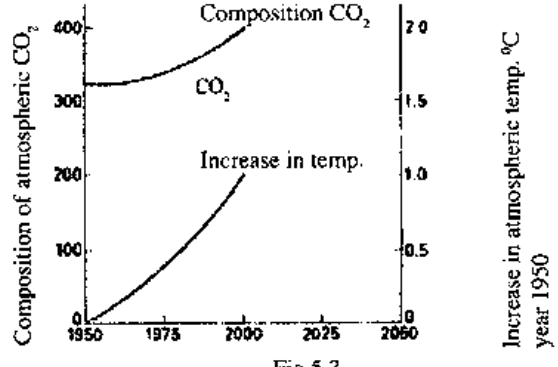


Fig.5.3

The increase in the proportion of carbon dioxide and the corresponding increase in atmospheric temperature is shown graphically in Fig 5.3 above. Conduct the following activity to understand the above relationship.

Assignment 5.1

You will need two thermometers and large glass vessels. Place one thermometer inside the glass vessel and the other open to the atmosphere as shown in Fig. 5.4. Note the temperatures in the two thermometers at the start. Note the readings on the two thermometers at 15 minute intervals.

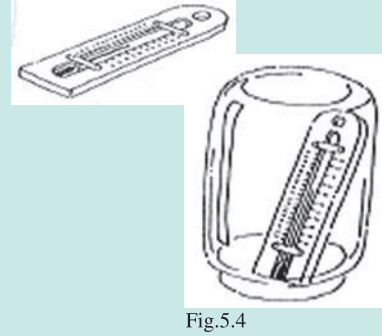


Fig.5.4

Accordibg to the above activity, the temperature inside the closed glass vessel will be higher than that of outside air. In cold countries, in order to create a temperature suitable for plant growth, enclosures made of glass are used and plants grown inside them. These are called green houses. The effect here is that much of the long wave length heat waves such as infra-red (IR) rays carrying heat into the glass house, are kept back by the glass walls and not allowed to leave. This is known as the green-house effect. An atmosphere where poly atomic molecules such as carbon dioxide, methane, chlorofluoro carbon (CFC), water vapour are present in high concentrations acts as a green house.

A large percent of radiated heat from sun falling on earth is reflected away from earth. But with the increase of green-house gases, the reflection of heat rays away from earth gets reduced. This occurs due to the absorption of heat rays by the molecules of these gases. This causes a warming of the globe. Given below are some consequences of global warming.

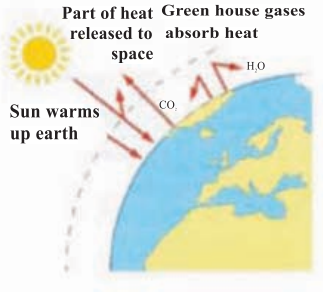


Fig.5.5 green house effect

Due to the warming up of earth,

- The ice in the glaciers at the two poles will start to melt.
- Ocean water will expand.
- Due to the above effect, water levels of the ocean will rise and some of the islands may go under water.
- World rainfall and weather patterns would change.

Acid rain

Rain water will become slightly acidic due the carbon dioxide of air dissolving in it. Accordingly, natural rainwater has a pH value of about 5.6. Yet it has been found that in certain instances rain water has a lower pH value than this, that is more acidic than normal. Although it was felt more around industrial towns in the past, now it has become an issue affecting the whole earth. The main reason for the increase in acidity in rain water has been identified as the increase in concentration of sulphur dioxide in air. The sulphur dioxide that dissolves in water forms sulphurous acid (H_2SO_3).

$$SO_2\,(g) + H_2O\,(l) \longrightarrow H_2SO_3\,(aq)$$

Sulphurous acid gets oxidized further to from sulphuric acid. This acidic water falling down as rain is called acid rain. Nitrogen dioxide gas also contributes to increasing the acidity of rain water by forming Nitrous (HNO_2) and Nitric (HNO_3) acids. Some of the environmental impacts due to this are stated below.

- Destruction of plants and forests
- Destruction of aquatic flora and fauna due to the acidic water collecting in water bodies
- Effect on the absorption of minerals by plants due to the increase of soil acidity
- Dissolving of minerals such as limestone
- Erosion of metallic constructions, buildings, statues and historical ruins

Fig.5.6 Effect of acid rain on forests

- Dissolving of certain toxic heavy metals resulting in an increase of such metal ion concentration in water bodies

Ozone layer depletion

Ozone is a gas made up of tri atomic oxygen molecules. There is a very thin layer of ozone gas about 25 km above the surface of earth. This acts as a protective cover which keeps off the high enegy ultra violet rays from reaching the earth.

In the higher levels of the atmosphere oxygen, gas absorbs ultraviolet (UV) rays and produces atomic oxygen.

$$O_2\,(g) \longrightarrow 2O\,(g)$$

This atomic oxygen is extremely active. They react with oxygen molecules forming ozone gas.

$$O\,(g) + O_2\,(g) \longrightarrow O_3\,(g)$$

The ozone so formed again becomes oxygen and comes into an equilibrium.

$$3O_2\,(g) \rightleftharpoons 2\,O_3\,(g)$$

In the higher levels of the atmosphere, CFCs absorb sun's energy and becomes atomic chlorine. This reacts with ozone, and breaks up the ozone molecule

$$Cl\,(g) + O_3\,(g) \longrightarrow ClO\,(g) + O_2\,(g)$$

Nitric oxide also causes damage to the ozone layer in a similar way.

$$NO(g) + O_3\,(g) \longrightarrow NO_2\,(g) + O_2\,(g)$$

In this way, the ozone layer slowly diminishes causing holes in the layer. As a result, high energy UV rays reach earth. Some of the ill-effects caused as a result are as follows:

- Cataracts in eyes
- Skin cancers
- Reduction of immunity
- Reduction of photosynthetic activity in plants
- Deformities in organisms

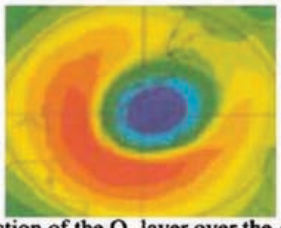


Fig. 5.7 The destruction of the O_3 layer over the Antarctic

Minimising the effects due to changes in the atmospheric composition

There are many attempts by various countries at individual level as well as global level to control the emission of gaseous components which are harmful to the environment. Certain laws and regulations at inter national level have been formulated. Some of the activities adopted are:

- Vehicle engines to be tuned to bring about complete combustion of fuels
- Issuing of reliability certificates of optimum performance yearly for all vehicles to be compulsory
- Control of gaseous emissions from vehicles by using **catalytic converters**
- Improving effciency of public transport systems,thus controlling private transport and thereby minimizing the use of fuel
- Removing the sulphur component from coal before use
- Refining the emissions from coal power plants and factories before releasing to the atmosphere

e.g. Sulphur dioxide gas is bubbled through a pulp of calcium hydroxide, precipitating it as calcium sulphite

- Banning the use of certain toxic gases such as CFCS
- Banning the use of petrol with lead components
- Popularising the use of solar energy, hydro power, tidal energy in place of use of fossil fuels.

5.2 Maintaining the composition of water at a level favourable for living organisms

Water as a solvent

You already know from daily experience, that many substances dissolve in water. Therefore it is extremely difficult to find a drop of absolutely pure water on earth. A large number of substances dissolve in water as it comes down through the atmosphere, seeps through the surface of earth and flows along the ground. Particularly acid rain falling on water causes many components of the

soil and rocks to dissolve in it. Further if soil is already polluted,a large range of substances get added to the water.

Drinking water

Water we use can be classified according to the sources from which it is obtained.

- Surface water from rivers and tanks of the lowlands
- Water from sources associated with hills and plains in the hill country
- Water from springs and other underground water resources.

The extent of pollution depends on the source of water. Therefore water is often purified in various ways before being used for drinking purposes.

Factors affecting the quality of water and their effects

When water is to be used for any particular purpose, it is very important to consider its quality. The World Health Organisation has introduced standards for drinking water. According to these standards, the chemical factors that affect the quality of water are identified as the element component, the ionic component and the pH value. In addition, the amount of dissolved organic matter, amount of air and pathogenic microorganisms also affect the quality of water. With respect to the chemical component, the standards for ions are given in table 5.2. If the values exceed these standards, such water is not suitable for drinking. Further it is shown that the pH range should be between 6-9 for drinking water.

Component	Standard amount / mg dm^{-3} (ppm)
chloride ions	600
magnesium ions	50
nitrate ions	45
zinc ions	15
copper ions	1.5
fluoride ions	0.5 - 1.5
ferrous ions	0.3
chromium ions	0.05

Table 5.2

Do you know?

The United Nations have declared 1980 - 90 as the "Water decade". It's objective was to provide pure drinking water and sanitation for all. But diseases such as dysentery, cholera, typhoid and other water born diseases still prevail in some countries. Still about five million children die of dysentery every year.

Salinity

The salinity of water increases with the salts dissolved in it. You are aware that fresh water fish will die when put into salt water, while salt water fish cannot survive in fresh water. They cannot survive in a medium that has a different salinity than that which they are adapted. Therefore, in considering the quality of water, salinity is a very important factor.

Excessive use of underground water, irrigation systems, extensive agricultural practices, and addition of soaps, detergents and alkalis to water cause an increase in the salinity of water. Some of the natural causes for the increase in salinity are **the mixing of fresh water and salt water due to the geographical situation in certain areas and phenomena such as tsunami.**

pH value

You already know that the pH value of a water sample indicates its acidic or basic nature. pH is also an important chemical factor affecting the quality of water. pH value will determine the type and quantity of the various components in water. Particularly, when deciding about the suitability for drinking and for agricultural purposes, pH is an important factor to be considered.

Heavy metals

High concentrations of heavy metals is also an important factor affecting the quality of water. Examples of some heavy metals are cadmium, lead, mercury, copper, and zinc.

Cadmium

Initially cadmium enters water from industrial waste and effluence from zinc mines. Cadmium is widely used in electroplating and production of orange pigments. Water is extremely poisonous if the parts of cadmium present billion-parts of drinking water exceeds the upper level of the standard for cadmium, that is **10 ppb ($10 \mu g\ dm^{-3}$). Cadmium can cause high blood pressure, kidney problems and destruction of red blood cells. Cadmium may displace the zinc component of certain enzymes and disrupt the action of the enzyme.**

Lead

The main source of lead in water systems is leaded petrol. According to the world **Health Organisation recommendations, the proportion of lead in drinking water should not exceed 50 ppb.**

In the past use of clay and glass vessels with applications of lead was a cause of lead poisoning. It is believed that lead poisoning was responsible for the fall of the Greek civilization.

Lead poisoning is believed to affect mental activity in children. Mild lead poisoning may cause anemia, muscle pain and excessive tiredness.

Mercury

Coal contains a very small quantity, about 1ppb of mercury. Yet since coal is used extensively it gets added to the atmosphere in large quantities. In laboratories and domestically , breaking of thermometers and pressure gauges may release mercury to the surroundings. The paints used for painting ships, industrial effluence cause an increase in the mercury concentration of water sources. Mercury accumilates in bodies of organisms along the food chain. Accumulation of mercury in the bodys **causes blindness, nervous disorders such as paralysis and deformities at birth.**

Do you know?

Minemata is a fishery village near Minemata Bay. In the period 1953-60, 111 cases of mercury poisoning and 43 deaths were reported from this area. The cause of this disaster was the accumulation of mercury along the food chains.

Hardness of water

Activity 5.2

- Dissolve a sample of slaked lime in water and prepare some lime water.
- Add 100 cm^3 of this lime water to an empty jam bottle.
- Pour 100 cm^3 of water into another similar jam bottle.
- Add half a teaspoonful of soap powder to each and stir.
- Record your observations about the appearance of foam in each.

Hardness of water is due to the calcium and magnesium ions in water. As you would have noticed in the above activity, hard water forms a scum on the surface of water. The action of the soap is hindered due to hardness.

If we heat water that is hard due to calcium hydrogencarbonate, the calcium ions will get precipitated as calcium carbonate.

$$Ca(HCO_3)_2(aq) \xrightarrow{\Delta} CaCO_3\,(s) + CO_2\,(g) + H_2O\,(l)$$

Hardness is removed in this manner. Thus, hardness caused by calcium or magnesium bicarbonate is called temporary hardness. Dissolved calcium sulphate and magnesium sulphate salts cannot be removed by heating, and is called permanent hardness. Both temporary and permanent hardness can be removed in the following ways.

Adding washing soda ($Na_2CO_3.10H_2O$), to hard water so that the calcium and magnesium ions are precipitated as their carbonates,

$$Na_2CO_3\,(aq) + Ca^{2+}\,(aq) \longrightarrow CaCO_3\,(s) + 2Na^{+}\,(aq)$$

Removing the Mg^{2+} and Ca^{2+} ions by sending through ion exchange towers.

Fluorides

According to scientists, if the fluoride ion concentration in water does not exceed 1 ppm it is not harmful to man or environment. In fact,certain countries try to maintain the proportion of fluoride at this level by adding sodium fluoride to the water supply. It is revealed that it prevents tooth decay. However , drinking water with a high concentration of fluorides is known to be harmful to teeth and may also cause kidney problems.

Do you know?

Certain areas in Sri Lanka has water with a high concentration of fluoride ions. Use of this water over a long period causes a permanent yelowish brown colouration of the teeth of the users.

Nitrates and phosphates

A part of the fertilisers added to agricultural lands get washed into waterways and get collected in them. Often sewage and household waste with alkalis too are released to waterways. This causes an increase in the concentration of nitrate and phosphate ions in water.

When the phosphate and nitrate ion concentration in water is high, excessive growth of algae takes place which can be seen as a bright green carpet on the surface of water. As these organisms die, they are subjected to bacterial action which produces a bad smell. Such an occurrence in water resources is called eutrophication.

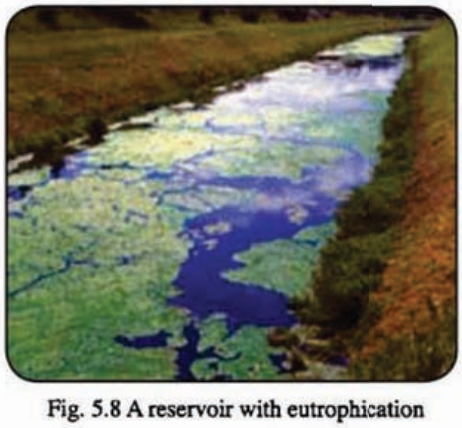


Fig. 5.8 A reservoir with eutrophication

Organic compounds

Yearly, millions of tons of organic compounds are prepared around the world. Most of them get added to the environment as industrial waste. Many synthetic organic compounds prepared for the purpose of destroying weeds, insects and other pests are also added to the environment. A large part of these end up in waterways. Quality of sea water is also reduced due to addition of mineral oils containing large quantities of organic substances. Persistant Organic Pollutants (POPs) have been particularly considered challenging organic compounds. Some of the characteristics of POPs is their high toxicity, ability to spread over a large area, and the ability to get accumulated in the bodies of organisms by entry along the food chains. POPs are known to be responsible for mutations at birth, mental disorders, impotency and lack of immunity.

Do you know?

Following chemicals are particularly harmful !
They are called the '*dirty dozen*'.

Pestcides	**Industrial chemicals**	**Industrial by-products and products of combustion**
Aldrin	Hexachlorobenzene	Dioxin
Chlordane	Polychlorinated biphenyls- PCBs	Furan
Mirex		
DDT		
Deildrin		
Endrin		
Heptachlor		
Toxaphene		

Gases soluble in water

The gases dissolved in water is of utmost importanceto aquatic organisms. The amount of oxygen dissolved in water that is needed for digesting the organic matter in water (produced as a result of biological activities), is called the Biochemical Oxygen Demand – BOD. This is an important indicator of the extent of pollution of water. The BOD value of pure water is about 1 ppm or even less. As the amount of organic matter in the water increases, the BOD value goes up.

Do you know?

About 8.826 mg of oxygen dissolves in $1dm^3$ of water at 25 ^{0}C. At this temperature, all of the oxygen dissolved in $1dm^3$ of water is needed to digest 8mg of organic matter.

Carbon dioxide in water reacts with water and forms a weak acid, carbonic acid. This releases hydrogencarbonate ions (HCO_3) and carbonate ions (CO_3^{2-}) to water. These ions help to maintain the pH value of water at a constant value.

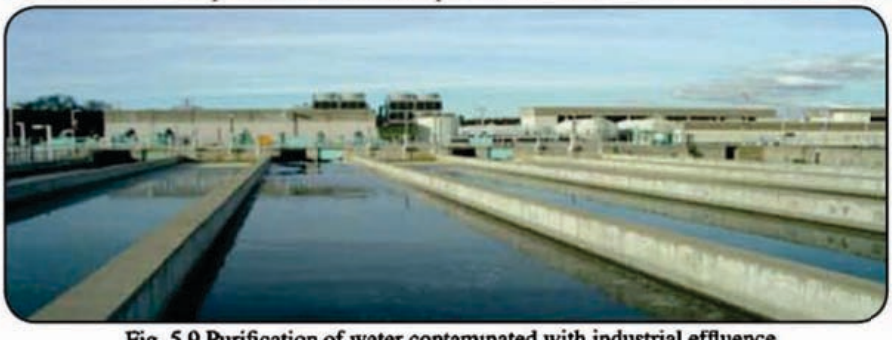


Fig. 5.9 Purification of water contaminated with industrial effluence

Maintaining the quality of water

In many countries, including Sri Lanka water mixed with sewage and household waste is released into the ocean, rivers or other water bodies without purification. Water containing such impurities are subjected to primary, secondary and tertiary purification before being released to water resources.

Primary purification – Removal of large and small solid waste, sand and grease by filtering and removing the scum floating on the surface.

Secondary purification - Assisting the digestive action of sewage by the aerobic bacteria by supplying air. This reduces the biological oxygen demand, BOD of water.

Tertiary purification – Removal of nitrate ions, phosphate ions and certain organic compounds.

Since water contaminated with industrial effluence contains various kinds of pollutants, specific purification methods are used for each. For example:

Heavy metal ions are precipitated as insoluble hydroxides.

$$Cr^{3+}(aq) + 3OH^-(aq) \longrightarrow Cr(OH)_3(s)$$

Heavy metal ions are removed by ion exchange methods.

$$2H^+(resin) + Cu^{2+}(aq) \longrightarrow Cu^{2+}(resin) + 2H^+(aq)$$

Soluble organic waste is removed by allowing to filter through activated carbon. (Here the organic substances are adsorbed over the surface of activated carbon.)

Organic waste is converted to harmless products using oxygen, hydrogen peroxide, ozone and chlorine.

Phosphate ions are precipitated using calcium hydroxide.

$$3\,Ca(OH)_2(aq) + 2PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6OH^-(aq)$$

5.3 Maintaining the favourable composition of the soil for living organisms

The most important component to organisms on the earth's crust is the soil. Soil has been formed by the weathering of rocks. Soil contains organic materials mixed in varying amounts, air ,water, other inorganic materials as well as soil organisms.

As we go down from the surface of the earth, clearly marked layers can be identified. A profile of soil is shown in Fig.5.10

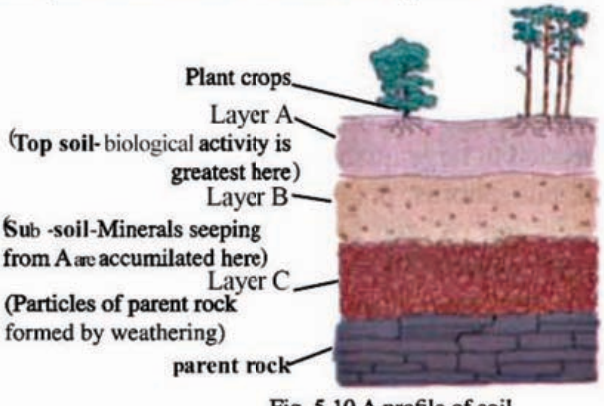


Fig. 5.10 A profile of soil

Assignment 1

Using easily available natural materials from the surroundings, prepare a poster to show the soil layers in a soil profile.

Soil texture

Soil contains solid particles of varying sizes. According to the size (diametre) of the particles, they can be divided into four types.

Gravel and coarse sand	2 – 0.2 mm
Fine sand	0.2 – 0.02 mm
Silt	0.02 – 0.002 mm
Clay particles	less than 0.002 mm

Since the percentage of the different particles is different in the soil of different places, the texture of soil is different. Based on this difference in composition, soil is classified as clayey, sandy or loamy soil.

Factors affecting the quality of the soil

Soil water, soil air, clay and other inorganic materials, humus and other organic matter and soil organisms are the main factors determining the quality of a soil.

Soil water

Soil water is found in three forms, namely hygroscopic water, capillary water and gravitational water. Hygroscopic water is the water which is strongly bound to soil particles. Higher plants cannot absorb this water. Capillary water is the water contained in the capillary spaces among soil particles. This form of water is mostly used by plants growing in the soil. Gravitational water seeps down due to the action of gravity through soil that is already saturated with water. This water which is held for a short time by the soil, is hardly used by plants.

Soil water is a solution of various ions. Hence this solution can be named 'soil solution'. Most of the nutrients needed by plants are absorbed from this solution.

Do you know?

Plants need macro-nutrients and micro-nutrients for their growth. The macro nutrients which are needed in large quantities are carbon, hydrogen, oxygen, nitrogen, magnesium, phosphorus, potassium, calcium and sulphur. Among these carbon, hydrogen and oxygen are obtained from air. All others are supplied from water. Micro-nutrients are needed in small quantities. They are boron, chlorine, copper, iron, manganese, molybdenum, and for certain plants sodium, silicon, and cobalt.

Soil air

Air is included in the empty spaces among soil particles. The composition of soil air is different from that of atmospheric air. The amount of air in different samples of soil taken from different places varies according to the size of the soil particles and the way they are packed. Soil air provides air essential for soil organisms and cells of the roots. Therefore, soil air plays an important role in maintaining the quality of soil.

Clay

The active inorganic component contained in soil is clay. All clays contain silicates (SiO_4^{4-}) and some clays have ions of potassium, sodium, magnesium, calcium and iron. The central atom of a silicate ion (SiO_4^{4-}) is silicon. The tetrahedron with the silicon atom in the centre has O atoms at the corners which are bonded with the silicon by covalent bonds.

The SiO_4^{4-} units of the tetrahedron form a long chain structure. Then the negative charge on each of the silicate units combine with positive ions and maintain the ionic balance of the soil. These negitive charges of the soil helps to retain cations such as Na^+, K^+, Ca^{2+}, Mg^{2+} and NH_4^+ in the soil. (cations = Positive ions)

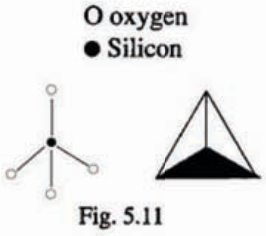


Fig. 5.11

This prevents cations dissolving in water and getting washed away so they are retained and can be used as nutrients by plants.

Capacity of cation exchange

As you already know, the long chain silicate in clay helps to retain cations. Some of these cations exchange with other cations in soil solution. The amount of cations in the soil which can exchange with ions in the soil solution is called the cation exchange capacity. Cation exchange capacity is one of the most important factors affecting the amount of nutrients taken by plants from the soil. If this value is high, it is considered a fertile soil.

Organic matter and humus

The amount of organic matter in soil is only about 5%, yet it is one of the main factors affecting the productivity of a soil. The main role of organic compounds is supplying food to soil organisms, contributing to ion exchange and improving the structure of soil. The organic matter that is insoluble in water and very slowly degraded by biological processes is called humus.

This is the component that remains after the digestive action of plant materials by bacteria and fungi. Humus does a number of functions towards maintaining the quality of soil. Humus;

- Increases the ability of the soil to retain water;
- Retains a large amount of cations, thereby increasing the amount of micro nutrients in the soil;
- Maintains the pH value of soil at an optimum level; and
- A sorbs the less soluble insecticides and certain weedicides.

pH value of the soil

This is an indicator of the acidity or basicity of the soil. pH value determines the presence of a certain ion in the soil, the amount in which it is present and the ability of plants to absorb them as nutrients. Hydrogen ions get into the soil by rain water and various activities of microorganisms. The removal of nutrients from the soil for plant growth and the removal of cations by water causes an increase in the acidity of the soil. The change in H^+ ions in the soil causes a change in the pH value of the soil. A soil with neutral pH value is more suitable for plant growth.

Changes in the quality of the soil and its influence

The quality of soil is maintained naturally when the influence of external factors is minimal. But, due to certain human activities and certain natural phenomena the quality of the soil may be reduced. Various development projects, deforestation and continued use of land for agriculture causes erosion of the top soil. This dissolves away the fine components such as clay and changes the texture of the soil unfavourably. This may result in changes in the amounts of soil water. The amount of organic matter getting added to the soil also decreases. The quality

of soil is further affected by the agro-chemicals used in agricultural activities which affect soil organisms. The solid particulate waste resulting from industries, domestic offs and sewage contains heavy metal particles such as arsenic. These too affect the composition of the soil solution unfavourably. Particularly acid rains, use of chemical fertilizers, and the other activities stated about, change the pH value and cation exchange capacity of soil unfavourably. Some of the ill effects of the change of the pH value in the soil are given below.

- Certain ions are removed in solution at low pH values.
- Certain ions get precipitated as insoluble compounds.

Nitrogen in the soil exists as NH_4^+ ions at pHvalue of less than 5.5, and as NO_3 ions at values higher than 5.5. Since plants absorb only NO_3^- ions, the amount of nitrogen that plants can absorb is very little below the pH of 5.

The heavy metal compounds are more soluble at low pH values , hence get easily washed away from the soil. You know, that since we remove a certain amount of nutrients when uprooting plants during harvesting we have to use chemical fertilizers in agricultural lands. But it does not contribute to improving the porous quality of the soil. This results in lowering the quality of soil texture which is an important property of soil.

Maintaining the quality of soil

Creating awareness among the farming community is essential in this regard.

Farmers should be encouraged for the following practices;

- To retain the residues of agricultural crops sufficient to maintain the texture and porosity of the soil. They should also be encouraged to use compost in place of chemical fertihzers.
- Biological control – Introducing organisms which depend on the pests but do not damage crops. Use virus varieties which are harmful to insects.
- Multi-crop agriculture – Growing many kinds of crops in the same land at the same time.
- Breeding crop varieties which are resistant to insects.
- Ensuring that the polluted water seeping out from bare land filled with garbage, is purified and released to the soil.
- Burning waste and garbage in special incinerators. Temperatures of these should be maintained high enough for complete combustion.

- Recycling of glass, plastic and metal objects instead of adding it to soil. Recycling of the above materials will ensure the protection of the environment, saving of energy resources and minimizing domestic waste.

Chemists have attempted to find solutions to the issues arising from the use of plastics by the production of biodegradable plastics, photodegradable plastics and water soluble plastics. These productions are already on the way.

Fig. 5.12 Photodegradable plastic

Fig. 5.13 Water soluble plastic

5.4 Using chemicals favourably in domestic affairs

In our day to day activities such as washing, cleaning , we are constantly using various chemical substances. These chemical substances are made up of many chemical compounds. If you examine the labels of the substances you use you will invariably see that a list of chemical compounds they are made up of.

Several groups of compounds that are used in everyday life are listed below.

Materials which may contain harmful compounds in their compostion are;

- Food additives
- Detergents
- Medicines and disinfectants
- Cosmetics
- Paints

Let us look at each of these in more detail.

Food additives

A practice coming down generations in the culinary field is to add various substances to food in order to increase the taste, smell, and appearance. Such substances are known as food additives.

Activity 5.3

Collect the labels of a variety of food packets, read through the list of compounds each one is made up of. Try to find out the reasons for adding each of them and classify them into groups.

Such a grouping of food additives are given in Table 5.3.

Additive	Purpose	Example
Nutrients	To improve the nutrient value	Vitamins, minerals, iodine
Flavours	To improve palatability	Condiment, salt, monosodium glutamate (MSG)
Preservatives	To prevent spoiling	Salt, $NaNO_2$
Anti-oxidants	To reduce the action of O_2 on food	Butylated hydroxy toluene
Colourings	To improve appearance	Carotene
Raising agents	To give lightness	Baking powder ($NaHCO_3$)
Sweeteners	To give sweetness	Sugar, saccharine
Bleaches	To change colour	SO_2

Table 5.3

Detergents

Detergents are also another group of chemicals widely used by us in our daily life. These include the soaps and shampoos used for our personal cleanliness, soaps and alkalis for household cleaning, and the detergents used for cleaning walls and floors. In the past 'wood ash' was used for most household cleaning activities. But at present there are many kinds of consumer goods for this purpose. There use is also getting more and more popular. The active ingredient in these substances is more efficient in cleaning objects. How does it happen? Let us find out.

Normal dirt dissolves in water, and can be removed by washing with water. But oil does not dissolve in water, Detergents help oil to dissolve in water. Soap is made by the reaction of animal or vegetable fat with a strong alkali such as sodium or potassium hydroxide. The fatty acids are long chain organic acids. Soaps are the sodium or potassium salts of these fatty acids.

Fatty acid (animal or vegetable) +Na OH/KOH →Sodium/potassium salt of fatty acid

These long chain molecules contain two parts, the head and the tail.Tail is not attracted to water molecules (hydrophobic), but it is attracted to oil. But the head is attracted to water (hydrophilic) but not attracted to oil.On contact with an oily substance, the tail gets embedded in the oil droplet but the head remains pointed to water.

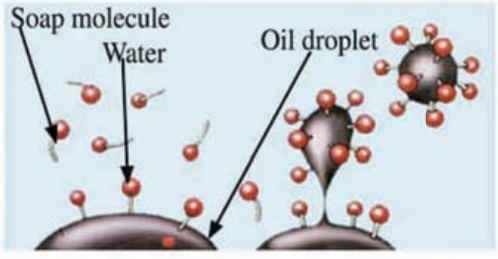


Fig.5.14 Action of detergents on oil

The detergent molecule pulls the oil into a rounded droplet which can float in water. This is called an emulsion. So, the detergent helps oil to emulsify with water.

One of the major disadvantages of soap is that, in hard water it combines with Ca^{2+} and Mg^{2+} ions and forms insoluble salts of fatty acids. This can be overcome by using synthetic detergents.Their activity is very similar to the salts of fatty acids, but are synthesized chemically. Their cleaning action is not affected by hardness of water.To improve the quality of detergents polyphosphate compounds are also added.

Medicines,anticeptics and disinfectants

There are many medicines which we use often without proper medical prescription. Some such medicines are:

Pain killers

Aspirin and paracetamol are two commonly used pain killers. They also have the ability to bring down the body temperature. In addition, aspirin has the ability to prevent clotting of blood, hence used presently to prevent heart attacks. Although aspirin is useful in these contexts, it has been found that it is harmful to the stomach lining. It may cause bleeding from the stomach lining and cause a burning sensation of the stomach(gastritis).

Antacids

Hydrochloric acid is secreted by certain cells of the stomach. This prevents bacterial growth and also assists in the digestion of certain components of food. The normal pH value in stomach contents ranges from 1.2 - 1.3. When excess food is taken, the stomach responds by increasing the secretion of acid. As a result the pH value of the stomach goes down (stomach acidity) causing discomfort.

In such cases, antacids are used. Antacids are weakly soluble bases or basic salts. Magnesium carbonate, aluminium hydroxide jelly and hydrated magnesium hydroxide(milk of magnesia) are the active reagents in most antacids.

Do you know?

Under normal conditions the inner lining of the stomach, the mucosa is not damaged by hydrochloric acid. The reason is that these cells are being replaced at a rate of about half million cells per minute.

Disinfectants and antiseptics

These are used to destroy germs around us.

Cosmetics

Cosmetics of all varieties for all kinds of purposes are also a group of chemicals commonly used by us. Some of them are:

Perfumes

Cosmetics which give out a pleasant smell are called perfumes. They consist of three main components called solvent or vehicle, fixative, and odourous substance. Solvent is used to disslove the odourous substances. Mixture of alchohol and water is commonly used as the solvent. The fixative maintains the volatility of this odourous substances correctly. Sandalwood oil is one example of a fixative. Both natural and artificial substances are used as odourous substances. Esters are commonly used as odourous substances.

Hair dyes and bleaches

Hair contains a brownish black melanin pigment and an iron- containing reddish pigment. Black hair has more of melanin pigment while the brown or blonde hair contains more of the iron pigment. At present, hair dyes are very popular. They are of three types.

- Some are temporary and can be removed by shampoo.
- Some are semi- permanent and go deep into the hairs.
- Some form chemical bonds with hair and are permanent.

Hydrogen peroxide is the active reagent in most bleaches.

Some of these chemicals bring about strong allergic reactions in some people.

Deodorants

Certain chemicals in sweat causes an unpleasant smell. This is further aggravated by the activity of bacteria residing on the skin. To alleviate this condition, deodorants are used. They help by drying up the sweat or hiding the smell of the sweat or by reacting with the smell producing substance and removing them. The active agent in most deodorants are aluminium salts such as aluminium sulphate and hydrate aluminium chloride. Certain other substances

are added to improve the smell and facilitate application.

Lipsitcks

Lipsticks are used to colour the lips as well as to prevent drying by sunlight and air. These are pigments suspended in high density hydrocarbons.

Paints

Paints are substances that give protection to a surface as well as acts as a coating of a desired colour. Any paint is made up of three main components, the pigment, the binder which does not evaporate and the vehicle or solvent, which is the evaporating substance.

Pigment : These are prepared by metal oxides or metal salts. Different pigments can absorb different colours of the spectrum giving a wide range of colours to the paints. Pigments also prevent discolouration by UV rays. Table 5.5 shows some common pigments and their colours.

Table 5.5

Pigment	Colour
Titanium oxide - TiO_2	white
Lead crhomate - $PbCrO_4$	yellow
Chromium oxide - Cr_2O_3	green
Carbon black	black

Fig. 5.15 Pigments and their colours

Metals are also used as pigments. Finely powdered gold, zinc, aluminium are some such elements.

Binder: Binder is the component which forms the coating that does not evaporate off. Linseed is a natural binder commonly used. These react with the oxygen of air and forms a layer of a complex polymer.

Vehicle: This is the volatile component which often reduces the viscosity of the paint making it easy to apply. For a binder which is soluble in organic compounds, hydrocarbons are used as the vehicle.e.g. turpentine. For water soluble binders water is used as the vehicle.

5.4.2 Effects of domestic chemicals

Although many chemicals have been in use for many years,their effects have been known only to a very small extent. Their effect are ;

- Causing harm to the permeability of the cell membrane or cell wall
- Causing harm to the action of genes
- Causing harm to the enzyme activity in the cell

Food additives

Food additives are added to retain the colours of dried fruits and vegetables as well as preventing microbial activity on fermented wines. Additive added are sulphites(SO_3^{2-}). Certain people may suffer from instant breathing difficulties after consuming such food. Sometimes it may even be fatal. Asthmatic condition may get aggravated among the allergic patients.Hence it is mandatory to state its presence on the labels of packetted or processed foods.

Detergents

The water soluble soaps are removed as precipitates of magnesium or calcium salts. The precipitates so formed are subjected to a process of biological digestion. But artificial detergents are neither precipitated nor biologically digested. The polyphosphate ions in detergents is a rich medium for growth of algae. Extensive growth of algae causes eutrification of water bodies. Further dissolved soaps and detergents from foam on the surface of water and reduce its surface tension.

Medicines

If you are a person who uses antacids and pain killers without a medical prescription, it is very important that you follow carefully the instructions on the packing.You should also store your medicines properly, out of reach of children and pets.

Disinfectants

These are used to destroy micro-organisms or germs.

Just as there are many 'germs" or micro-organisms which are pathogenic and cause a number of diseases in man and animals, it must also be remembered that micro-organisms are our friends. If not for them our garbage would pile up, our cess pits would overflow, and our soil would get depleted of fertility in a very short time. They bring about decay and help to recycle materials, giving them back to the soil. Excessive use of disinfectants may destroy useful bacteria as well.

Cosmetics

The effects of cosmetics depend on the type, quantity, how often it is used and the ingredients in the product. Certain kinds of colones, scents and hair sprays which have aerosols can be harmful. The responsible chemical has been found to be chloro flouro carbons (CFCS category of compounds). As a results many products are now been produced free of this.

Paints

Paints and polishes affect the environment in two ways.One is by releasing harmful organic substances to the environment. Other is the production of a layer of polymers which are not biodegradable. In addition, certain paints contain heavy metal ions such as lead which are poisonous to the inmates of the house. Therefore, when buying paints it is important to avoid such harmful products.

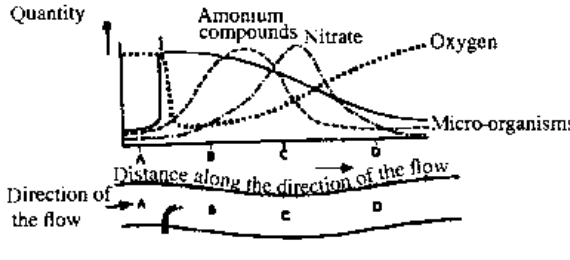
5.4.3 Minimising the unfavourable effects of domestic chemicals

In order to minimize the harmful effects of chemicals used by us regularly, it is important to take some basic precautions. Any left over chemicals or their packages shouldn't be disposed indiscriminately. They should be disposed out of the way of children and animals. Always try to reduce the use of chemicals; instead use environmental friendly alternatives. Selecting products of correct standard, following the instructions to the letter are some more useful hints. Proper storage is also important to avoid the reach of children contamination of food or even causing fires.

Exercises

1. The graph given below shows how the levels of oxygen, ammonium compounds, nitrates and micro-organisms change along a river from a point where effluence is being released.

   i) Using the graph, show two evidences to indicate that the favourable composition of the water changed after the addition of the effluent.



ii) The composition of oxygen has dropped considerablyafter the addition of the effluent. What is the reason for this?

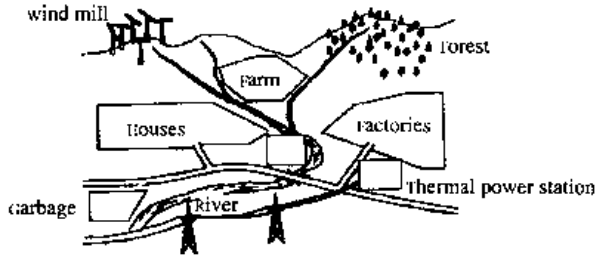
iii) It was noticed that a large amount of mosses were growing at point C of the river. What is the reason for this observation?

iv) The effluent released to the river had 0.000002 ppm of mercury. Yet certain species of water birds living at points B and C had 124 ppm of mercury in their bodies. Explain this scientifically.

2. Figure below is a map of a small village close to a town.

i) Indicate three sources of air pollution shown on the map. Explain the environmental issues that can arise due to one of the factors indicated.

ii) Name two sources of energy in this village, and explain which one of these is more environmental friendly giving three reasons for your choice.



iii) The farm shown in the map is maintained well by using such methods as multi- crop agriculture, use of compost as fertilizer and biological pest control methods. Explain how each of these methods help to maintain the composition of the soil at a favourable level.