Chapter

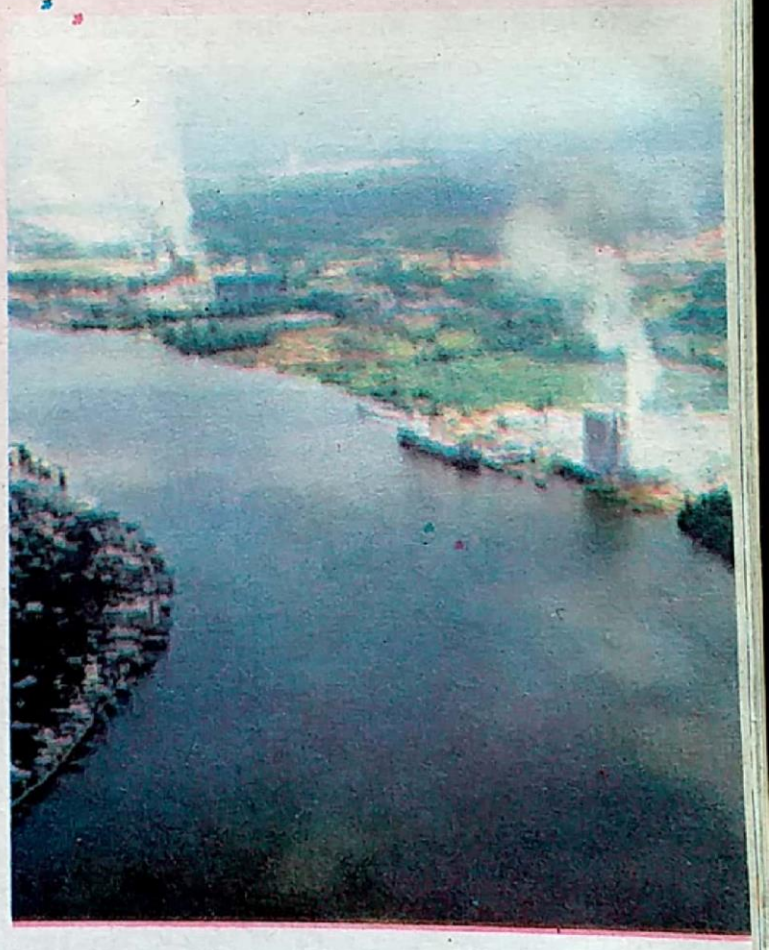
15

Environmental Chemistry II

(Water)

In this chapter you will be able to:

- Describe the occurrence of water and its importance in the environment including industry.
- Review our dependence on water and the importance of maintaining its quality.
- Describe the composition and properties of water.
- Differentiate among soft, temporary and permanent hardness of water.
- Identify water pollutants.
- Describe industrial wastes and household wastes as water pollutants.
- Describe the effects of these pollutants on life.
- Describe the various types of water borne diseases.



Introduction

Water is one of the most essential substance for life and wherever living organisms are present, it is invariably found with them. Many elements are important to sustain life on earth, but no single substance is as vital as water. Humans can live without food for more than two months, but they cannot live without water for more than a week. Human body contains about 70 percent of water while plants contains from 50-80 percent of water. It is necessary to maintain various biological processes. The vital function of protoplasm is due to the presence of constant amount of water.

However water is a universal solvent and occurs in nature in impure state. Therefore water present in springs, streams, rivers, lakes and seas contains chlorides, sulphates, carbonates and bicarbonates of sodium, potassium, magnesium and calcium. In addition to the above some man made chemicals also get dissolved in water and make it harmful for human, animals and plants.

15.1 Occurrence of water

Water is one of the most abundant natural resources present on earth. It has been estimated that the total volume of water present on earth surface is about 1.33billion cubic kilometers. It covers nearly 70–75 percent of earth surface.

The major reservoirs of water on earth surface are oceans, ice caps and glaciers, underground water, inland water and atmospheric water. The oceans contain more than 97 percent of the total water. The rest of water is in the form of glaciers, ice caps, underground water and inland water. The inland water includes rivers, lakes, canals, streams and soil moisture. Besides this, atmosphere also contains considerable quantity of water as water vapours.

Although enormous amount of water is present on earth surface, yet the fresh water needed for human requirements is only 0.2 percent of the total. More than 97 percent of the total water is present in oceans which is unfit for human consumption due to high concentration of salts. Another 2.2 percent is locked in ice caps and glaciers. On land most of the fresh water lies underground.

TABLE. 15. 1

WATER RESERVIORE		AMOUNT OF WATER
i.	Oceans	Approx. 97%
ii.	Glaciers and ice caps	2.2%
iii.	Underground water	0.6%
iv.	Inland water	0.2%
v.	Atmospheric water	0.001%

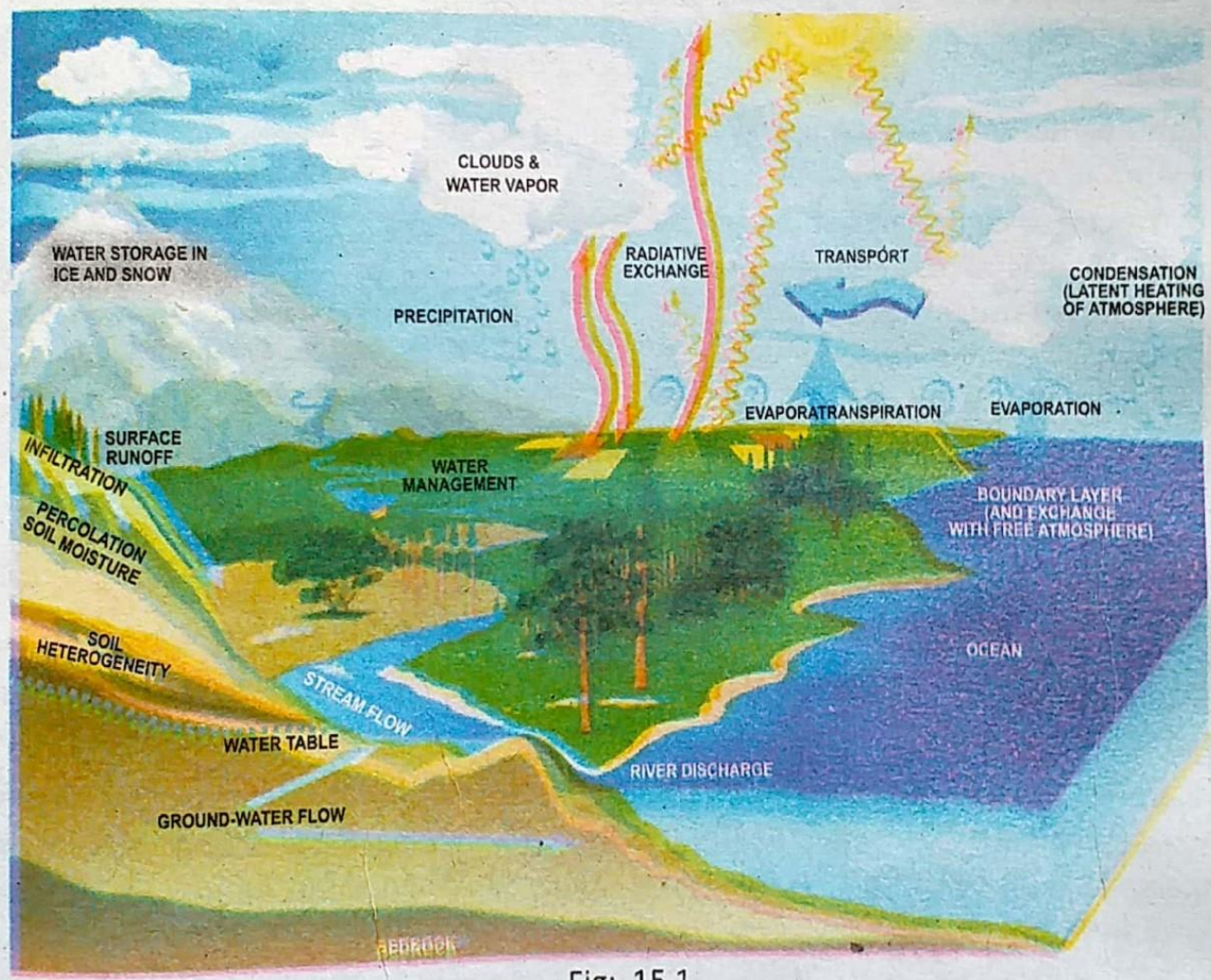


Fig: 15.1

15.2 Composition of water

Water is a compound of hydrogen and oxygen. However before 1776 AD, it was considered as an element. In 1776 AD, Priestly experimentally proved that water is not an element but is a compound of hydrogen and oxygen.

Composition of water by volume

Water contains two parts of hydrogen and one part of oxygen by volume. This ratio can be determined experimentally by the electrolysis of water in Hofmann's voltameter in the presence of an electrolyte. By passing electric current through acidified water, it gives two parts of hydrogen and one part of oxygen (fig 15.2).

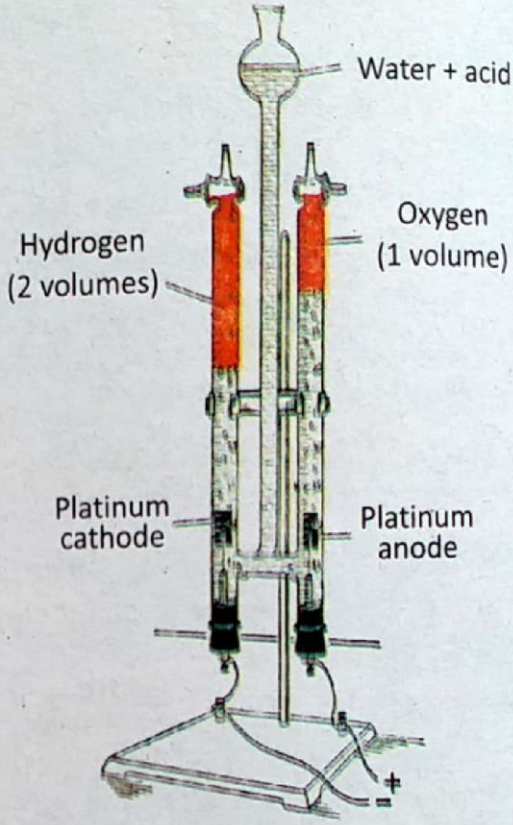


Fig. Analysis of water by volume

Fig:. 15.2

Composition of water by mass

Water is composed of one part of hydrogen to eight parts of oxygen by mass. It was experimentally proved by Joseph Proust that hydrogen and oxygen combined to form water in the ratio of 1:8 by mass. Since, the atomic mass of hydrogen is one, and that of oxygen is sixteen, so according to the formula H_2O, the ratio between hydrogen and oxygen would be 1:8.

15.3 Properties of water

(a) Physical properties of water

i) Physical state

Pure water is colourless(transparent), odourless and tasteless. The taste of drinking water is due to the presence of dissolved gases and salts. Water exists in nature in all the three states i.e. solid (ice), liquid and gaseous (vapour).

ii) Melting point and boiling point

Under normal atmospheric pressure, liquid water changes into solid ice at 0°C and boils to form steam at 100°C. However water vapour in air exists at all temperatures. The melting and boiling points of water are

unexpectedly high as compared to other chemically similar compounds. This and other unusual properties of water are due to hydrogen bonding in it.

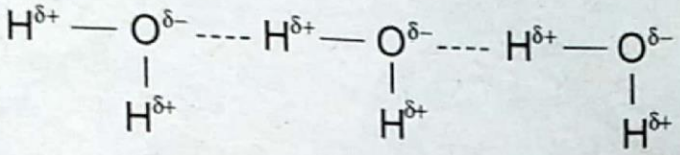


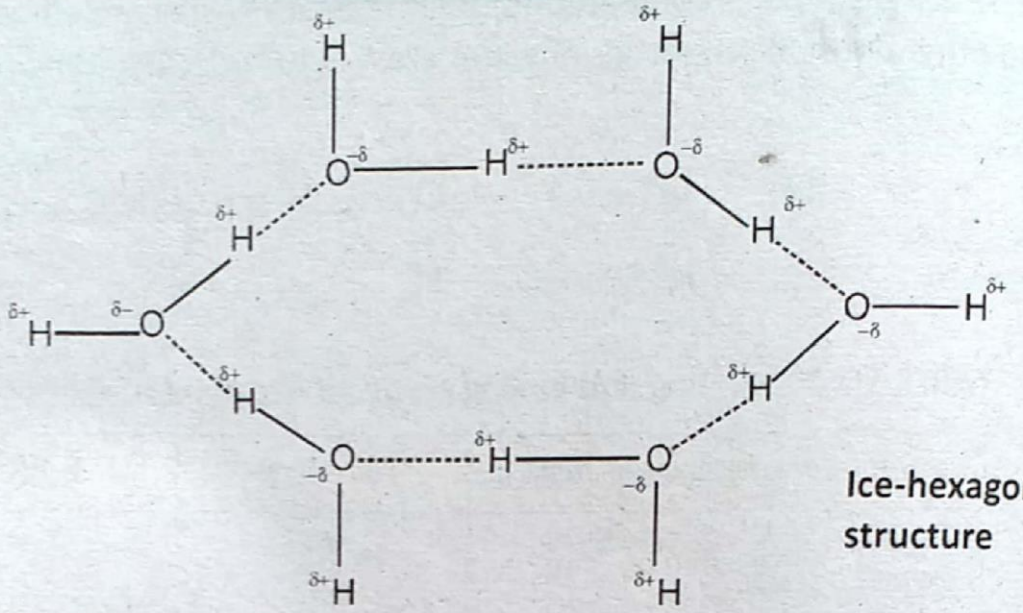
TABLE 15. 2 Melting and boiling points of Group VI A Hydrides

Substances	Molecular mass (g)	M.P(C°)	B.P(C°)
H_2O	18	0	100
H_2S	34	-83	-60
H_2Se	81	-66	-41
H_2Te	129.6	-49	-2

iii) **Density**

The volume of most of the solids and liquids increases with increase in temperature and decreases with decrease in temperature in a regular manner. However water shows a unique behaviour in this regard. This unique property of water is called anomalous behaviour of water. When water is cooled from 100°C, its density gradually increases from 0.9584g/ml to 1.000g/ml at 4°C. Up to this temperature water behaves as other liquids. However on further cooling, below 4°C the effect reverses and the density gradually decreases reaching to 0.917g/ml at 0°C. At this temperature water freezes into ice. Thus ice is lighter and therefore floats on the surface of water. The expansion of ice is due to the formation of hexagonal structures. In these structures six water molecules arrange themselves in the form of a ring having empty spaces. As a result volume increases and density being inversely proportional to volume decreases.

As the water expands on freezing, bottles filled with water when placed in the freezer crack. In cold weather an antifreeze "glycol" is added to car radiator to prevent freezing of water. Similarly water supply pipes may also burst during severe winters if not kept open, due to expansion of water on freezing.



Ice-hexagonal structure

IV. Heat capacity

Heat capacity is the capacity of a substance to absorb heat. The heat capacity of a substance is expressed in terms of specific heat.

"The specific heat capacity of a substance is the amount of heat required to raise the temperature of one gram of a substance through one degree centigrade.

One gram of water requires 4.2 joules of heat to raise its temperature by one degree centigrade. This is much higher than the specific heats of many other common substances.

TABLE 15.03: Specific heat of water compared with that of other substances

SUBSTANCES	SPECIFIC HEAT ($J\ g^{-1}{}^{\circ}C^{-1}$)
Water	4.2
Ethanol	2.4
Iron	0.45
Copper	0.376
Mercury	0.1

Due to high specific heat, water undergoes temperature changes very slowly as compared to other substances. Therefore it is used in radiators for heating rooms. The vast amount of water on the earth surface acts as a giant thermostat. It regulates the temperature of the earth. Without the huge volume of the water in oceans, the earth would have heated up too much quickly during the day time and cooled too much quickly at night.

V) **Latent heat values**

a) **Latent heat of fusion**

If we take some ice in a beaker and heat it with constant stirring, it will be noticed that although heat is being supplied the temperature does not rise until all the ice in the beaker has melted.

"The amount of energy required to change a given amount of solid into liquid state at its melting point is called latent heat of fusion"

The latent heat of fusion of water is 6kJ/mol (334kj/kg).

b) **Latent heat of vaporization**

When we heat water in beaker, it will start boiling at 100°C. At this point if the supply of heat is continued, the temperature of water does not rise until all of it is converted into steam.

"The amount of energy required to change a given amount of liquid into gaseous state at its boiling point is called latent heat of vaporization"

The latent heat of vaporization of water is 41kJ/mol (2277kj/kg) at 100°C.

VI) **Solvent action**

Water is a remarkable solvent. It has the ability to dissolve many substances. Due to this fact it is termed as universal solvent. This property is very beneficial for us and finds a large number of applications at home and industry. However, the same property of water is responsible for water pollution as well.

Activities

- Put a cube of ice into a beaker containing water. Does it floats on the surface of water? Why?
- Take some ice in beaker and heat it on a burner. Does the temperature increase until all the ice has melted? Why?
- Take some water in a beaker. Add cooking oil into it. Does it dissolve in water? Why?

(b) CHEMICAL PROPERTIES OF WATER

I. Thermal stability

Water is thermally stable compound that only one percent of its molecules decomposes into its components i.e. H_2 and O_2 at about 2000°C.

$$2H_2O_{(g)} \xrightarrow{2000°C} 2H_{2(g)} + O_{2(g)}$$

II. Reaction with metals

Water reacts readily with certain metals in a number of ways. Cold water reacts vigorously with sodium, potassium and calcium forming metal hydroxides liberating H_2 gas.

$$2Na_{(s)} + 2H_2O_{(l)} \longrightarrow 2NaOH_{(aq)} + H_{2(g)}\uparrow$$
$$2K_{(s)} + 2H_2O_{(l)} \longrightarrow 2KOH_{(aq)} + H_{2(g)}\uparrow$$
$$Ca_{(s)} + 2H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)} + H_{2(g)}\uparrow$$

Water as steam reacts with less reactive metals like Zinc, Magnesium and Iron to form metal oxides and hydrogen gas.

$$Zn_{(s)} + H_2O_{(l)} \longrightarrow ZnO_{(s)} + H_{2(g)}\uparrow$$
$$Mg_{(s)} + H_2O_{(l)} \longrightarrow MgO_{(s)} + H_{2(g)}\uparrow$$

Steam reacts with red hot iron to form magnetic oxide and H_2 gas

$$3Fe_{(s)} + 4H_2O_{(g)} \longrightarrow Fe_3O_{4(s)} + 4H_{2(g)}\uparrow$$

Other metals like copper, gold, mercury and platinum do not react with water at any conditions.

III. Reaction with non-metals

Water reacts with non-metals under different conditions to form a number of products.

a) With Chlorine

When Cl_2 gas is passed through water it reacts to form hydrochloric (HCl) and hypochlorus (HOCl) acids. Hypochlorus acid is unstable and decomposes to give atomic oxygen which decolourizes the dye molecule. So chlorine can be used as a bleaching agent and as germicide.

$$H_2O_{(l)} + Cl_{2(g)} \longrightarrow HCl_{(aq)} + HOCl_{(aq)}$$
$$HOCl_{(aq)} \longrightarrow HCl_{(aq)} + [O]$$

b) With Carbon

Steam reacts with red-hot coke to form a mixture of carbon monoxide and hydrogen gases ($CO+H_2$). This gaseous mixture is called water gas. Water gas is used as fuel.

$$H_2O_{(g)} + C_{(s)} \longrightarrow CO_{(g)} + H_{2(g)}$$
(water gas)

c) With Silicon

Steam reacts with silicon to produce silicon dioxide and hydrogen gas.

$$Si_{(s)} + 2H_2O_{(g)} \longrightarrow SiO_{2(s)} + 2H_{2(g)}$$

d) With Sulphur

Steam reacts with sulphur producing hydrogen sulphide and sulphur dioxide gases.

$$3S_{(s)} + 2H_2O_{(g)} \longrightarrow 2H_2S_{(g)} + SO_{2(g)}$$

IV. Reaction with metal oxides :

Water reacts with metal oxides to form metal hydroxides (bases)

$$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$$
$$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2(aq)}$$
$$ZnO_{(s)} + H_2O_{(l)} \longrightarrow Zn(OH)_{2(aq)}$$

V. With non-metal oxides

Water reacts with non-metal oxides to produce acids as,

$$H_2O_{(l)} + CO_{2(g)} \longrightarrow H_2CO_{3(aq)}$$
$$H_2O_{(l)} + 2NO_{2(g)} \longrightarrow HNO_{3(aq)} + HNO_{2(aq)}$$
$$H_2O_{(l)} + SO_{3(g)} \longrightarrow H_2SO_{4(aq)}$$

VI. Hydrolysis reaction

The reaction of a salt of weak acid or weak base and water to form acidic or basic solution is called hydrolysis.

In this reaction the dissolved salt reacts with water turning the solution either basic or acidic. In this reaction water splits into H^+ and OH^- ions. It is the reverse process of neutraliz

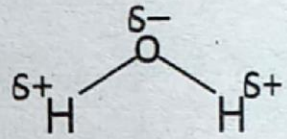
$$NH_4Cl_{(s)} + H_2O_{(l)} \longrightarrow NH_4OH_{(aq)} + HCl_{(aq)}$$
$$CH_3COONa_{(s)} + H_2O_{(l)} \longrightarrow CH_3COOH_{(aq)} + NaOH_{(aq)}$$

Activities

- Add a few drops of phenolphthalein in aqueous solution of sodium acetate. What happens? Why?
- Pass carbon dioxide gas through hard water. Why does it turn milky?
- Put few crystals of potash alum (patakry) in muddy water. What happens?

15.4 Water as a solvent

Water is a universal solvent for many inorganic and certain organic compounds. This characteristic property of water that it dissolves more or less of everything is due to the following two reasons.

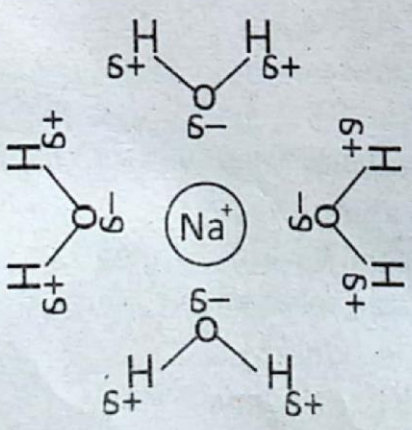


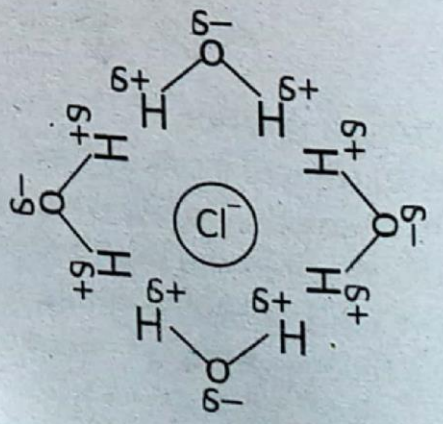
1) Polarity:

Consider the structure of water.

Water molecules have a polar structure, the oxygen end of the water molecules is partially negatively charged while the hydrogen end is partially positively charged. Due to this property polar substances like mineral acids, bases and salts dissolve in water. Some of the covalent compounds having hydroxyl group OH^-, can also be dissolved in water e.g. glucose, sugar and alcohols.

When an ionic compound like NaCl is placed in water, the breaking of the attractive forces or the ionic bonds occur. The water molecules orient in such a way that their negative poles are towards the positive ions. Similarly the positive poles of water molecules orient themselves around the negative ions.





2) Dielectric Constant:

Coulomb's law states that the force of attraction between two oppositely charged bodies is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

Mathematically, force $\propto \frac{(x)(y)}{r^2}$

Where 'x' and 'y' are two opposite charges and 'r' is the distance between them.

or $\text{Force} = \frac{(x)(y)}{Dr^2}$ Where 'D' is the proportionality constant and called the dielectric constant of the medium or water in which the charged ions of solute are present.

The above equation tells us that the greater is the value of 'D' the smaller will be the value of the force of attraction between the charges. The smaller the values of 'D' the greater will be force of attraction between the oppositely charged ions. Thus it will be easier to separate the two opposite charges of ionic solute from one another (to make solution) in a liquid having a high dielectric constant. Water has a high dielectric constant of 80 at 18^0C. Thus the positive and negative ions of a polar salt dissolved in water will have less force of attraction and would remain soluble. Other liquids have the value of dielectric constant extremely small as compared to water and therefore, these are not good solvents.

Society, Technology and Science

Chemistry helps to maintain a clean swimming pool by removing pathogenic organisms. Chlorine based disinfectants are most frequently applied for cleaning of swmming pools. Chlorine is usually added to water as hypochlorous acid (HOCl). Chlorine kills pathogenic microorganisms that are present in the water. When too much chlorine is present, it can cause eye irritation. The minimum concentration of chlorine in swimming pool is 0.5 mg/Land maximum level is 1.5mg/L.

15.5 Soft & Hard Water

Water, which easily gives lather with soap, is called soft water. On the other hand when it forms scum or curds with soap and affects the cleaning action of soap is known as hard water.

Hard water does not form lather readily with soap. It forms scum during washing of clothes and dirt cannot be removed readily. Thus hard water wastes soap. The hardness of water is due to the presence of bicarbonates, sulphates and chlorides of calcium and magnesium in water.

15.5.1 Types of Hard Water

There are two types of hard water.

i. Temporary Hard Water

ii. Permanent Hard Water

(i). Temporary Hard Water

The most common cause of temporary hardness of water is the dissolved calcium bicarbonate or magnesium bicarbonate. Rainwater dissolves carbon dioxide of the air, which reacts, with the calcium carbonate of rocks forming calcium bicarbonate.

$$H_2O_{(l)} + CO_{2\,(g)} + CaCO_{3(s)} \longrightarrow Ca(HCO_3)_{2\,(aq)}$$

These salts are soluble in water and exist in the form of positive and negative ions as shown below.

$$Ca(HCO_3)_2 \longrightarrow Ca^{+2}_{(aq)} + 2HCO^{-1}_{3\,(aq)}$$

$$Mg(HCO_3)_2 \longrightarrow Mg^{2+}_{(aq)} + 2HCO^{-1}_{3\,(aq)}$$

15.5.2 Methods for removal of Temporary Hardness

(i) By Boiling:

The temporary hardness of water is removed by simply boiling.

$$Ca(HCO_3)_{2\,(aq)} \xrightarrow{\text{boil}} CaCO_{3\,(s)} + CO_{2\,(g)} + H_2O_{(l)}$$

Calcium carbonate being insoluble precipitates and settles down. Now any soap added, will form lather easily.

(ii) Clark's Method:

This method is used to remove hardness on a large scale. A calculated amount of lime water $Ca(OH)_2$, is added to the reservoir containing temporary hard water. The soluble hydrogen carbonates of Ca^{++} and Mg^{++} are converted into insoluble carbonates, which settle down at the bottom and soft water is drained off for use.

$$Ca(HCO_3)_{2\,(aq)} + Ca(OH)_{2\,(aq)} \longrightarrow 2CaCO_{3(s)} + 2H_2O_{(l)}$$

$$Mg(HCO_3)_{2\,(aq)} + Ca(OH)_{2\,(aq)} \longrightarrow MgCO_{3(s)} + CaCO_{3(s)} + 2H_2O_{(l)}$$

(2) Permanent Hardness:

Permanent hardness is caused by the presence of soluble salts of calcium or magnesium such as sulphates and chlorides. Simply boiling the water cannot decompose these salts. Calcium and magnesium salts in water are present in ionic form.

$$CaCl_{2\,(aq)} \longrightarrow Ca^{+2}{}_{(aq)} + 2Cl^{-}{}_{(aq)}$$

$$MgSO_{4\,(aq)} \longrightarrow Mg^{+2}{}_{(aq)} + SO_4{}^{-2}{}_{(aq)}$$

15.5.3 Methods for removal of permanent hardness:

(i) Reaction with Washing Soda

Permanent hardness can be removed by adding chemicals, which convert soluble salts into insoluble salts or precipitates. Thus washing soda is usually added to permanent hard water to remove its hardness. For example; by using Na_2CO_3 (Washing Soda), the salts causing hardness react as follows.

$$Na_2CO_{3(\,aq)} + CaSO_4 \longrightarrow CaCO_{3\,(s)} + Na_2SO_{4\,(aq)}$$

$$Na_2CO_{3(\,aq)} + CaCl_{2\,(aq)} \longrightarrow CaCO_{3\,(s)} + 2NaCl_{\,(aq)}$$

By adding Na_2CO_3, the soluble Ca^{++} or Mg^{++} ions are converted into insoluble $CaCO_3$ or $MgCO_3$, respectively.

(ii) Ion Exchange Method:

Now a days this technique is applied in homes for softening of hard water for the purpose of drinking. Hard water on passing through the resin (sodium zeolite), attract Ca^{++} and Mg^{++} ions. The mode of reaction can be represented as;

$$CaSO_{4\,(aq)} + \text{Sodium Zeolite}_{(s)} \longrightarrow \text{Ca-Zeolite}_{(s)} + Na_2SO_{4(aq)}$$

Na-Zeolite resin can be obtained naturally or may be prepared artificially. After some days, this resin becomes inactive and its activity can be regenerated by treating it with concentrated solution of common salt.

$$\text{Ca-Zeolite}_{\,(s)} + NaCl_{\,(aq)} \longrightarrow \text{Na-Zeolite}_{\,(s)} + CaCl_{2(aq)}$$

Soaps are the salts of fattyacids. When soap is added to hard water. It gets ionized into sodium ion and stearate ion. The Ca^{++} ion of hard water react with stearate and produce Ca–stearate. So it hampers the lather formation. As a result the cleaning action of soap is also affected.

$$C_{17}H_{35}COONa \xrightarrow{\text{Hard water}} C_{17}H_{35}COO^{-} + Na^{+}$$

Sodium stearate — Stearate ion — Sodium ion

$$Ca^{+2} + 2C_{17}H_{35}COO^{-} \longrightarrow Ca(C_{17}H_{35}COO)_2$$

Calcium ion — Stearate ion — Calcium stearate (scum)

15.5.4 Disadvantages of Hard Water

1. A large quantity of soap is used which is wasted in the formation of scum or curd. After that more soap will be required for actual washing.
2. Hard water when used in boilers for producing steam in industries, steam engines or turbines, calcium and magnesium salts settle down at the bottom forming hard insulating scales. As a result more fuel is consumed in producing steam. Besides it damages the material of the boiler due to over heating.
3. Drinking hard water produces numerous diseases of stomach and intestines.

15.3 Water pollution

Water is an excellent solvent and can dissolve vast variety of substances. Therefore natural water, when it flows or seeps through the surface of the earth, dissolves minerals including salts and other substances. Despite of these mineral impurities water of most lakes, rivers, springs, and wells is considered fit for drinking and other domestic uses. Water pollution occurs when undesirable foreign substances are introduced into natural water. The substances may be chemical or biological in nature. Common pollutants include human or animal waste, disease-producing organisms, radioactive material, toxic metals such as lead or mercury, agricultural chemicals such as pesticides, herbicides, and fertilizers. Hot water discharged from power plants causes "thermal pollution". Pollutants in water are dangerous for human or animal consumption, and harm crops. Water is considered as polluted and unfit for drinking when it is contaminated with substances (pollutants) which are harmful for human beings and other living organisms.

The substances that cause water pollution are called pollutants. These pollutants get dissolved in water from the soil, atmosphere, fields, factories, farm houses, volcanoes, storms, algae blooms, earthquakes and homes etc.

The major sources of water pollutants are:

- **Industrial wastes**
- **Agricultural wastes**
- **Household wastes**

15.3.1 Industrial wastes

As populations and production grew, industrial and household refuse accumulated, and it became clear that many discarded materials did not simply disappear, but were spread through the water table, absorbed by lower forms of life and passed into the food chain, causing deaths, birth defects, and mental problems.

Water pollution represents a serious problem in developing nations, which have high populations and manufacturing facilities that do not meet safety standards. It is alarming that most industries have been started without proper planning and waste treatment plants. They just dispose of untreated toxic waste into nearby drains, canals or rivers.

Manufacturing and service industries have high demands of water for cooling, processing and for cleaning purposes. Most of it is taken from the adjoining river, canal, stream or underground source and again discharged into these sources laden with toxic wastes. Groundwater pollution occurs when used water is returned to the hydrological cycle. Industrial waste contains highly toxic compounds of mercury, cadmium, lead, chromium, arsenic and antimony. In addition to the above it also contains acids, bases, dyes, oils and grease.

(Fig;. 15.3)

15.3.2 Household waste

Household waste is a waste which is generated in the day to day operations of a household. It can include everything from lawn clippings to burnout light bulbs. A busy household can generate a great deal of waste, and the amount of household waste increases radically in developed nations which rely heavily on packing for a wide variety of products.

Household waste can broadly be divided into three categories.

a) Waste water
b) Untreated sewage
c) Solid waste

a) Waste water or grey water

It includes the water we used in kitchens, washrooms and cleaning floors etc. In most cases this water is directly discharged into the water bodies. The various substances that we use for keeping our houses clean add to water pollution as they contain harmful chemicals. In the past, people mostly used soaps made from animal and vegetable fat for all types of washing. But most of today's cleaning products are synthetic detergents and come from the petrochemical industry. Most detergents and washing powders contain phosphates, which are used to soften the water among other things. These and other chemicals like medicines, acids, bleaches, dyes, insecticides, rodent killer, waxes, hair colour etc affect the health of all forms of life in the water.

b) Untreated sewage or black water

It is the major source of water pollution, because it contains pathogens such as bacteria, viruses, and protozoans. In Pakistan about 2 million tonnes of wet human excreta are annually produced in the urban sector of which about 50% go into water bodies to pollute them. According to National Conservation Strategy about 40% deaths are related to water borne diseases.

In our country, drinking water supply lines and open sewage drains in the streets are laid side by side. As a result water is frequently contaminated when pipes erode. Furthermore, due to low quality of sewage pipes and improper safety seals cause a lot of leakage. This outflow from sewage mixes with the water table and the contamination is carried to deeper levels. Hence the under groundwater which is considered safe becomes adulterated with pollutants.

c) **Solid waste**

It is also called urban waste or domestic waste. It is either in solid or semisolid form. It contain food, newspapers, glass bottles, cans, metals etc. Today, many people dump their garbage into streams, lakes, rivers, and seas, thus making water bodies the final resting place of cans, bottles, plastics, and other household products. In cities, it is collected by municipality within a given area and stored in open fields without proper disposal. Chemicals from this material dissolve into rain water while it is being filtered through that material. The process is called leaching and the resulting mixture is called leachate. It contains decomposed organic matter, rust, newspaper ink, pesticides, fertilizer and other hazardous chemicals. Leachate either seeps into the soil and pollutes underground water or finds its way to rivers and streams through rain water.

(Fig:. 15.4)

15.3.3 Agricultural Wastes

Agricultural waste is waste produced as a result of various agricultural operations. It includes manure and other wastes from farms, poultry houses and slaughterhouses; harvest waste; fertilizer run- off from fields; pesticides that enter into water, air or soils and salt and silt drained from fields.

Agricultural wastes include both natural (organic) and synthetic wastes. Main synthetic waste include packaging, non-packaging plastics (e.g. silage and horticultural films); agrochemicals; animal health products (e.g.used syringes); wastes from machinery (e.g. oil, tyres and batteries) and building waste (e.g. asbestos sheeting).

15.4 Water born diseases and Effects of water pollutants

The effects of water pollutants are not only devastating to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability. Eventually, it is a hazard to human health. Nobody can escape the effects of water pollution.

The individual and the community can help minimize water pollution. By simple housekeeping and management practices the amount of waste generated can be minimized.

The major effects of water pollutants are as under.

a) Cause of infectious diseases

Human infectious diseases are among the most serious effect of water pollution, especially in developing countries like Pakistan, where sanitation is inadequate or even non-existent. Water born diseases occur when parasites or other diseases causing microorganisms are transmitted via contaminated water, particularly water contaminated by pathogens originating from excreta. These include typhoid, cholera, dysentery, amoebiasis, ascariasis and hepatitis etc.

b) Nutrient pollution

It is the most chronic environmental problem in the coastal areas, rivers, streams and lakes. The discharges of nitrogen, phosphorus and other nutrients come from agriculture, waste disposal, coastal development and fossil fuel. This enrichment of nutrients in water bodies is called Eutrophication. It stimulates harmful overgrowth of algae, which can have direct toxic effect, as certain types of algae are toxic (red and brown). Zooplankton eat the toxic algae and begin passing the toxins up the food chain, affecting the sea birds, sea mammals and humans. The result can be illness and sometime death. The algal growth also blocks the sun light needed by sea grasses, which serve as nurseries for many important fish species. Furthermore it also reduces the clarity, making it hard for marine animals to find food.

When the algae finally die, they sink to the bottom and begin decomposing. The process uses oxygen from the surrounding water and make it difficult for aquatic animals to survive and the region becomes a dead zone.

c) Chemical contamination

Some of the major effects of chemical contamination are as under.

i) Pesticides affect and damage the nervous system, liver, reproductive system and endocrine glands, DNA. They also cause cancer and other acutely toxic and chronic effects.

ii) Oil and petrochemicals can alter the ecology of aquatic habitats and the physiology of marine organisms. In human beings it causes gastro intestinal irritation, liver and kidney damage, and nervous system effects.

iii) Mercury and its compounds are used in many industries. It Find its way into the water bodies primarily through air pollution and industrial waste. Mercury gets into the body through food especially sea food. It accumulates in the blood, liver, kidneys and brain tissues. In young children it causes autism, brain damage, learning defects and incomplete mental development. In adults mercury causes Parkinson, Alzheimer's disease and heart disease.

iv) Persistent organic pollutants (POP) such as DDT, dioxins and PCB enter our body through food. As they are fat soluble, therefore they accumulate in fatty tissues of animals and human. POPs causes disruption of hormones in human and animals, affects reproductive organs and breast cancer in women.

d) Thermal water pollution

A lot of heat is generated in most industrial manufacturing processes. The cheapest way to release this heat into the environment is to draw water from the nearby surface water, pass it through the plant and return heated water back into the same source. The warmer water affects the aquatic life in two ways,

i) The warmer water decreases the solubility of oxygen and many aquatic organisms will die due to the shortage of oxygen.

ii) Many aquatic animals especially young can not survive above 30°C and will die.

Water, which is prepared for different purposes is called treated water e.g distilled water, drinking water and chlorinated water of swimming pools. Water is passed through different process in order to remove impurities from water and make it suitable for drinking.

First water is stored in settling basin and treated with calcium hydroxide and aluminum sulphate to remove suspended impurities and dust. It is then filtered through sand and gravel bed to remove remaining suspended particles. After this water is passed through charcoal to remove colour and odour. At the last stage chlorine is added in water to kill microorganism such as bacteria and germs etc. Now this water is suitable for drinking and other purposes.

KEY POINTS

- Water present in springs, streams, rivers, lakes and seas contains chlorides, sulphates, carbonates and bicarbonates of sodium, potassium, magnesium and calcium.
- The unusual physical properties of water are due to hydrogen bonding in it.
- The vast amount of water on the earth surface acts as a giant thermostat. It regulates the temperature of the earth.
- The amount of energy required to change a given amount of solid into liquid state is called latent heat of fusion.
- The amount of energy required to change a given amount of liquid into gaseous state at its boiling point is called latent heat of vaporization.
- Due to high latent heat values of water make it a useful coolant.
- The dielectric constant of water is 80 at 18°C.
- Water is thermally so stable compound that only one percent of its molecules decomposes into its components i.e. H_2 and O_2 even at 2000°C.
- Steam reacts with red-hot coke to form a mixture of carbon monoxide and hydrogen gases ($CO + H_2$). This gaseous mixture is called water gas. Water gas is used as fuel.
- That water which form scums with soap and affects the cleaning action of soap is called hard water.
- Hardness of water may be temporary or permanent.
- Temporary hardness of water can be removed either by boiling or by Clark's method.
- Water is considered as polluted and unfit for drinking when it is contaminated with substances (pollutants) which are harmful for human beings and other living organisms.

- Most detergents and washing powders contain phosphates, which are used to soften the water.
- Untreated sewage contains pathogens such as bacteria, viruses, and protozoan.
- Leachate contains decomposed organic matter, rust, newspaper ink, pesticides, fertilizer and other hazardous chemicals.
- This enrichment of nutrients in water bodies is called Eutrophication. It stimulates harmful over growth of algae, which can have direct toxic effect, as certain types of algae are toxic (red and brown).
- Pesticides affect and damage the nervous system, liver, reproductive organs, endocrine glands and DNA.
- Mercury accumulates in the blood, liver, kidneys and brain tissues. In young children it causes autism, brain damage, learning defects and incomplete mental development. In adults mercury causes Parkinson, Alzheimer's disease and heart disease.
- The warmer water decreases the solubility of oxygen and many aquatic organisms will die due to the shortage of oxygen.

EXERCISE

1. Choose the correct option for each of the following statements.

i) The total volume of water present on earth surface is,

a) 1.33 million km^3 b) 1.33 billion km^3

c) 1.33 trillion km^3 d) 1.71 km^3

ii) The vital function of protoplasm is due to the presence of,

a) Water b) Minerals

c) Fats d) calcium

iii) The quantity of fresh water present on earth surface is only about.

a) 2.6% b) 2.2%

c) 0.04% d) 0.2%

iv) In water, ratio of oxygen and hydrogen by mass is,

a) 2:1 b) 1:2

c) 8:1 d) 1:8

v) The reason of unusual physical properties of water is due to the presence of,

a) Hydrogen bonding b) Covalent bond

c) Coordinate covalent bond d) none of these

vi) The density of water is one gram per centimeter cube at,

a) 0°C b) 4°C

c) 60°C d) 100°C

vii) The volume of water increases, when its temperature decreases below,

a) 4°C b) 5°C

c) 10°C d) 20°C

viii) The enormous quantity of water present on earth surface act as giant thermostat, due to its high,

a) Boiling point b) Density

c) Heat capacity d) Latent heat values

ix) The latent heat of fusion of water is,

a) 41 kj/mol b) 6 kj/mol

c) 4.2 kj/mol d) 2.4 kj/mol

x) Dielectric constant of water at 18°C is,

a) 60 b) 68

c) 75 d) 80

xi) Water gas is a mixture of,

a) Steam & air
b) hydrogen & oxygen
c) Carbon monoxide & hydrogen
d) None of these

xii) Chlorine acts as bleaching agent in the presence of

a) HCl
b) H_2O
c) NaOH
d) HNO_3

xiii) The chemical formula of magnetic oxide is,

a) Fe_3O_4
b) Fe_2O_3
c) FeO
d) $Fe_2O_3.H_2O$

xiv) Rain water is acidic in nature, because air contain,

a) Oxygen
b) Carbon dioxide
c) Nitrogen
d) All of these

xv) Nutrient pollution of water bodies is caused by,

a) Pathogens
b) Calcium & Magnesium
c) Nitrates & Phosphates
d) Acid rain

xvi) Most of the aquatic animals can not survive above,

a) 20°C
b) 25°C
c) 30°C
d) 40°C

xvii) Which one of the following diseases is caused by mercury,

a) Parkinson
b) Cholera
c) Typhoid
d) Hepatitis

2. Give brief answers to each of the following questions.

i. Why the temperatures of the coastal areas remain moderate throughout the year?
ii. Why ice floats on the surface of water?
iii. Why H_2O is liquid at room temperature while H_2S is gas?
iv. How the enormous quantity of water present on earth surface acts as a giant thermostat?
v. Why water has soothing effect on the body in summer?
vi. Why water is a universal solvent? Explain.
vii. The aqueous solution of ammonium chloride is acidic. Why?
viii. Why fire starts burning on the surface of water, when a piece of sodium metal is put into it?
ix. Explain why it is advisable to drink boiled water.
x. Water extinguishes the burning coal. How both can be used as fuel?

xi. What is Eutrophication? How does it pollute water?

xii. What are the effects of chemical contamination?

xiii. Why chlorine acts as bleaching agent in the presence of water?

xiv. What is leachate? How does it gets dissolved in water?

xv. What is thermal pollution? How does it affect the aquatic life?

3. Comprehensive questions.

i. Describe the physical properties of water.

ii. Write balance chemical equations for the chemical reactions of water with the following.

(a) K (b) Ca (c) Zn (d) Fe

(e) Cl_2 (f) C (g) Na_2O (h) NO_2

(i) CH_3COONa

iii. Discuss the following.

a) Industrial wastes.

b) Household wastes.

iv. Describe in detail, the effects of water pollutants on life.

v. Water is an excellent solvent. Explain how this property is beneficial for life but sometimes a nuisance for us.