18

Air and Water

You have already studied that air is a mixture of gases, which we cannot see. It is the main abiotic component of the environment. Air is an extremely important natural resource. Air is also necessary for all the living organisms, because they breathe in air. A human being breathes about 22,000 times in a day and takes about 16 kg of air into the body during this process.

Further, the air envelope, which surrounds the surface of the earth, presses the earth's surface and creates a pressure on it. This air pressure, also called atmospheric pressure, is found to be useful. It would be interesting to know about air in this context also.

Like air, water is another abiotic component of the environment, which is also essential for all living beings. Water is the most abundant and renewable natural resource. It covers about three quarters of earth crust. Water occurs in nature in the free state as well as in the combined state. The different properties of water make it useful, important and essential in our daily life. We will also learn about water and its properties in this lesson.

OBJECTIVES

After completing this lesson, you will be able to:

- tabulate various component of air according to their amount;
- explain the importance and utility of various components (O_2, N_2, CO_2) of air;
- measure atmospheric pressure and its variation with height;
- discuss the various atmospheric phenomena;
- list different sources of water;
- list simple methods for making water potable;
- describe various properties of water;
- recognise the utility of water for various purposes;
- argue in favour of rainwater harvesting.

18.1 COMPOSITION OF AIR

Ancient philosophers considered air as one of the most vital element. **Mayow** in 1674 proved that air is not an element but the mixture of two substances, one of which is active and the other is non-active. **Lavoiser** in 1789 named the active element as oxygen and said that it is 1/5 of the total volume of air. The non-active

element is nitrogen and it is about 4/5th of the total volume of air. The ratio of oxygen and nitrogen in the air is about 1:4 by volume.

The major components of air are nitrogen (N_2) and oxygen (O_2), while the minor components are argon (Ar), carbon dioxide (CO_2) and some are trace gases like neon (Ne), helium (He), krypton (Kr) and xenon (Xe). The composition of dry air at sea level is given in table 18.1.

Table 18.1 : Composition of air

Gas	Composition (% by volume)	Gas	Composition (% by volume)
N_2	78.03	Ne	0.0015
O_2	20.09	He	0.000524
Ar	0.94	Kr	0.000014
CO_2	0.033	Xe	0.000006

Water is excluded from this table because its concentration in air varies drastically from location to location.

Let us perform a simple activity to study the presence of oxygen and nitrogen in the air.

ACTIVITY 18.1

Aim : To show the presence of oxygen and nitrogen in air

What is required? About 5cm long test tube, a beaker, water, graph paper, cotton wool and a small piece of yellow phosphorus.

What to do?

- Take the small piece of phosphorus on cotton wool.
- Insert the cotton wool inside a test tube.
- Now place the tube in inverted position in the beaker.
- Pour the water in beaker in such a way that 5 cm length of tube should be above the water.
- With the help of stand, hold the test tube in this position for one hour (Fig 18.1).

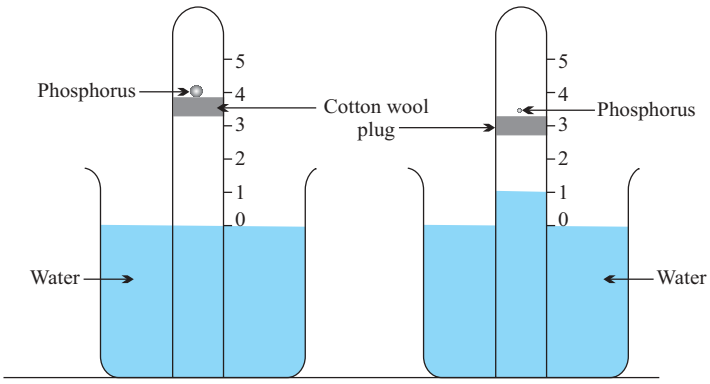


Fig. 18.1 Experimental set-up to show that air contains oxygen and nitrogen

What to observe?

After one hour you will see that water level in the test tube rises up by 1 cm.

Why is it so?

The oxygen present in air within the test tube slowly reacts with phosphorus and forms the oxide of phosphorus. The oxide dissolves in water to form phosphoric acid, which can be shown as follows:

$$\underset{\text{phosphorus}}{P_4\,(s)} + \underset{\text{oxygen}}{5O_2\,(g)} \longrightarrow \underset{\text{oxide of phosphorus}}{P_4O_{10}\,(s)}$$

$$\underset{\text{oxide of phosphorus}}{P_4O_{10}\,(s)} + \underset{\text{water}}{6H_2O\,(l)} \longrightarrow \underset{\text{phosphoric acid}}{4H_3PO_4\,(l)}$$

The pressure of air within the tube falls, because the oxygen completely reacts with phosphorus. To make up this loss in pressure, the air from outside exerts pressure and hence, forces the water to rise upward within the tube.

From this activity it is clear that air consist 1 part oxygen and 4 parts nitrogen because the level of water rises by 1 cm out of the initial volume of 5 cm.

Let us perform another activity that shows the presence of carbon dioxide in air.

ACTIVITY 18.2

Aim : To show the presence of carbon dioxide in air

What is required? A test tube, freshly prepared lime water, a cork with two holes, two glass tubes bent at right angles.

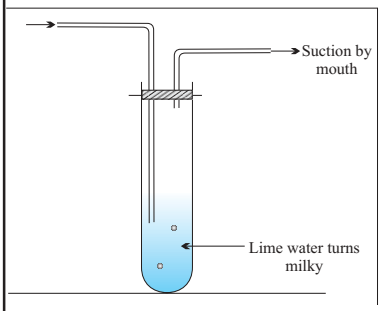


Fig. 18.2 To show that air contains carbon dioxide

What to do?

- Take about 4 mL freshly prepared lime water in a test tube.
- Fix a cork (having two holes) in the mouth of the test tube.
- Fix the two glass tubes in two holes in such a way that only one tube should be dipped in lime water but the other one should be above the lime water as shown in Fig. 18.2.
- Suck the air from the tube, which is not dipping in limewater. Due to suction the pressure of the air within the test tube falls.

What to observe?

To make for this loss in pressure, the air from outside enters into the tube through the tube dipping in limewater and air bubbles are liberated in limewater.

You will see that after a minute the limewater turns milky. We know that only carbon dioxide can turn limewater milky. So this activity clearly shows the presence of carbon dioxide in the air.

CHECK YOUR PROGRESS 18.1

1. Is air an element or a mixture?
2. What are the major constituents of air?
3. What is the ratio of major constituents of air?
4. Does the percentage of CO_2 remain constant in air or it vary from place to place?
5. Does the percentage of water remain constant in air or it vary from place to place?

18.2 IMPORTANCE OF VARIOUS COMPONENTS OF AIR

Oxygen, nitrogen and carbon dioxide are useful for human beings and plants. Without oxygen and nitrogen it is impossible to survive.

18.2.1 Importance and utility of oxygen

Since we live on the surface of the earth, we are surrounded by air, which contains oxygen. Oxygen is the main part of the air i.e. about 21%. We know that the life is not possible without oxygen. Therefore, oxygen is very much essential for life. The importance and utility of oxygen are as follows:

(a) **General uses**

- Oxygen is absolutely necessary for respiration.
- It is the supporter of combustion.
- Liquid O_2 is used as oxidant in rocket fuel called as LOX (Liquid oxidant).
- In nature it dissolves in water. The dissolved oxygen keeps the water fresh and is a source of respiration for aquatic life.
- In some situations it is used for artificial respiration such as:
  - in the submarines and by deep sea divers.
  - climbers, during high altitude climbing and also aviaters during high altitude flying.
  - firemen during fire fighting.
- Corrosion is the term usually applied to the deterioration of metals by an electrochemical process. The most common example of corrosion is the formation of rust on iron. Oxygen gas and water must be present for iron to rust. It clearly indicates that oxygen is necessary for corrosion.
- Oxygen combines with almost all elements to form oxides.

(b) **Medical uses**

- **Carbogen:** It is a mixture of 95% oxygen and 5% carbon dioxide. It stimulates natural breathing. It is given to the patients suffering from asthma or for reviving patients from drowning or gas poisoning.
- **Anaesthesia:** It is a mixture of oxygen and nitrous oxide, which is used in surgical operations.

(c) **Industrial uses**

- **In steel industry:** Since oxygen produces more heat as compared to air (because air contains some non reactive substances); it is used in place of air for the purification of iron.

- **For cutting and welding purposes:** Oxygen is mixed with hydrogen (hydrogen torch) or acetylene known as oxyacetylene torch. These are used for cutting and welding purposes.
- It is also used for the manufacture of sulphuric acid from sulphur and nitric acid from ammonia (NH_3).

18.2.2 Importance and utility of nitrogen

Nitrogen is the main constituent of proteins. A number of amino acids containing nitrogen join together to form protein. It is essential for the life of living beings. Its main uses are:

- It dilutes the activity of oxygen: If the amount of oxygen is increased in the air then the process like metabolism, combustion and corrosion will became very fast and becomes harmful. The presence of nitrogen dilutes the concentration of oxygen and thus, the combustion of fuel during burning and combustion of food during respiration takes place at moderate rate.
- The compounds of nitrogen are of vital importance to plants as they help them to manufacture proteins. Living beings obtain protein from plants.

18.2.3 Importance and utility of carbon dioxide

The percentage of carbon dioxide in air varies from place to place. The areas where more fuel containing carbon is burnt have more carbon dioxide. It is necessary for the production of food i.e. photosynthesis in plants. Its main uses are:

- During photosynthesis plants absorb carbon dioxide and water vapour from air. In the presence of chlorophyll and sunlight, they are converted to carbohydrates.
- It also provides Ca^{2+} and Mg^{2+} ions in the soil, which are necessary for the growth of plants. It dissolves in water and can also dissolve rocks containing calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$). The salts formed are Ca $(HCO_3)_2$ and Mg$(HCO_3)_2$. These salts give taste of natural water and also supply these ions to the plants.
- It is also used in food preservation. In the presence of CO_2 the grains are prevented from being destroyed by insects.
- CO_2 is a green house gas. It traps infrared radiations .
- Solid CO_2 is also known as dry ice which is used as refrigerant.
- As it can be dissolve in water, it is used for the preparation of soft drinks.
- CO_2 is used in fire extinguishers to put off fire.

CHECK YOUR PROGRESS 18.2

1. Oxygen is essential for life, why? Give one example.
2. Carbon dioxide acts as food for plants. Name the process in which it happens.
3. What is dry ice?
4. Name the element which is the main constituent of proteins.

18.3 THE AIR AND ITS PRESSURE

We know that the air is a mixture of gases and particles of these gases have weight due to gravity. It shows that the air has weight. Anything that has weight pushes and presses against things. The air presses down on the earth's surface and creates a pressure on it. So there is a force exerted by gas particles of air, which act downwards on the surface of the earth.

The force of air column acting per unit area of a surface results in a pressure exerted by atmosphere. This pressure is called atmospheric pressure. The atmospheric pressure is about 1kg wt cm^{-2} or 10 ton wt m^{-2}

Let us perform an activity to show that air exerts pressure

ACTIVITY 18.3

Aim : To show that air exerts pressure

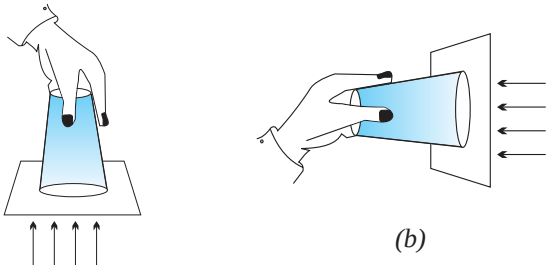
What is required? A glass tumbler, a piece of cardboard and water.

What to do?

- Fill the glass tumbler with water.
- Put the piece of cardboard on the top of the glass tumbler.
- Hold the glass tumbler firmly with the palm of your hand.
- Grip the base of glass tumbler with your other hand. Turn the glass tumbler quickly upside downs as shown in figure 18.3.
- Remove the palm of your hand carefully below the cardboard.

What do you observe?

You will find that the cardboard and the water remain in their place. Can you think of the reason behind this? The water in the glass tumbler stays because air is exerting a pressure on the cardboard. The pressure of air against the cardboard is greater than pressure of water against the card board. If you turn the glass side ways and in any other position, the water still remains in the glass showing that air exerts pressure in all directions.



(a) *(b)*

Fig. 18.3 Air exerts pressure

In our everyday life, atmospheric pressure plays an important role in the working of many things, for example, working of a straw, working of a syringe or ink dropper, working of a lift pump etc. Think and try to explain how atmospheric pressure helps in the working of these above mentioned things?

18.3.1 Normal or standard pressure and its units

By international agreements, the normal or standard pressure is the pressure exerted by 76cm of mercury column. It is shown that,

Normal pressure = hρg

Where h = height of mercury column= 76 cm of Hg

ρ = density of mercury = 13.6×10^3 kg m^{-3}

g = acceleration due to gravity = 9.8 m s^{-2}

Therefore, the pressure exerted by a column of mercury at a height of 76 cm = $0.76 \times (13.6 \times 10^3) \times 9.8$ N m^{-2}

$= 1.014 \times 10^5$N m^{-2}

Thus,

$$\boxed{1 \text{ atmosphere} = 1.014 \times 10^5 \text{N m}^{-2}}$$

The unit of pressure used in meteorology is known as 1 bar where by definition

$$\boxed{1 \text{ bar} = 10^5 \text{N m}^{-2}}$$

$$\boxed{\text{Thus, 1 atmosphere} = 1.014 \text{ bar}}$$

Another unit used for atmospheric pressure is known as torr

Where, 1 torr = 1mm of mercury = 133.3 N m^{-2}

Thus,

$$\boxed{1 \text{ atmosphere} = 760 \text{ torr}}$$

1 torr =1mm Hg

1 atmosphere = 760 mm Hg =760 torr

The SI unit of pressure is the Pascal (Pa), defined as one Newton per square metre. 1Pa = $1N/m^2$. The relationship between atmosphere and Pascal is,

1 atmosphere = 101.325 kPa or 1.01325×10^5 Pa

Since 1000 Pa = 1kPa

1 atmosphere = 1.01325×10^2 kPa

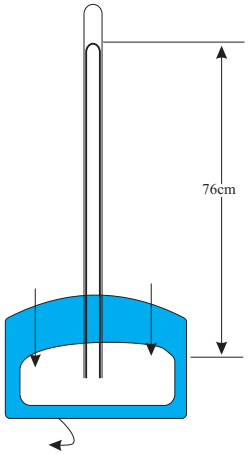
18.3.2 Measurement of atmospheric pressure

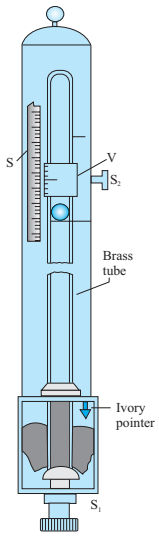
The instrument used to measure atmospheric pressure is called **barometer**. There are different types of barometers such as, Simple barometer, Fortin barometer, Aneroid barometer etc.

Simple barometer consists of long glass tube, closed at one end and filled with mercury. If the tube is carefully inverted in a dish of mercury in such a way that no air enters the tube, then some mercury will flow out of the tube into the dish, creating a vacuum at the top as shown in fig 18.4. The weight of the mercury remaining in the tube is supported by atmospheric pressure acting on the surface of the mercury in the dish.

Fortin's barometer consists of a long vertical glass tube about 80 cm long. It is completely filled with mercury and inverted over a cistern containing mercury. A small **ivory peg** is fitted into the lid of the cistern. While reading the atmospheric pressure, the tip of ivory peg should touch the level of mercury on which the atmospheric pressure acts (Fig 18.5).

An **Aneroid barometer** is more portable and cheaper than mercury type. No liquid is used here. The main features are as shown in the figure 18.6.





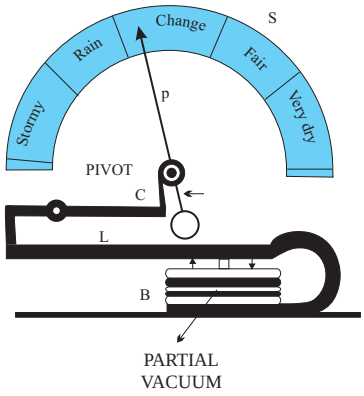


Fig. 18.4 Simple barometer *Fig. 18.5 Fortin's barometer* *Fig. 18.6 Aneroid barometer*

B : Sealed metal box of corrugated sheet which is partially evacuated and sealed. Increase in atmospheric pressure causes the top to **cave in** while decrease allows it to expand.

L : A lever which magnifies the movement of the metal box.

C : A chain wrapped round the spindle of the pointer.

P : It is pulled by lever. This moves the pointer over a scale S.

18.3.3 Variation of air pressure with height

The atoms and molecules of the gases in the atmosphere like those of all other matter, are subject to earth's gravitational pull. As a consequence, the atmosphere is much denser near the surface of earth than at higher altitudes. In fact, the density of air decreases very rapidly with increasing distance from earth.

Thus, atmospheric pressure decreases with altitude. Often at higher altitudes, people find their nose bleeding because blood pressure is much more than the pressure outside (i.e. atmospheric pressure).

CHECK YOUR PROGRESS 18.3

1. What is the unit of pressure?
2. At high altitude the people find their nose bleeding. Why?

18.4 ATMOSPHERE

The region of air around earth is called atmosphere. The atmosphere protects us and all living things from harmful radiations like ultraviolet rays etc. We can divide the atmosphere into different layers according to temperature, pressure variation and composition. The main layers of the atmosphere (Fig. 18.7) from the surface of earth upward are troposphere (0-10km), stratosphere (10-50km), mesosphere (50-85 km) and thermosphere (85-500 km).

The most active region is the troposphere, the layer of the atmosphere, which contains about 18% of the total mass of air and practically all the atmosphere's water vapours. It is the thinnest layer of atmosphere and here all the dramatic events of the weather (such as rain) occur.

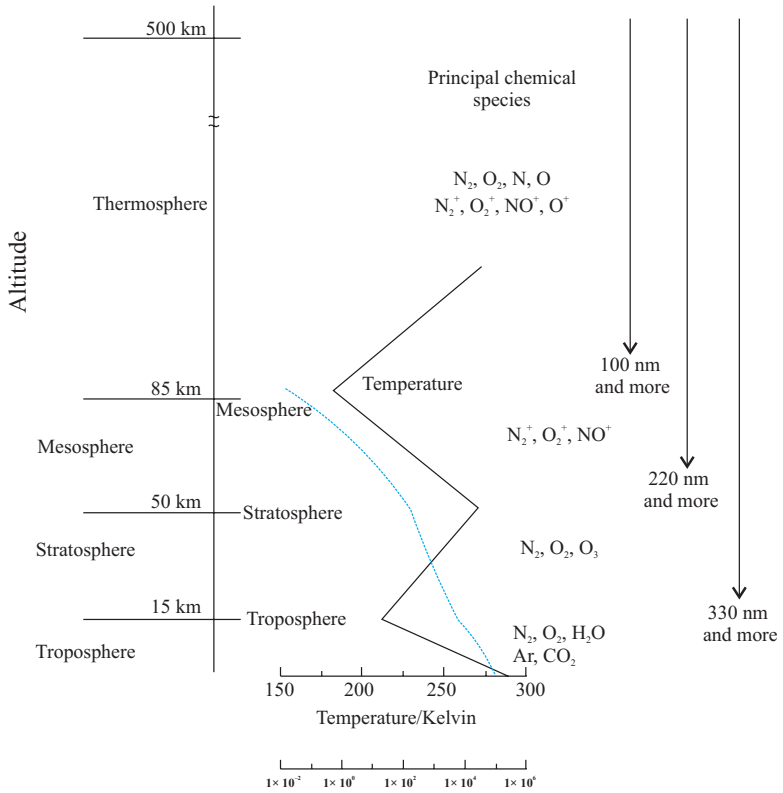


Fig. 18.7 Layers of the atmosphere

18.4.1 Evaporation

We know that air contains water vapour. Their amount in the air is not the same everywhere. It is the maximum in the low latitudes and over oceans. The atmosphere over polar regions and land has less amount of water vapour. It is also more in summer than in winter.

Though water vapour comprises a very small part of the atmosphere, it plays an important role in heating and cooling of the atmosphere and in the day to day change in weather. In fact clouds, rain, snow, fog, frost and dew that we experience, result from water vapour in the atmosphere.

But how does water vapours come in the atmosphere? It comes in the atmosphere through a process called **evaporation** due to solar heat. In fact evaporation is a process in which water from any source change into vapour state due to heat.

18.4.2 Cloud formation

Condensation of water vapour in the atmosphere leads to the formation of clouds. Clouds are formed when moist air rises upwards and is cooled as it rises. When the dew point i.e. the temperature at which the water begins to change into water drops, is reached, condensation of water vapour and the formation of very tiny droplets of water or ice crystal occurs. They cling to the dust particles in the air. These millions of minute water droplets or tiny ice crystals almost hang in the air rather than fall. They are blown as clouds by the wind. Clouds are of different types according to their shapes and height. If you watch the sky carefully you will be able to see that clouds are of different types.

18.4.3 Rain

When clouds are cooled owing to rising up or when they are blown into cooler region of the atmosphere, the small droplets of water in them become still cooler and they come closer to each other. A number of droplets combine to form big drop of water. These drops are so big that they can no longer float in the air, they fall downwards on the earth. As they fall, they pickup more and more small drops of water on their way down. The falling of these big drops of water from the clouds is known as **rain.** This process is called as **precipitation.**

The instrument used to measure rainfall is called **rain gauge**. Rainfall is measured in centimeters. The maximum rainfall occurs in the countries near equatorial regions and South-East Asia. In these regions, annual rainfall is 200 cm or more. The lowest rainfall occurs in Tundra Pradesh, central Asia and hot deserts, where it is less than 25cm. The medium rainfall (between 25cm to 200cm) occurs in west European countries, Tega regions and China.

18.4.4 Relative humidity

The existence of water vapour in the atmosphere, is known as humidity. Humidity of the air is related to its temperature. For example, during summer, you must have experienced days when both the temperature and humidity are high.

Relative humidity is the ratio of the mass of water vapour actually present in a certain volume of air at room temperature to the mass of water vapour required to saturate the same volume of air at that temperature.

The instrument used to measure relative humidity is called **hygrometer**.

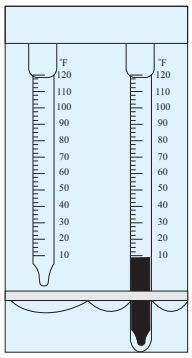


Fig. 18.8 Hygrometer

CHECK YOUR PROGRESS 18.4

1. Name the instrument used to measure:
   i) atmospheric pressure.
   ii) relative humidity.
   iii) rainfall.
2. Name the process through which water vapours come in air.

18.5 WATER - ITS SOURCES AND PROPERTIES

18.5.1 Sources of water

Other than air, water is the most important substance needed by living beings. Living beings cannot live long without water. The water is available in plenty on earth. It fills the seas, rivers and lakes, which cover more than three-fourth of the earth surface. It is also find inside the crust of the earth. Most of the water that we get from the wells comes from this source.

The natural sources of water are rain, spring, well, river and sea.

(a) Rain water: The rain water is considered to be the purest form of natural water (distilled water) free from impurities. Why do we say so? We know that water from sea and rivers get evaporated into water vapour by the heat of sun. During this process of evaporation, impurities are left behind. When the water vapours go high up in the air they condense to form clouds. The water drops come down as rain.

(b) Spring water: Springs are formed by percolation of rain water into soil. Spring supply water to wells and lakes.

(c) Well water: The rain water seeps through the soil and goes down. On digging the well this underground water is available to us. This is known as well water. This water is not pure and contains impurities such as suspended particles, bacteria and other microorganisms.

(d) River water: Rivers form by melting of snow on the mountains and also sometimes from the rain water. It is also not pure and not fit for drinking.

(e) Sea water: Out of these sources, sea water is the largest natural source of water. However, it is the source of common salt and is the most impure form of water. All the impurities dissolved in river water are carried into the sea. As such, sea water can not be used for drinking purpose. There is a constant cyclic movement of water throughout the globe, which is called water cycle. Fig 18.9 shows the diagram of water cycle in biosphere.

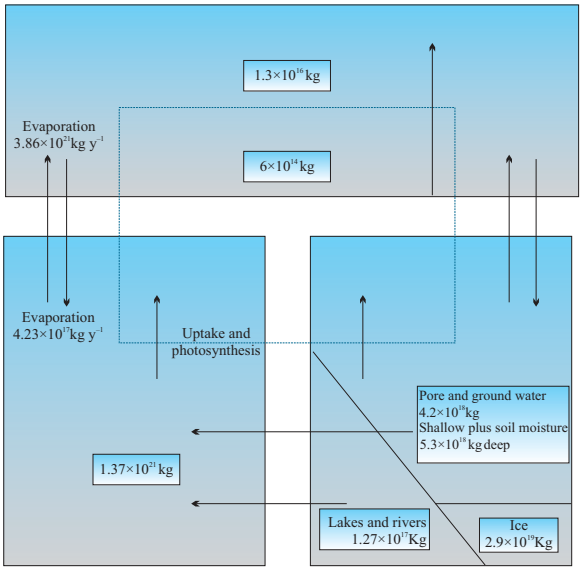


Fig. 18.9 Water cycle in nature

18.5.2 Purification of water for drinking

Water from different sources contains different substances in different amounts. In addition to salts found in sea water, water from other natural sources may contain foreign materials like suspended solids, minerals, certain compounds viruses, bacteria, eggs of insects and other animals, algae, protozoa and other aquatic plants. Such water is not safe for drinking and causes many harmful effects in the body.

There are different ways of purifying water for drinking. These are:

- **By boiling** during which bacteria and other germs die. When boiled water is allowed to cool, heavy impurities collect at the bottom and dissolved salts form a thin layer on the surface called scum. Now if we filter the water, the filtered water is safe for drinking.
- **By decantation and filtration**.
- **By chlorine treatment** in which small living organisms and bacteria are killed.

18.5.3 Properties of water

Water, which seems to us to be a common ordinary material, is really a highly unusual substance with many unique properties which makes its use important and essential in our daily life.

18. 5.3a Water acts as universal solvent

Water is certainly one of the best and most useful solvents that we have. It has a unique property to dissolve many substances starting from solids such as common salts, sugar, to gases like oxygen, carbon dioxide etc. Indeed, so many substances dissolve in water that is why it is called as a universal solvent. This property is useful for plants to take in their food materials and minerals from the soil. It helps us to absorb food that we eat, in the form of water solution. Many chemical reactions also take place only in solution form in water i.e. aqueous solution.

18.5.3b Lather formation

Water forms lather with soap which is used for cleaning purpose. But sometimes water from some sources like rivers or hand pumps does not produce any lather with soap. Why?

This is because of the presence of dissolved salts in water. Water, which we get from taps, contains lesser amounts of dissolved salts in it than water that we get from hand pumps. The dissolved salts are usually bicarbonates, sulphates and chlorides of calcium and magnesium. These salts prevent lathering but how?

The soap is a sodium salt called sodium stearate. This is soluble in water. However the calcium and magnesium stearates are insoluble and so when soap is added to hard water, which contains calcium and magnesium ions, a precipitate of Ca or Mg stearate is formed. This appears as a greasy scum. The formation of scum wastes soap (does not forms lather) and makes it more difficult to clean things.

$$\underset{\text{(Soap)}}{\text{Sodium stearate}} + \text{Calcium sulphate} \longrightarrow \underset{\text{(Scum)}}{\text{Calcium stearate}} + \text{Sodium sulphate}$$

Hence we can say that,

- Water which forms lather with soap is called **soft water**.

- Water which does not form lather is called **hard water**.
- The hardness of water is due to the presence of salts of magnesium and calcium in water**.**

18.5.3c Conversion of hard water into soft water

Hard water does not form lather with soap –can this hard water be converted into soft water? Yes, hard water can be converted into soft water. Let us see how ? The removal of **Ca** and **Mg** ions which are responsible for hardness is called the softening of water.

Hardness of water is of two types namely,

- Temporary hardness
- Permanent hardness

a) Temporary hardness

Temporary hardness of water is due to the presence of soluble bicarbonates of calcium and magnesium. It is also called **carbonate hardness**. It can be removed by boiling and by soda lime process.

(i) By boiling: On boiling hard water, the calcium or magnesium bicarbonate present is decomposed and give magnesium or calcium carbonate. These carbonate salts are insoluble in water. They settle down easily and water can be decanted. Decantation is the process of separation of solid from the liquid by allowing the former to settle down and pouring off the latter.

$$\underset{\text{calcium bicarbonate (Soluble)}}{Ca(HCO_3)_2} \xrightarrow{\text{Heat}} \underset{\text{calcium carbonate (Insoluble)}}{CaCO_3} + H_2O + CO_2$$

$$\underset{\text{magnesium bicarbonate (Soluble)}}{Mg(HCO_3)_2} \xrightarrow{\text{Heat}} \underset{\text{magnesium carbonate (Insoluble)}}{MgCO_3} + H_2O + CO_2$$

(ii) By soda lime (Clark's method): When a calculated amount of lime is added to hard water, then the soluble bicarbonates are converted to insoluble carbonates as follows:

$$Ca(HCO_3)_2 + \underset{\text{lime}}{Ca(OH)_2} \longrightarrow 2CaCO_3 + 2H_2O$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2MgCO_3 + 2H_2O$$

b) Permanent hardness

Permanent hardness of water is due the presence of soluble chlorides and sulphates of calcium and magnesium. It is also known as **non-carbonate hardness**.

It can be removed by addition of washing soda and by the ion exchange method.

A brief description of removal of permanent hardness of water is given below:

(i) By addition of washing soda: The hard water is treated with the calculated quantity of washing soda (Sodium carbonate). Washing soda reacts with chloride

and sulphate of calcium and magnesium to form precipitate of calcium and magnesium carbonate.

The reactions are as follows:

$$\underset{\text{calcium chloride}}{CaCl_2} + \underset{\text{sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{sodium chloride}}{NaCl}$$

$$\underset{\text{magnesium sulphate}}{MgSO_4} + \underset{\text{sodium carbonate}}{Na_2CO_3} \longrightarrow \underset{\text{magnesium carbonate}}{MgCO_3} + \underset{\text{sodium sulphate}}{Na_2SO_4}$$

The precipitate settles down and the water can be removed by decantation.

(ii) By ion exchange method: Two types of ion exchangers can be used, namely, inorganic ion exchanger and organic ion exchanger. In **inorganic ion exchange** process, complex compounds known as **Zeolite** are used to soften the hard water. The salts causing the hardness of water are precipitated as insoluble zeolite of calcium and magnesium.On the large scale, this process is carried out in tanks as shown in figure 18.10

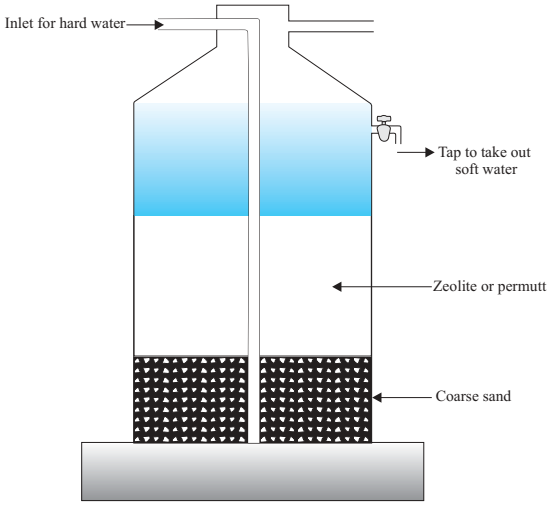
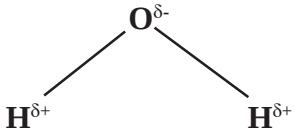


Fig. 18.10 Obtaining soft water on a large scale using tanks

By using organic ion exchanger the water obtained is free from cations and anions and is known as **deionized water** or **demineralized water.**

18.5.3d Polar nature of water

Water is very effective solvent for ionic compounds. Although water is an electrically neutral molecule, it has a small positive charge (on the H atoms) and a negative charge (on the O atoms), Therefore, it is a polar solvent.



Let us perform an activity, which proves the polar nature of wate**r**

ACTIVITY 18.4

Aim: To study the polar nature of water

What is required? Burette, water, ebonite rod (negatively charged), glass rod (positively charge) and burette stand.

What to do?

- Take a burette and fill it with water.
- Fix the burette vertically in a burette stand.

- Open the stopcock of the burette and allow the water to flow.
- Take a ebonite rod (negatively charged by rubbing one end with fur) near the water

What to observe?

You will see that the stream of water is attracted towards negatively charged rod (Fig. 18.11a). Why? Because the water molecules have positive charge.

Similarly, now we take a glass rod near water, which is positively charged. You will see the rod again attracts the stream of water. This indicates that water molecule also has negative charge (Fig. 18.11b). This proves the polar nature of water.

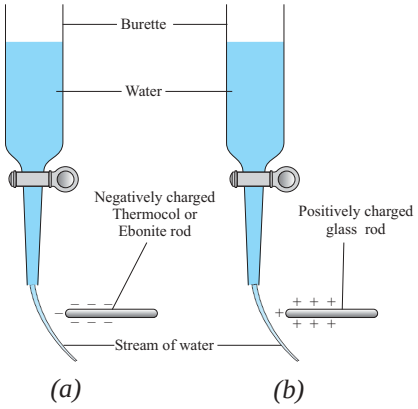


Fig. 18.11 To show that water is polar in nature

18.5.3e Surface tension

Surface tension is the property of all the liquids. Due to this tension water drops try to occupy a minimum surface area. Hence, the water droplets always tend to take the shape of a sphere.

The tension exerted by molecules of water present on the surface layer is called as surface tension.

To understand this let us perform an activity.

ACTIVITY 18.5

Aim: To study surface tension

What is required? Glass and razor blade.

What to do?

Take a glass full of water. Put a safety razor blade (having a coating of very thin layer of wax) gently on the surface of water.

What to observe?

You will find that it remains there although it is heavier than water.

Have a close look at the surface of water. You will find a thin film of water on the lower surface of the blade.

Why is it so? The upper layer of water is acting like a tight sheet. Why is the sheet tight? Due to intermolecular forces i.e. forces between the molecules of the liquid surface and the blade, there is a tension or force acting on the surface of the thin film of the liquid.

18.5.3f Capillarity – Rise of water

When a capillary tube with a fine bore is dipped in water, water rises in the capillary. The extent to which the water rises depends on the diameter of the capillary. The smaller the diameter of the capillary the higher will be the rise of water in the capillary tube.

This property of rise of water inside a capillary is called capillarity.

This is the property, by which water from the soil enters the leaves and branches of the plants through its stems.

When a piece of cloth or bloating paper is placed on water, it soaks the water by this process of capillary action. The thread strands in the cloth and cellulose of the bloating paper serves like very fine bore tubes for the water to rise.

18.5.4 Density of water

Water behaves in an unusual way when it is heated from 0 °C. As the temperature rises from 0 °C to 4 °C it actually contracts. However, at 4 °C upwards it expands like any other liquid. This means that water takes up least space at 4 °C. It has the greatest density at this temperature and will sink through warmer or colder water around it.

Density of a substance is defined as its mass per unit volume.

Measurements on different volume of water at 4 °C show that,

1 m^3 of water has a mass of 1000 kg.

2 m^3 of water has a mass of 2000 kg. And so on.

Thus, the density of water at 4 °C is found to be,

$$\text{Density} = \frac{\text{Mass of water}}{\text{Volume of water}} = \frac{\text{1000 kg of water}}{1 m^3}$$

$$= 1000 \text{ kg } m^{-3} \text{ or } 1 \text{g } cm^{-3}$$

Because of this property of water, we can explain why it takes months for a lake to freeze while a small bucket of water can freeze over night on a bitterly cold day.

18.5.5 Specific gravity or relative density

The relative density of a substance is the ratio between density of a substance and density of water at 4 °C. It tells us that how many times more dense is the substance than water i.e.

$$\text{Relative density (RD)} = \frac{\text{Density of a substance}}{\text{Density of water at 4 °C}}$$

As Relative Density is a ratio, it has no unit. For a particular substance its numerical value is always constant irrespective of whatever system of units are used. It is known as **specific gravity**. Another formula for calculating relative density or specific gravity is,

$$\text{RD} = \frac{\text{Mass of substance}}{\text{Mass of the same volume of water at 4 °C}}$$

CHECK YOUR PROGRESS 18.5

1. How much earth surface is covered by water?
2. Name any two sources of water.
3. Is rainwater pure or impure?
4. What is the role of chlorination during purification of water?
5. If water does not form lather, which type of water is it?
6. Name the type of hardness due to presence of bicarbonate of Ca^{2+} or Mg^{2+}.
7. Name the type of hardness due to presence of chloride or sulphate of Ca^{2+} or Mg^{2+}.
8. Which type of hardness is removed by the following
   (i) boiling
   (ii) ion exchange method
9. Is water a polar or nonpolar solvent?
10. What is the unit of density?

18.6 UTILITY OF WATER

Water is used for many purposes, including growing crops, metallurgical operations to obtain metals such as copper, generating electricity, watering lawns, cleaning drinking and recreation. We can say that water is essential for life of living organisms. Without water, plants and animal cells cannot function and they ultimately die. Let us discuss the role of water for domestic use, agricultural use, industrial use and for the generation of electricity.

18.6.1 Domestic uses of water

Water plays an important role in domestic purposes, for example, it is used for cooking food, to wash utensils, clothes and clean the floor of houses. It is also used for whitewashing. It is used to take bath. Water dissolves the waste material of body such as stool, urine etc. and hence provides a good medium for extracting the body waste. The salts and the nutrients of the food dissolve in water. Therefore, these nutrients are easily absorbed by our body.

18.6.2 Agricultural uses of water

Water plays a similar important role in the plants life as in the human body. In agriculture sector water is used for the irrigation of crops, it helps in the germination of seeds and growth of plants. The nutrients provided by fertilizers to the soil are soluble in water. These dissolved nutrients are easily absorbed by the plants. Water is required for the preparation of food by plants (photosynthesis). It also acts as medium for the transport of nutrients and minerals from one part of the plant to other parts. It helps in maintaining firmness and structure of plant parts by providing appropriate pressure to the plant tissue. It is required for respiration by aquatic plants.

18.6.3 Industrial uses of water

Water is used as a coolant in industries, for example the production of NH_3 in Haber's process. It is also used in production of ice and as coolant in vehicles. It is used for the production of steam in industrial boilers and in steam engines. It is used as solvent in many industrial processes. Water is used to prepare many chemical compounds, for example H_2SO_4 is prepared by dissolving SO_3 in water and HNO_3 by dissolving NO_2 in water. Water is also used to prepare fuels like hydrogen gas and water gas.

18.6.4 Uses of water to generate electricity

There are many different ways to harness the energy from water. The most common way of capturing this energy is hydroelectric power. Electricity is generated by falling water.

Water is used in thermal power stations or nuclear power station to produce steam for the generation of the electricity.

18.6.5 Rain water harvesting

Over the years rising population, growth in industrialization and expending agriculture have pushed up the demand for water. Efforts have been made to collect water by building dams and reservoirs and creating ground water structures such as wells. Some countries have also tried to recycle and **desalinate water**. Wise conversion of water has become the need of the day. The idea of ground water recharging is gaining its importance in many of the cities. This is being done through **rain water harvesting.**

Rainwater harvesting essentially means collecting rain water on the roofs of building and storing it underground for latter use. Not only does this recharging arrest underground depletion of water but also raises the declining water level and can help augment water supply.

While many people may not realize it, but those few centimeters of annual rainfall are a valuable resource. Harvesting rainwater not only helps reduce the possibility of flooding, but it also decreases the community's dependence for ground water for demestic uses. Rain water is perfectly suited for landscape irrigation, use in room coolers, washing and many other home applications. When rain water is used in room coolers and for washing needs, hardness deposits do no accumulate and there is no problem with soap scum. Harvested water may also be used for personal consumption, but it must be filtered and treated prior to use. By reducing runoff and rain water that falls on your house or field, you can put a valuable water resource to work around your house.

Thus, the benefits of harvesting rain water can be summarized as follows.

- Conserves valuable ground water.
- Reduces local flooding and drainage problems.
- Decreases landscaping and property maintenance needs.
- Provides excellent quality water for many household uses.
- It can be used for domestic purposes such as for vegetables, flowers, trees and shrubs and seedling in a green house etc.

CHECK YOUR PROGRESS 18.6

1. What are the uses of harvesting rain water?

LET US REVISE

- The major components of air are nitrogen and oxygen. The air also contains argon, carbon dioxide and some trace gases like neon, helium, krypton and xenon. It also contains water vapour.
- The weight i.e. the force of air column acting per unit area results in a pressure exerted by atmosphere called the atmospheric pressure.
- Atmospheric pressure plays an important role in our every day life in the working of common things like ink dropper, to straw, to lift pumps.
- The state of atmosphere in relation to the amount of water vapour is known as humidity.
- Mass per unit volume of a substance is known as its density.
- Next to air, water is the most abundant substance available to us. The natural source of water is rain, spring, wells, rivers and sea.
- The following properties of water make it suitable for use in our everyday life:
- ability to dissolve many things i.e. to behave as a universal solvent.
- lather formation.
- surface tension.
- capillarity.
- density of water at 4^oC being 1 g cm^{-3}.
- Relative density is the ratio between the density of a substance to the density of water at 4^oC.
- Water resources in a country is managed for proper and judicial use by constructing dams, canals, reservoir, wells and tube wells. Water collected in dams is not only used for irrigation but also to generate electricity.
- Rain water can be conserved by recharging it to ground or using it for various other purposes. This is known as rainwater harvesting.

TERMINAL EXERCISES

A. Multiple choice type questions.

1. Air is
   a) compound
   b) element
   c) mixture
   d) non of these

2. Major components of air are
   a) $CO_2 + H_2O$
   b) $N_2 + O_2$
   c) $CO_2 + He$
   d) $H_2O + Xe$

3. Carbogen is the mixture of
   a) $O_2 + CO_2$
   b) $O_2 + N_2$
   c) $O_2 + CO$
   d) $CO_2 + CO$

4. The instrument used to measure humidity is
   a) barometer
   b) hygrometer
   c) lactometer
   d) none of these

5. Water has maximum density at
   a) 0 °C b) 10 °C c) 5 °C d) 4 °C

B. Descriptive type questions.

1. Name the various components of air.
2. Air is considered a mixture, why?
3. Prove by an activity that air is a mixture of different gases.
4. List the utility of oxygen and nitrogen in our lives.
5. What is atmospheric pressure? How is it measured using simple barometer?
6. How does the atmospheric pressure depend on altitude? Write down the units of atmospheric pressure.
7. Name the different types of barometers. Explain the working of Aneroid barometer with diagram.
8. Give an activity, which proves that air exerts pressure.
9. What is relative humidity? How is it measured?
10. What is evaporation? How does it help in the formation of clouds?
11. What are the different source of water? Explain any two.
12. Why is water called as universal solvent? On what basis the following components dissolve in water: NaCl, Sugar and NH_3?
13. Explain water cycle with the help of a suitable diagram.
14. What are the different ways to purify drinking water? What is the role of chlorination?
15. Water is a polar solvent. Give an activity to prove it.
16. What do you mean by hard and soft water? Explain the types of hardness in water.
17. How are the temporary and permanent hardness removed from water?
18. Explain the following properties of water
    (i) Surface tension (ii) Density
19. What is rainwater harvesting? How is it beneficial for everyday life?
20. List the utility of water for, domestic purpose, agriculture, industry and generation of electricity.
21. What do you mean by conservation of water? How is it useful?

ANSWERS TO CHECK YOUR PROGRESS

18.1

1. Mixture
2. Nitrogen and oxygen
3. 4:1
4. It varies from place to place.
5. It varies from place to place.

18.2

1. Needed for respiration by plants and animals
2. Photosynthesis
3. Solid CO_2
4. Nitrogen

18.3

1. Pascal
2. Low pressure.

18.4

1. (i) Barometer
   (ii) Hygrometer
   (iii) Rain gauge
2. Evaporation.

18.5

1. Three fourth
2. Rain and sea
3. Pure
4. To kill microorganism
5. Hard water
6. Temporary
7. Permanent
8. (i) Temporary, (ii) permanent
9. Polar
10. g cm^{-3}

18.6

1. It conserves valuable ground water.
2. It reduces local flooding and drainage problems
3. It decreases landscaping and property maintenance needs
4. It provides quality water for many household needs
5. It can be used for domestic purposes

GLOSSARY

Atmospheric pressure: The force of air column acting per unit area results in a pressure exerted by atmosphere.

Barometer: Instrument used to measure atmospheric pressure.

Cloud: Condensation of water vapour in the atmosphere.

Dew point: The temperature at which the water begins to change into water drops.

Density: Mass per unit volume of any substance.

Evaporation: Vaporization of water due to solar heat.

Greenhouse effect: Trapping of infrared radiations, increased concentration of CO_2.

Humidity: The state of atmosphere in relation to the amount of water vapour it contains is known as humidity.

Hard water: Water that do not form lather with soap.

Hygrometer: Instrument used to measure relative humidity.

Pascal (Pa): The SI unit of pressure. One Pascal in one Newton per square meter. One atmosphere is equal to 1.01325×10^5Pa.

Relative humidity: It is ratio of the mass of water vapour actually present in a certain volume of air at room temperature to the mass of water vapour required to saturate the same volume of air at the same temperature.

Rain: The falling of big drops of water from the clouds is known as rain.

Soft water: water that form lather with soap.

Surface tension: Tension exerted by the molecules of water present in the upper layer is called surface tension.