

# ENVIRONMENTAL CHEMISTRY-II

## WATER

### Conceptual Linkage

Before reading this chapter, the student must know the:

- Basics of pollution and its importance in our life
- Sources of pollution
- Basic characteristics of water

### Time Allocation

|                    |       |
|--------------------|-------|
| Teaching periods   | = 10  |
| Assessment periods | = 02  |
| Weightage          | = 08% |

### LEARNING OUTCOMES

Students will be able to:

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

### Introduction

Water is an essential part of all living forms on this planet, and without water no life is even thought to have the existence. Water which is

very important referred as “Hydrosphere” of the earth atmosphere. Although, the water is abundant in earth but the water actually available for the use of human beings is limited. Water scarcity is very common at majority of areas in earth. This scarcity is because of the distribution and usage of water. Water is an important essential for us and we use water in our daily life on a large scale, especially for drinking, washing cultivation and other purposes.

## 15.1 Water

Water constitutes an important part of our environment and covers 71% the Earth's surface, of this saltwater of oceans and ground saline water holds 97.5%, The 2.5% is the fresh water. This fresh water glaciers and polar ice caps hold 68.7%, 30.1% of this fresh water is the ground water, available for our use. It means that only a small fraction of the total water content of the earth is available for us, which is about 0.7%.

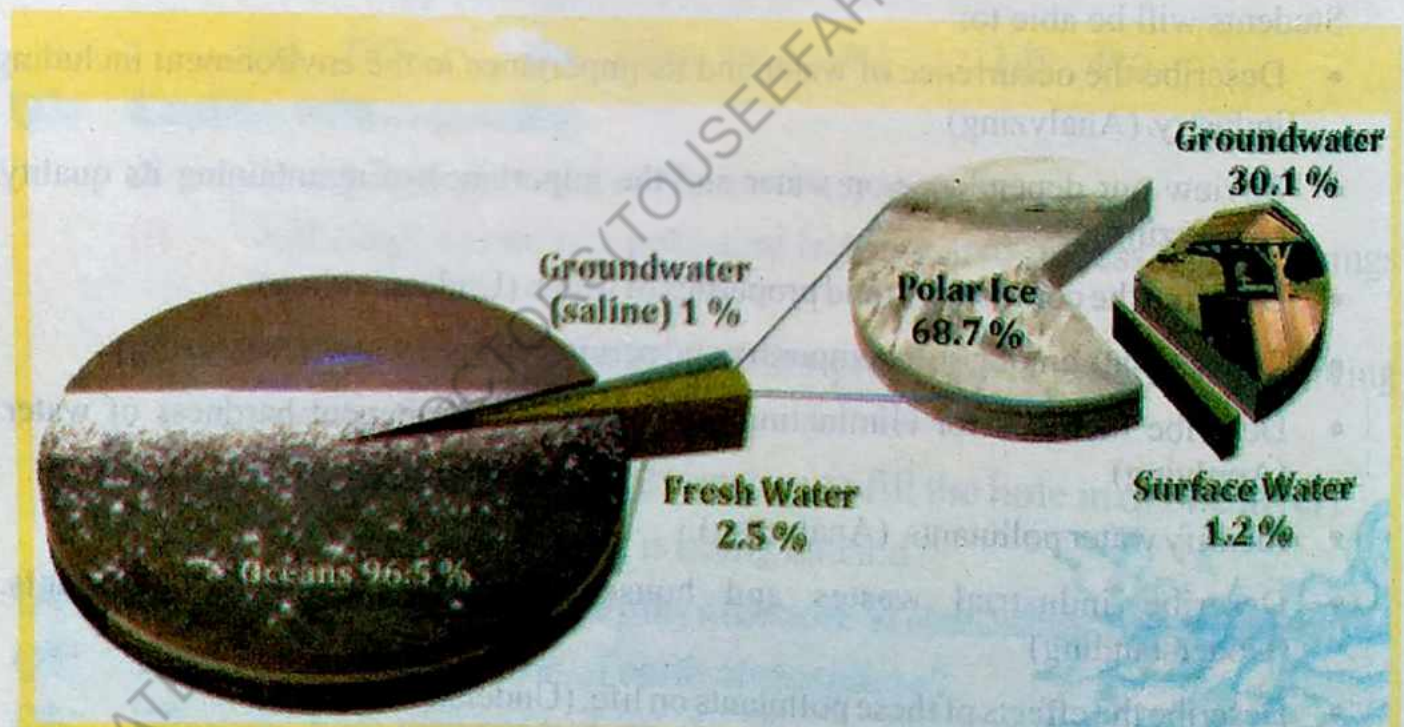


Fig. 15.1: Water resources on earth

Water captured in all of the above stated forms moves perpetually through the water cycle of evaporation, transpiration, precipitation, and runs off usually reaching the sea.

The water cycle is well explained by the following figure-15.2.

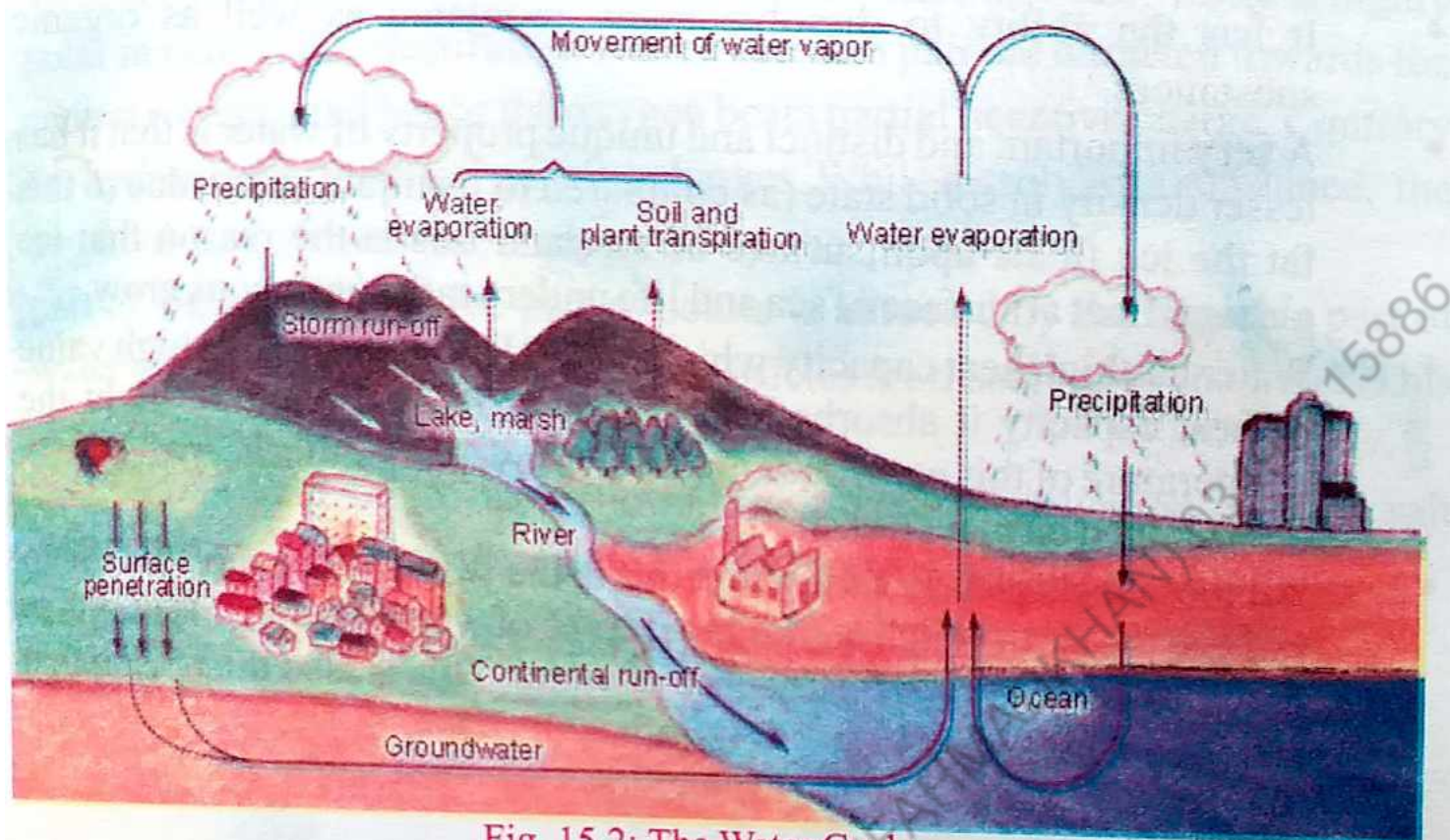


Fig. 15.2: The Water Cycle

The humans have been disturbing the water cycle from centuries and this disturbance has been accelerated with the beginning of industrialization. Mostly the sewage of industries is excreted through the same passage that the water uses for its flow in nature and hence the problem of polluting the water arises in major.

The use of polluted water causes many diseases to living organisms and thus endangers the life of the planet. This is also a duty of environmental chemists and scientists to overcome such situations. In this chapter we will discuss the water, its basic properties and the problem of water pollution and its prevention measures in detail.

### 15.1.1 Properties of Water

Pure water shows some very interesting features, it is colourless, and tasteless compound having molecular formula  $H_2O$  having following important characters:

- At normal temperature and pressure it occurs in liquid state.
- It is neutral compound and does not shows any acidic or basic properties.

- It has the ability to dissolve many inorganic as well as organic substances.
- A very important and distinct and unique property of water is that it has lesser density in solid state (as compared to its liquid state), due to this fact the ice floats upon surface of sea, and this is the reason that ice glaciers float at surface of sea and life underneath continuously grows.
- Water has high heat capacity which is  $4.18 \text{ Jg}^{-1} \text{C}^{-1}$ , due to this high value of heat capacity it absorbs heat energy at day time and at night the temperature of this earth does not fall to low values this keeps the life to be sustained on planet earth.
- All these facts clearly show that this is the water, that keeps the life to run and the earth which has large reserves of water (about 3/4) is able to carry life due to this high quantity of water. This is also the reason that scientists while exploring life on other planets see the presence of water first on a prior basis.

## 15.2 Water as a solvent

Water is an excellent solvent, and it dissolves most of inorganic and many organic compounds.

The chemical formula of water shows that it is composed of two types of atoms i.e. the oxygen and the hydrogen atoms these atoms are linked with each other with an angle of  $104.45^\circ$  between the 'H- $\ddot{\text{O}}$ -H' atoms, and the distance between the 'O-H' is  $0.9584 \text{ \AA}$ .

Pure water boils at  $100^\circ \text{C}$  and freezes at  $0^\circ \text{C}$ .

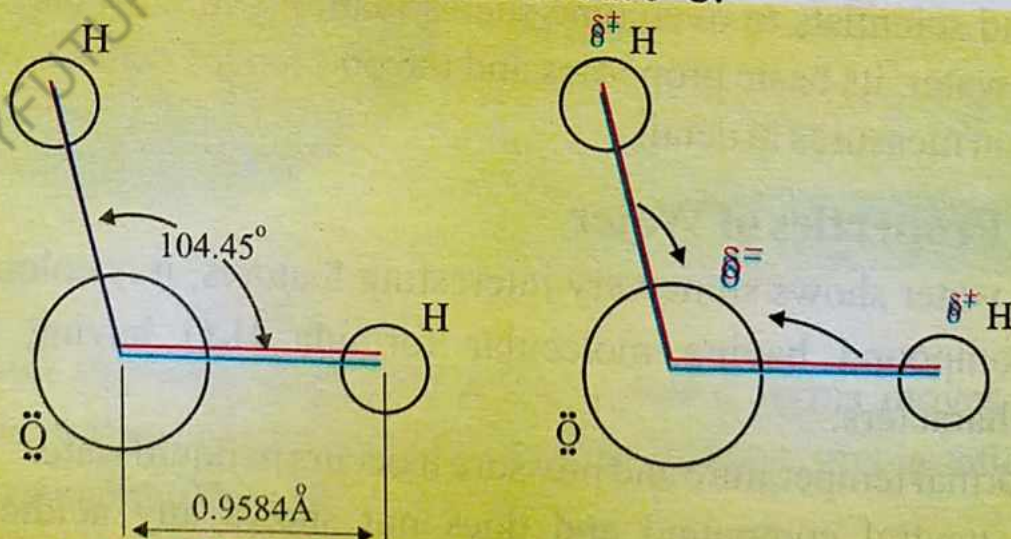


Fig. 15.3: (a) Molecular structure of water showing angles between H-O-H (b) Polarity in Water Molecule

This high solubility is due to the polar nature of water. Water is highly polar in nature, the electrons of shared electron pair are attracted towards the central oxygen, and hence the oxygen bears partial negative charge, Contrary the hydrogen bears partial positive charges. While dissolving a substance, the negative part of the solute is captured by the positive part of water, and positive part of solute is attracted by the negative part of water molecule, and hence the solute particles are dissolved by the water. This process is termed as solvation.

Following figure-15.5 shows this process of solvation of table salt (NaCl), enabling you to understand the phenomenon easily.

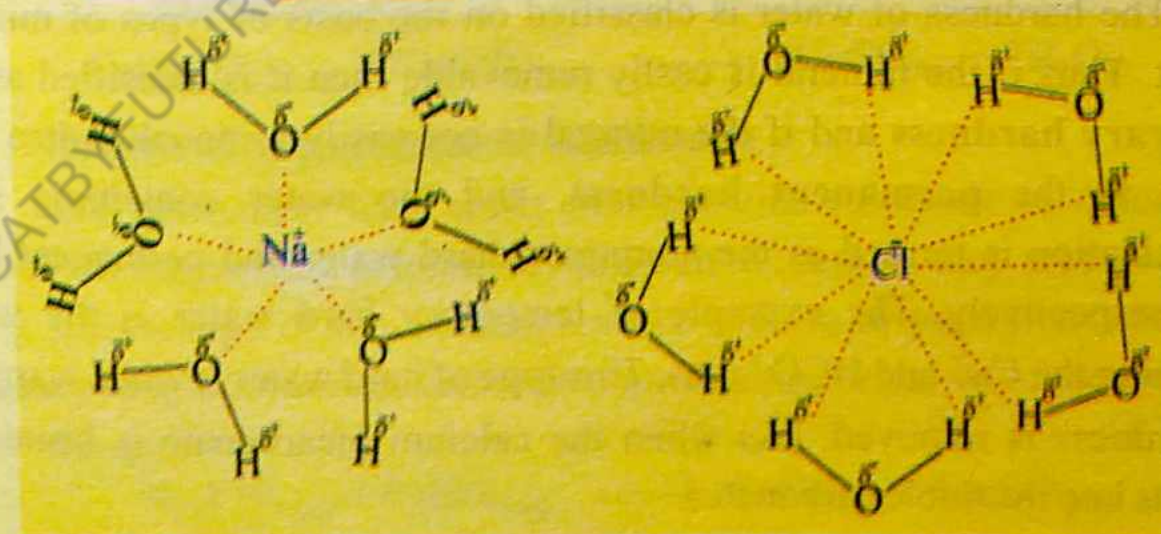
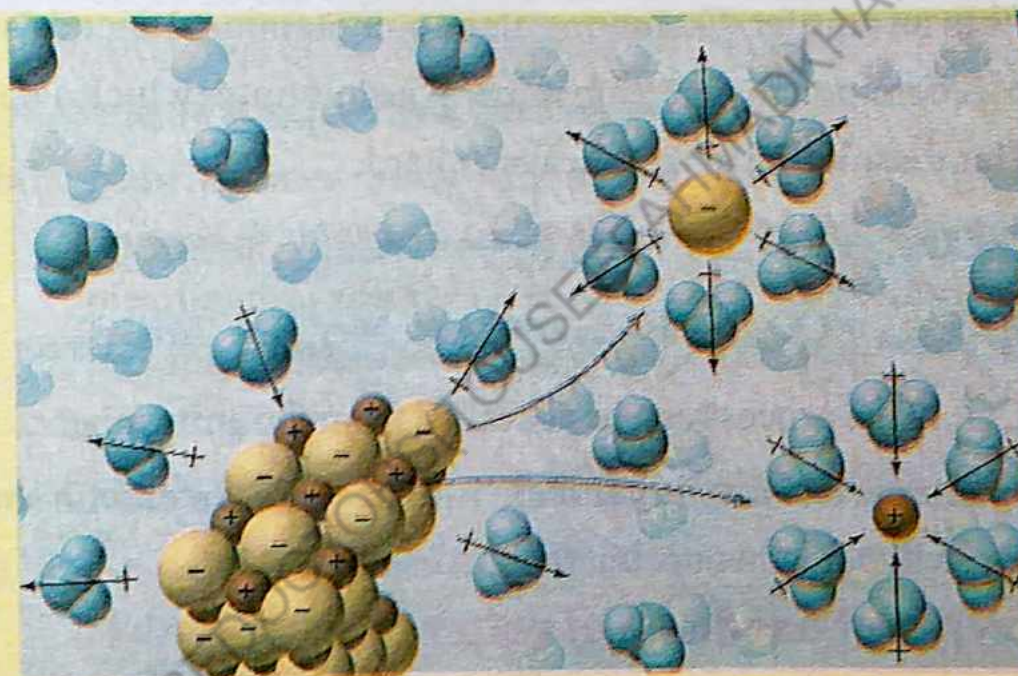


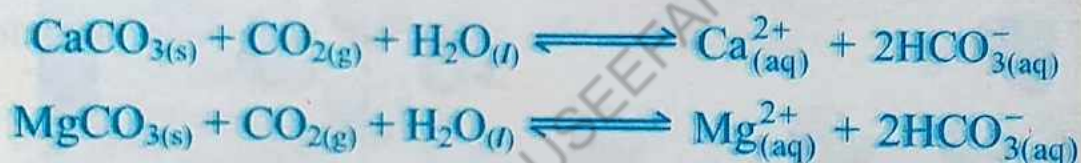
Fig. 15.4: Solvation process of water and NaCl

So this is clear that upon solvation the polar substances breakup into ions and these ions are masked by the water molecule (through their poles), and thus some new forces develop in this solute—solvent interaction.

### 15.3 Soft and hard water

The term hard water is used for the water which is rich in mineral contents, especially calcium or magnesium ions and their bicarbonates and sulphates.

When rain water passes through the locations where the source of these ions are located, usually these ions enter a water supply by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum. A common magnesium mineral is dolomite (which also contains calcium). This dissolution makes the water hard.



The  $\text{CO}_2$  in the process can be absorbed from the atmosphere.

A very simple test for the hardness is to treat the water with soap, if the water is hard it will not lather up, but the soft easily lathers.

### 15.4 Types of hardness of water

The hardness of water is classified on the basis of types of mineral content. Thus if the mineral is easily removable then it is classified as the **temporary hardness** and if the mineral is not easily removable then it is termed as the **permanent hardness**, and the water containing such contamination is termed as the temporary hard water and permanent hard water respectively. The example of temporary hard water is the water containing the  $\text{Ca}^{2+}$  and  $\text{HCO}_3^-$  ions. This type of hard water is when warmed, the hardness is removed, (As when the calcium bicarbonate is heated, it converts into insoluble carbonate).



The insoluble carbonate settles down and simple decantation gives water free of this.

The permanent hardness is that which cannot be removed by simple methods. In such hardness the sulphates of  $\text{Ca}^{2+}$  or  $\text{Mg}^{2+}$  or both are present as mineral contents, which become more soluble by heating so they can't be removed by heating. Although some complex methods are available for softening of this type, e.g. ion exchange method.

## 15.5 Methods of removing hardness

Several methods are available for water softening, these methods largely depends upon the type of ions that have made the water hard. Thus there are two categories of removing hardness of water.

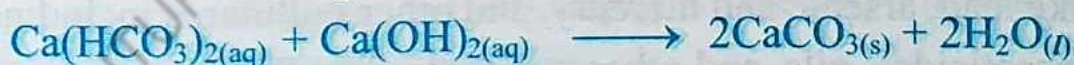
### I) Removal of temporary hardness:

This type of hardness is relatively easy to remove,

- i) **Removing hardness by boiling:** When the water is boiled the bicarbonate changes to insoluble carbonates, these solid precipitates can be easily removed just by decantation or filtration. e.g.

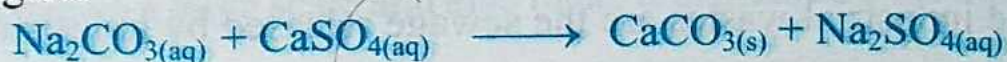


- ii) **The Clark's method:** This method involves the addition of slaked lime, this converts dissolved bicarbonates into insoluble carbonates. e.g.



### II) Removal of permanent hardness:

The permanent hard water that contains sulphates or chlorides of calcium or magnesium is relatively difficult to remove, they are removed by using special type of ion exchangers like sodium or potassium zeolites or soluble sodium/potassium carbonates (or washing soda) which serve also as ion exchangers.



## 15.6 Disadvantages of using hard water

The hard water usage has many disadvantages; some of these disadvantages are discussed following.

In the hard water the soap or shampoo does not lathers up and so cleaning the skin, scalp or the cloths is not achieved in a good manner. Similarly, the insoluble salts that get left behind from using regular shampoo in hard water tend to leave hair rougher and harder to detangle.

A very serious problem is that the salts in hard water deposits in boilers and pipes, these deposits can even block the passage of steam flow and the system can blow up. Such accidents have caused loss of lives many times.



Fig. 15.5: Salts deposition inside of boiler pipes

## 15.7 The Water pollution

The term "water pollution" is described to represent the adverse effect upon the water contents, like lakes, rivers, oceans, or ground water by contaminations made by humans. The water pollution has many causes, but the important one is the wastes discharged by the industries that contain heavy metals like lead, arsenic and mercury, and other pollutants including organic toxins, insecticides, oils, and other materials. The Water pollution is a great problem faced by the human beings, and is the direct result of industrialization. It has not only endangered the water life and ecosystem but also to the human beings directly and indirectly. Following are the important types of wastes responsible for the water pollution.

### 15.7.1 Industrial wastes

The industrial wastes are the sewage released by industries or mines. These wastes are released in large amounts and have caused a great damage to

living beings at many areas of the world due to having toxic substances dissolved in it.



Fig. 15.6: Contaminated water from industries

Such releases include heavy metals, organic wastes and many other toxic substances endangers the aquatic life and when such contaminated species are taken as a food by humans or used for cultivation or drinking purposes, also has a fatal effect to them.

### 15.7.2 Household wastes

The household wastes that pollute the water resources mainly consists of organic debris, which on mixing with ground water resources makes it unfavorable for drinking. These debris may also contain germs of various diseases, such as hepatitis, cholera, GIT (Gastro Intestinal Tract), typhoid and many others. Beside organic debris, there are many other pollutants on household level that pollute the water, these include insecticides or pesticides, lye preparations, food wastes, and very important the polyethylene products.

### 15.7.3 Agriculture wastes

The agriculture wastes mainly consists of pesticides preparations, which when sprayed are then washed away to near water reservoirs and thus pollute them on large scale, killing the life forms there and thus causing a great ecological problem. The other agriculture wastes are different types of fertilizers (both organic and inorganic). These fertilizers contaminate the drinking water on a large scale and also make it difficult for the aquatic life to survive.

## 15.8 Water borne diseases

The water borne diseases are those which are caused by drinking or handling contaminated water. There are many cases where the contaminated water has caused death to living organisms directly, especially when contaminated by the pesticide preparations and mercury compounds. Some contaminations like high fluoride content can cause abnormalities to bone formations. The acid rain also has an adverse effect upon the living organisms.

The sewage of industries is excreted in water channels which contains harmful poisoning compounds, the fish and other life forms dwelling in the water channels are then become affected by this polluted water, thus the contaminations in the sewage enters into food chain, such contaminated fishes when eaten by the birds and animals (including humans) show an adverse effect on their life.

Not only the chemically polluted water is injurious to the ecosystem but biological contaminations that include the micro organisms are evenly polluting the water sources and affecting the living organisms directly.

There is also a large list of diseases caused by the germs that nourish in contaminated water. Some most common in our country are following.

### **Gastro or Gastric intestinal diseases:**

Intestinal diseases usually called Gastro are the most common in our country which is caused by the usage of contaminated water. This kills thousands of humans each year. The main diseases of this series include Cholera and diarrhea.

### **Hepatitis**

The hepatitis is the disease that damages liver and is caused by a virus which is mainly present in the contaminated water.

### **GIT worms**

There are many worms that live in the gastro intestinal tract (GIT) of humans, especially in the small intestine. These worms include Round

worms, Hook worms, Tap worms, Pin worms and Whip worms etc. Again the main reason of their introduction and transmission is the contaminated water. These worms cause diarrhea, Anemia, Itching, Irritation of GIT and rectum.

### **Jaundice**

Jaundice is a yellow discoloration of the skin, mucous membranes, and the whites of the eyes caused by increased amounts of bilirubin in the blood. GIT is a sign of an underlying disease process. The jaundice is often seen in liver disease such as hepatitis or liver cancer. It may also indicate obstruction of the biliary tract, for example by gallstones or pancreatic cancer.

### **Typhoid fever:**

Typhoid fever is a bacterial disease which is caused and spreads by the use of contaminated water. This is a fatal disease if not treated well.

Beside these diseases stated above there is a number of diseases which are linked indirectly with the contaminated water e.g. the Malaria. In fact most of the bacteria and virus have their life cycle in water hence contaminated water is the main cause of the diseases they cause.

### **Interesting Information**

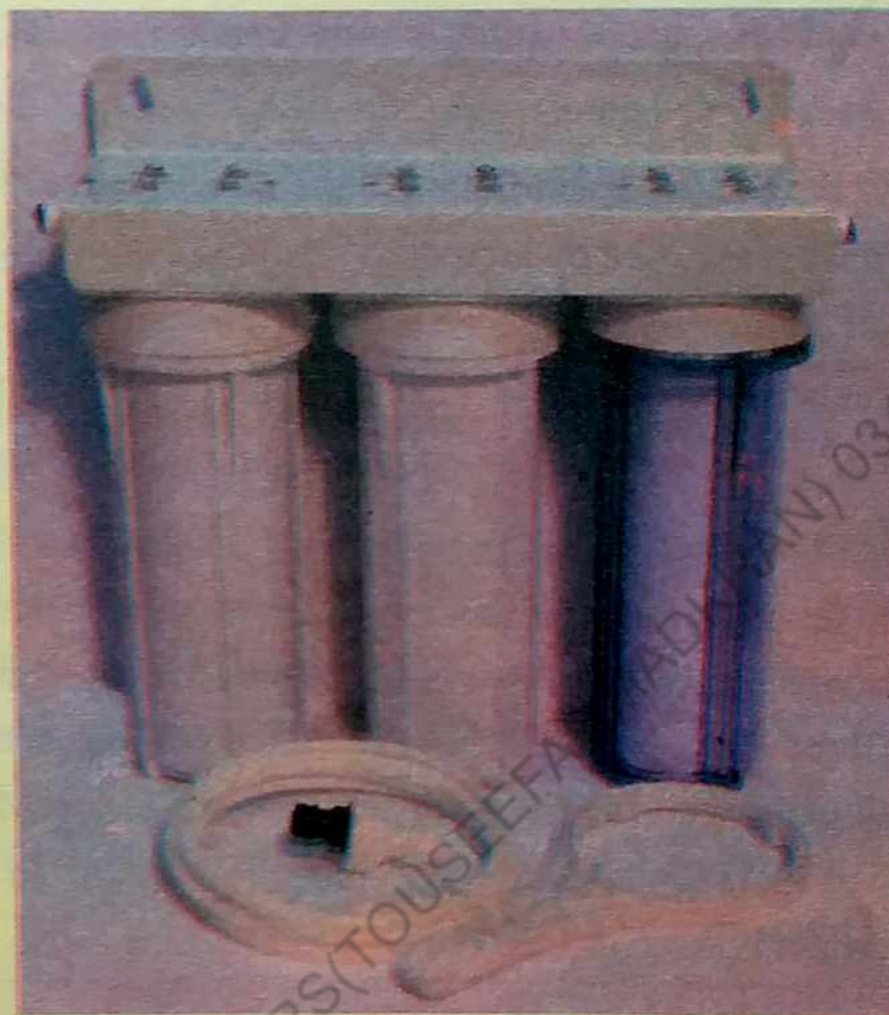
A quick and easy way to obtain good quality drinkable water is the use of 3 stage advanced filtration processed water filters. This uses a combination of Sediment Filter, Activated Carbon Filter and UV Disinfection to give safe drinking water.

The Sediment filtration unit acts as a sieve to remove the particulate matter of specific size present in the water.

The second unit which is usually consisting of activated charcoal carbon filter which is actually a porous substance and is used to absorb both organic and inorganic odourous and coloured substances from water.

The third and final unit is an Ultraviolet light energy producing unit and it acts to kill the germs and microorganisms present in the water. Hence after passing from three units the water obtained is of good quality for drinking purpose.

But remember the units especially the charcoal one has to be replaced when the pores are filled up with particles.



## Summary of the Chapter

- ❖ Water forms an essential part of earth, and forms Hydrosphere of the planet.
- ❖ About 97.5% of the total water content is saline and unusable for general use.
- ❖ Only 0.7% of the total water can be used for drinking and other usage by humans.
- ❖ Water captured in different forms moves perpetually through the water cycle of evaporation, transpiration, precipitation, and runs off reaching the sea.
- ❖ Pure water is a colourless, odourless, and tasteless but the water we use has taste due to different dissolved salts, as water is an excellent solvent.
- ❖ If water has dissolved bicarbonates or sulphates of calcium or magnesium, it is said to be hard water.
- ❖ Hard water causes diarrhea on drinking, and does not produces lather with soap, and upon boiling salts are deposited on inner walls of pipes and boilers.
- ❖ When water is contaminated with chemicals and microorganisms that make it disease causing, it is called polluted water.
- ❖ There are many sources that contaminate water; these sources could be from industries, house hold wastages, from microorganisms, or other human activities.
- ❖ The polluted water causes many diseases.

## Exercise

**Q1: Fill in the blanks with suitable words.**

- i) Water covers ..... % of the earth.
- ii) Fresh water reserves are ..... % of total water content of earth.
- iii) Pure water has ..... smell.
- iv) The water can dissolve most of the ..... and some ..... compounds.
- v) The water in the Antarctic ice sheet constitute ..... % of fresh reservoir.
- vi) The percentage of water out of total water content that we can drink is .....
- vii) Water pollution is caused due to dissolved ..... and .....
- viii) Gastro is caused by .....
- ix) Jaundice is recognized by ..... pigmentation of body parts.
- x) High Fluoride content causes ..... disease.

**Q2: Choose the correct answer.**

- i) Pure water has the taste:
  - (a) Salty
  - (b) Sweet
  - (c) sour
  - (d) tasteless
- ii) The hard water contains the bicarbonates and sulphates of:
  - (a) Ca
  - (b) Mg
  - (c) both of these
  - (d) none of these
- iii) The major responsibility for polluting the water goes to:
  - (a) humans
  - (b) Animals
  - (c) natural disasters
  - (d) died fishes
- iv) The hard water can be drunk safely:
  - (a) true
  - (b) false

- (c) depends upon the type of impurity
- (d) none of above
- v) The hard water can be used for washing:
  - (a) quite easily
  - (b) with difficulty
  - (c) can not be used
  - (d) hard water does not exists
- vi) The percentage of water locked in polar ice sheet is:
  - (a) 68.7%
  - (b) 2%
  - (c) 1%
  - (d) 30%
- vii) The largest fresh water source of earth is:
  - (a) Oceans
  - (b) Rivers
  - (c) Ground water resources
  - (d) Polar ice caps
- viii) Solvation is the process that makes:
  - (a) Solution
  - (b) Pure water
  - (c) Desalinated water
  - (d) Mineral water
- ix) The hard water is the water that contains ions of metal bicarbonate, sulphate or chloride ionis of:
  - (a) Mg only
  - (b) Sulphates
  - (c) Phosphates
  - (d) Calcium or Magnesium
- x) The major cause of water pollution is:
  - (a) Sewage of Industries
  - (b) Acid rains
  - (c) Chlorofluoro carbons
  - (d) improper water channels

**Q3: Explain with reasoning.**

- i) The rain water is always soft in nature.
- ii) How UV energy can be used to make water drinkable?
- iii) Although the pure water is tasteless, but when we buy bottled water it shows marked taste.
- iv) Use of Pesticides should not be encouraged.
- v) How Malaria fever is associated with water?

**Q4: How the water effects our environment?**

**Q5: What is the difference between the hard and soft water? Can the hardness be removed?**

**Q6: Why water dissolves the most of common compounds?**

**Q7: Write a note on water pollution.**

**Q8: How can the untreated water can be made fit for drinking?**