



15

ENVIRONMENTAL CHEMISTRY II: WATER



After completing this lesson, you will be able to:

**This is 12 days lesson
(period including homework)**

- 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 hard water.
- Describe methods for eliminating 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 waterborne diseases.
- Test water quality by checking its color, odor, hardness and conductivity.
- Determine the boiling point of water.
- Perform distillation of impure water samples.
- Explain how hard water hampers the cleansing action of soap.
- Explain how and why water treatment is essential for water to be drinkable.
- Compare modern water treatment and sewage treatment centers and processes.
- Explain how chemistry helps maintain a clean swimming pool.



Reading

Where does the water in your kitchen and bathroom come from? Because water comes from different sources, it varies in quality. Would you drink water that has colour, bad taste or unpleasant odour? In the morning when you get up, what do you do? You brush your teeth, take shower, flush the toilet etc. What happens to the water that goes down the drain? Can you use this water again? Waste water is often dumped into open gutters and allowed to run directly into streams, rivers and oceans. This practice spreads diseases and threatens aquatic life also. How? This you will learn in this chapter. The presence of disease causing bacteria affects the quality of water. Water from both public and private supplies often needs some kind of treatment



to ensure that it is clean and safe to drink. Waste water should also be passed through some treatment process to remove un-wanted substances, before it is released into lakes, rivers or oceans. Otherwise, it would also affect marine life and through food chain, the human beings. This knowledge will help you in grade XII to understand

- Water quality
- Waste water treatment.

15.1 PROPERTIES OF WATER

15.1.1 Occurrence:

Water is one of the most important substances on Earth. It is present in enormous quantity on Earth. It has been estimated that total amount of water present on earth is about 1.33 billion cubic kilometers which nearly covers 71% of the Earth's crust. Figure 15.1 shows the distribution of water on earth.

Although an enormous amount of water is found on the Earth, but the fresh water available to man is only 0.2% of the total. Even this small percentage of water is not evenly distributed. Some areas are rich in fresh water while certain areas have little or no fresh water.

Sea water contains large amount of dissolved salts. Sodium chloride is the most abundant salt in sea water. It is present up to 3.4% in it. This water is unfit for human use.

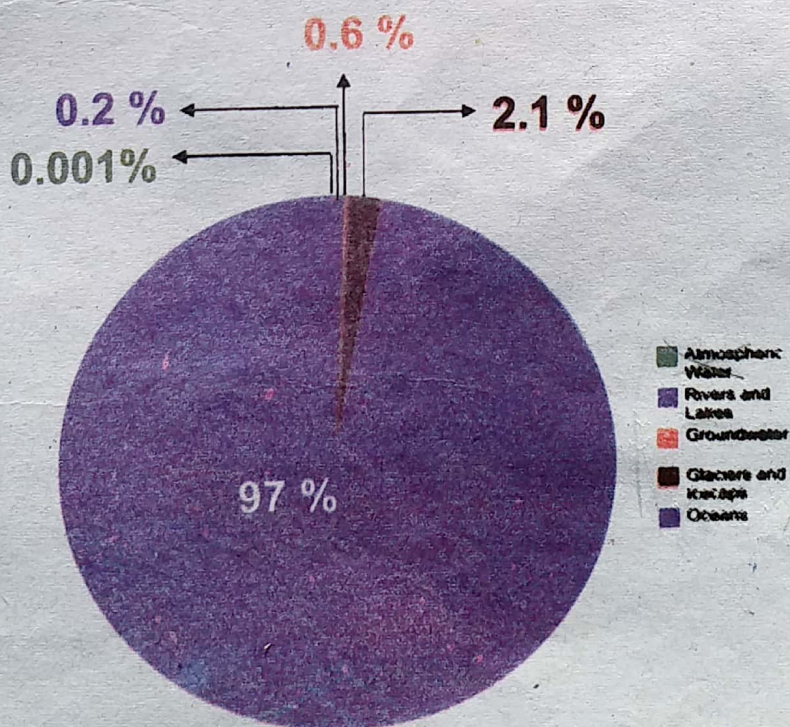


Figure 15.1 Distribution of water on Earth



15.1.2 Importance of water

Earth is the only planet in the solar system that contains water. All living things need water for their survival. You can live without food for 3 to 4 weeks, but cannot survive without water for more than 3 or 4 days. Our body cannot work without water just as car cannot run without gas or oil. In fact, all the cell and organ functions of our body depend on water. It serves as a lubricant in digestion and joints. The water in saliva helps facilitate chewing and swallowing. Water also regulates our body temperature, through perspiration.

- Water is crucial for sustaining the reactions that keep us alive. For instance digestion, distribution of food through blood, removal of waste matter from the body.
- It cools automobile engines, nuclear power plants, steel mills and parts of heavy machinery in industrial units.
- It provides means of transportation on the earth surface.
- Farmers need a large amount of water for their fields for growing fruits, vegetables and crops.
- We need water for drinking, cooking and cleaning.
- It is also used to generate electricity.



Self-Assessment Exercise 15.1

List household, industrial and agricultural uses of water

15.1.3 Properties of water:

- Water is the only substance that exists in three different states on Earth. Can you name these states?
- Pure water is transparent, colourless, odourless and tasteless. It boils at 100°C and freezes at 0°C at the sea level.
- Density of most of the solids and liquids, generally increases on heating and decreases on cooling. Water, however, shows strange behavior in this regard. On cooling it contracts up to 4°C . At this temperature its density becomes maximum. On further cooling water expands, hence its density decreases. So water expands when freezes. Because of this ice floats on the top of water. The consequences of this strange behavior are immense for life on earth. Ice forms on the surfaces of lakes only and insulates the lower layers of water. This enables fish and other aquatic organisms to survive in winter.
- Water has a high **heat capacity**. So much heat is required to raise the temperature of 1.0 g of water by 1°C . Conversely, much heat is given off by water for even a small drop in temperature. The vast amount of water on the surface of Earth thus acts as a giant heat



reservoir to moderate daily temperature variations. For this reason water is an excellent cooler in industries.

- Water has a high heat of **vaporization**. So a large amount of heat is required to evaporate small amount of water. This is of enormous importance for us. How? Large amount of body heat can be dissipated by the evaporation of small amount of water (perspiration) from the skin. This property also accounts for the climate-modifying property of lakes and oceans. Thus in summer it is cooler near a large water body of water (lakes, river, and seas) than in interior land areas.

15.1.4 Composition of Water

How can you split water?

Water is normally a poor conductor of electricity. However, when electricity is passed through acidified water in a voltameter, water decomposes (Figure 15.2). It gives hydrogen and oxygen. At which electrode hydrogen is produced?

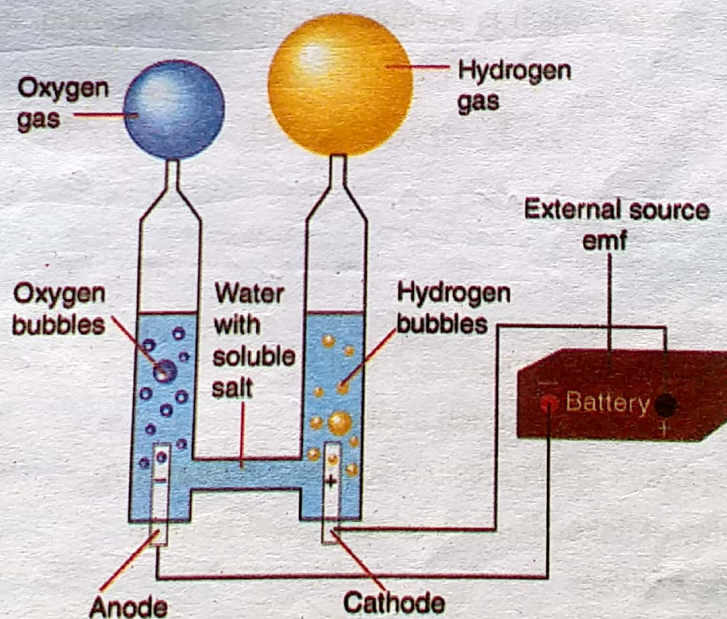
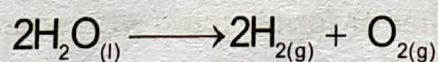


Figure 15.2 The electrolysis of water

The process is called electrolysis and the reaction can be written as



The splitting of water molecules produces double amount of hydrogen as compared to oxygen. This means hydrogen and oxygen in water are in the ratio of **2:1** by volume.

15.2 WATER AS SOLVENT

Water is very good at dissolving substances. For this reason natural water such as rainwater and groundwater is not pure water. As water falls through the atmosphere, it dissolves, a little oxygen, nitrogen, carbon dioxide, and dust particles. During thunder storms, it also



dissolves nitric acid. Ground water dissolves minerals from rocks and soils as it moves along on or beneath Earth's surface. Ground water also dissolves many substances from decaying plants and animals.

The ability of water to dissolve a wide variety of substances is due to its two properties, the polarity of water molecules and the ability of water molecules to form hydrogen bonds. You have learned about these properties in grade IX. Water molecules are strongly attracted to ions and polar molecules with which water can form hydrogen bonds. If these attractions are strong enough, they overcome the attractions between the molecules or ions of the other substance and in this way the substance dissolves. Thus water soluble substances include a wide range of substances. They may be ionic solids, polar substances and hydrogen bonded compounds.

Water quality is defined by its physical, chemical, biological and aesthetic characteristics. A healthy environment is one in which the water quality supports community of organisms and protect public health. If water quality is not maintained, not only environment will suffer but the commercial and recreational value of our water resources will also diminish. Many of our own uses depend on water quality, which is suitable for drinking. Washing, irrigation, fishing and recreation.

15.3 SOFT AND HARD WATER



Activity 15.1

- Take two beakers and label them as A and B.
- Place 50 cm³ distilled water in each beaker.
- Dissolve small amount of magnesium sulphate in beaker A.
- Put small quantity of flaked laundry soap in each beaker.
- Stir well both the beakers.
- What happens?

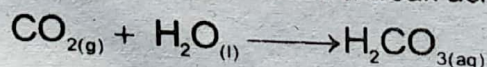
Water that easily gives lather with soap and does not form scum is called soft water.

Water that gives little lather or forms scum with soap is called hard water.

Which water is soft, tap water or distilled water?

Have you ever noticed that the pan which is regularly used for boiling water gets white or yellowish deposits at its bottom and sides?

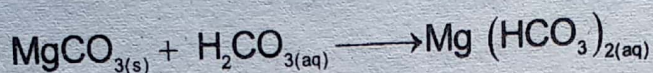
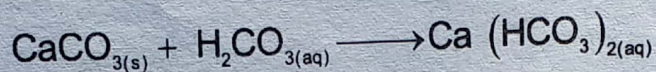
Rainwater dissolves carbon dioxide as it falls through the atmosphere. Carbon dioxide reacts with water to produce carbonic acid, which is a weak acid.





15 Environmental Chemistry II: Water

This carbonated water passes over or through the rocks containing calcium carbonate or magnesium carbonate, the acid present in it attacks these rocks. It slowly dissolves them, forming calcium and magnesium hydrogen carbonates.



Some rocks may contain gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) or anhydride (CaSO_4) or Kieserite ($\text{MgSO}_4 \cdot \text{H}_2\text{O}$) which is sparingly soluble in water. The presence of these dissolved salts causes the water to become hard.



Self-Assessment Exercise 15.2

1. List substances that cause hardness in water,
2. Differentiate between soft and hard water.

15.4 TYPES OF HARDNESS OF WATER.



Activity 15.2

- Take two beakers and label them as A and B.
- Place 50 cm³ of distilled water in beaker A and 50 cm³ tap water in beaker B.
- Mix small amount of calcium or magnesium sulphate in beaker A.
- Heat both the beaker on burner to boil water.
- Continue boiling for some time and cool.
- Add small amount of flaked laundry soap in each beaker.
- Stir well and observe.
- Which water produces good lather with soap?

Hardness in water can be divided into two types, **temporary** and **permanent**.

Temporary hardness is so called because it can be removed by boiling.

Permanent hardness is so called because it cannot be removed by boiling

Temporary hardness is caused by the presence of dissolved calcium or magnesium hydrogen carbonates. Whereas permanent hardness is caused by the presence of dissolved sulphates and chlorides of calcium or magnesium.



Hard water hampers cleansing action of soap. Hard water keeps soap from getting laundry and dishes really clean, causing to spend more on extra soap and cleaning products.

Society, Technology and Science

It is difficult to make the soap lather in hard water. Instead, the water becomes cloudy. This cloudiness is due to the formation of a white precipitate by the reaction of Ca^{+2} or Mg^{+2} ions present in hard water and soap. This white precipitate is known as scum. Hard water leaves scum on the fabrics, which gives a grey or yellow appearance to white fabrics. (So hard water hampers cleansing action of soap. *Why?*)

Science Titbits

To overcome the problem of scum formation in hard water, detergents have been produced. Detergents do not produce a scum. This is because they do not react with calcium or magnesium ions present in hard water. Also detergent molecules are biodegradable. Bacteria can easily break these molecules, So they do not persists in the environment.

15.5 METHODS OF REMOVING HARDNESS



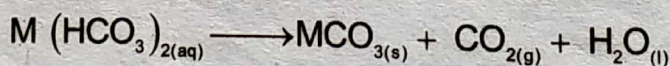
Activity 15.3

- Take some temporary hard water in a pan.
- Heat it to make water boil.
- Boil it for about 10 to 15 minutes.
- Cool it and test with soap, what happens?

a) Methods to remove temporary hardness

i) By Boiling

Hardness of water can be removed simply by boiling. During boiling the soluble calcium and magnesium hydrogen carbonates are decomposed forming insoluble carbonates. Since Ca^{+2} and Mg^{+2} ions are removed as insoluble carbonates, water becomes soft.



Where $\text{M} = \text{Ca}^{+2}$ or Mg^{+2}

Unfortunately, this method is too expensive to remove temporary hardness of water on the large scale.



Self-Assessment Exercise 15.3

Write chemical equations to show the changes that occur when hard water containing calcium hydrogen carbonate and Calcium hydrogen carbonate is boiled.

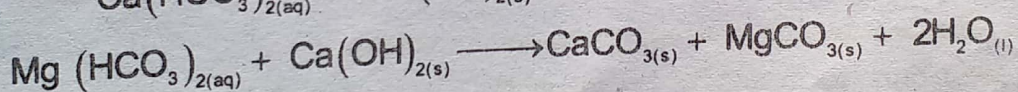
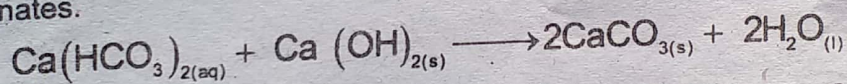


Activity 15.4

- Place some temporary hard water in a pan.
- Add small amount of slaked lime, $\text{Ca}(\text{OH})_2$ in it.
- Mix it well and leave for some time.
- Transfer, supernatant liquid in another pan.
- Mix some soap in it.
- What happens?

ii) By adding slaked lime (Clark's method)

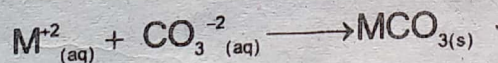
Temporary hardness in water on the large scale can be removed by adding an estimated amount of slaked lime in it. The slaked lime reacts with the hydrogen carbonates to form insoluble carbonates.



b) Methods to remove permanent hardness

i) By adding washing soda.

On the large scale permanent hardness in water can be removed by adding washing soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$). Ca^{+2} and Mg^{+2} ions are removed as their insoluble carbonates.



Where $\text{M} = \text{Ca}^{+2}, \text{Mg}^{+2}$

ii) By Ion Exchange Resins

The hard water is passed through a container filled with a suitable resin containing sodium ions. Zeolite is one of the natural ion exchanger. Chemically it is sodium aluminum silicate. It is usually written as Na_2Z . The Ca^{+2} or Mg^{+2} ions causing the hardness are exchanged with Na^+ ions in the resin.



Where $\text{M}^{+2} = \text{Ca}^{+2}, \text{Mg}^{+2}$



The used up zeolite can be regenerated by heating with concentrated solution of NaCl. This makes the process economical.



Self-Assessment Exercise 15.4

Complete the following reactions

- i) $\text{Ca}(\text{HCO}_3)_{2(aq)} \xrightarrow{\text{heat}}$
- ii) $\text{Ca}(\text{HCO}_3)_{2(aq)} + \text{Ca}(\text{OH})_2 \longrightarrow$
- iii) $\text{Ca}^{+2}_{(aq)} + \text{Na}_2\text{Z} \longrightarrow$
- iv) $\text{Mg}^{+2}_{(aq)} + \text{Na}_2\text{Z} \longrightarrow$
- v) $\text{Mg}^{+2}_{(aq)} + \text{CO}_3^{-2}_{(aq)} \longrightarrow$
- vi) $\text{Ca}^{+2}_{(aq)} + \text{CO}_3^{-2}_{(aq)} \longrightarrow$

15.6 DISADVANTAGES OF WATER HARDNESS

- Hard water wastes a lot of soap, when used for washing.
- The soap forms scum with hard water, which adhere to the clothes being washed. Scum can spoil the finish of some fabrics.
- Cause kettles to fur.
- Can cause hot water pipes, boilers and car radiators to block due to the formation of insoluble calcium and magnesium salts, causing great damage.

15.7 WATER POLLUTION

Water is very good at dissolving substances. This is due to the polarity of the water molecules and the ability of its molecules to form hydrogen bonds. As water from rain and snow flows over rocks and through soil, it dissolves minerals. The fresh water we drink or use for our daily life processes is a dilute solution containing a number of minerals. When these minerals are in sufficient concentration, water becomes unfit for human use. Many human activities also result in the contamination of the surface and ground water. Several forms of pollutants affect water bodies. The human activities such as (house hold wastes, agricultural wastes, livestock wastes, pesticides, oil leaks, detergents, septic tanks, petroleum; natural gas production) may result in contamination of water bodies. We will discuss about household wastes and industrial wastes in this unit. You will learn about other types of wastes in higher grades.

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(2)



15 Environmental Chemistry II: Water

Household Wastes

Household wastes include, human wastes, livestock wastes, soaps and detergents, paints and oil, food and vegetable wastes, garbage etc. Although detergents have strong cleansing action than soap, but they remain in water for a long time and make water unfit for aquatic life. When household water containing detergents is discharged in lakes, ponds, rivers etc. it causes death of aquatic life. Chemical and bacterial contents in household water can contaminate surface and underground water. Bacterial contents may cause infectious diseases such as cholera, jaundice, hepatitis, typhoid, dysentery etc.

Industrial Wastes

Manufacturing of industrial products is always accompanied by some by-products and waste effluents. These waste products may be in the form of waste heat, smoke, solid or waste water effluents. These wastes may contain highly toxic compounds and heavy metals such as Pd, Cd, Cr, Hg, As, Sb etc. These toxic substances cause serious health problems, such as nervous disorder, anemia, high blood pressure, kidney diseases, nausea, dizziness and cancer.

Industrial units generally discharge their wastes either to open land or into water bodies, lakes, ponds, rivers or oceans. Water from leather tanneries contains large quantities of chromium (VI) salts. Chromium (VI) ions are highly toxic and known to cause cancer. Industrial wastes cause irreversible degeneration of the environment causing serious health problems for public and marine life.

Society, Technology and Science

Water treatment is essential for many reasons.

- Through water purification, we can avoid drinking impure and contaminated water, which causes many epidemic diseases and unsafe for healthy life.
- It removes bacteria, viruses and parasites which may cause diarrhoea, dysentery, botulism, typhoid, cholera, polio and hepatitis.
- It also removes heavy metals like, As, ^{B, A}Bi, Cr and Pb which can cause long term neurological problems, kidney diseases, nausea, dizziness and cancer.
- It also improves the flavor and appearance.

Society, Technology and Science

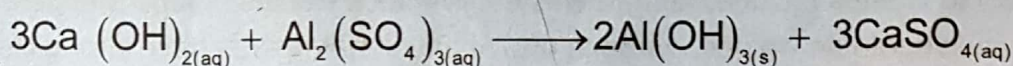
Raw Water treatment

The raw water is treated in a municipal water purification plant, to make it fit for drinking and domestic purposes (See figure 15.3). Various stages in this treatment are

1. **Sedimentation:** It is the process in which water is allowed to stand in a reservoir. The suspended matter sinks to the bottom.



- 2. Coagulation:** It is the process in which water is treated with slaked lime and alum. These materials react to form a gelatinous mass of aluminum hydroxide



The aluminum hydroxide carries down dirt particles and bacteria.

3. Filtration:

The water is then filtered through sand and gravel. Sometimes it is filtered through charcoal to remove coloured and odorous compounds.

4. Chlorination:

In the final step, chlorine is added to kill any remaining bacteria. Chlorine reacts with water to form hypochlorous acid HClO which kills bacteria.

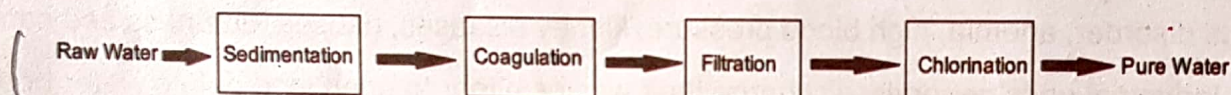


Figure 15.3: Flow sheet diagram for water purification plant

Long Question

Society, Technology and Science

Sewage Water Treatment

2016 Paper

In many countries, sewage water is passed through certain treatment stages before it is discharged into a lake, stream, river or ocean. This treatment involves following steps.

1. Primary sewage treatment

(See figure 15.4)

Primary treatment removes some of the solids as sludge. For this purpose waste water is allowed to stand in a large sedimentation tank to remove suspended particles.

2. Secondary Sewage Treatment

Effluent from the primary treatment is passed through sand and gravel filters. There is some aeration in this step, and aerobic bacteria convert most of the organic matter to stable inorganic materials.

3. Activated Sludge Treatment

The sewage is then placed in tanks and aerated with large blowers. This results in the formation of large, porous clumps, which absorb contaminants. The aerobic bacteria further convert the organic material to sludge. This sludge is stored on land or sometimes used as fertilizer.

4. Chlorination

The effluent from sewage plant is treated with chlorine to kill any remaining pathogenic microorganisms.

**Self-Assessment Exercise 15.5**

Compare modern water treatment and sewage treatment centers and processes.



Figure 15.4 Flow sheet diagram for primary sewage treatment plan

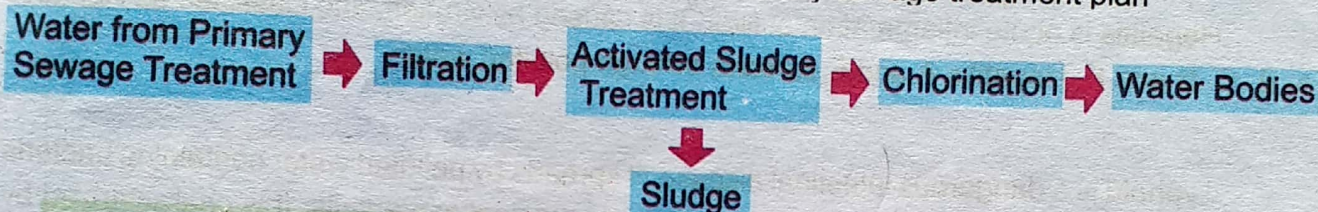


Figure 15.5 Flow sheet diagram for secondary sewage treatment plant

15.8. WATERBORNE DISEASE

Human wastes are dumped on the ground or into the nearest stream. Human waste contains pathogenic microorganisms. These organisms are transmitted through food, water and direct contact. These microorganisms may cause typhoid fever, dysentery and hepatitis. Chemical and bacterial contents in livestock waste can pollute surface and ground water causing above mentioned diseases. Hepatitis a viral disease occasionally spread through drinking water.

Unclean water supplies, poor sanitation and poor hygiene kill 2,668,000 people worldwide each year.

Water in swimming pools is purified from pathogenic organisms by aeration and chlorination.

Some waterborne diseases are given below.

Cholera

Cholera is an intestinal disease. It is caused by bacteria such as vibrio cholerae, E.coli etc. which may be present in water contaminated with human wastes. It is characterized by vomiting and purging.

Dysentery

Dysentery is also an intestinal disease. It is caused by parasite, Entamoeba. This infection is transmitted by faecal contamination of water or food by encysted organism. Patients have mild

Do you know?

Chlorination is not effective against viruses such as those that cause hepatitis.

Society, Technology and Science

Swimming is an important recreational activity. Biological contamination has also lessened the recreational value of water. However, aeration and chlorination treatment of swimming pool water has lessened the threat of biological contamination.



to severe abdominal cramps, diarrhea, chocolate coloured stool with mucous and sometimes with blood.

Jaundice

This disease proceeds from obstruction of liver. Excess of bile from the liver enters in the blood and causes yellowness of skin and eyes. It leads to loss of appetite, weakness and fatigue.

Hepatitis

Hepatitis is acute inflammation of liver. It is caused by viruses, and classified as Hepatitis A, B, C, D and E. Hepatitis A and E spreads through polluted water.

Typhoid

Typhoid is a dangerous intestinal disease. It spreads by polluted water containing bacteria such as salmonella typhi, salmonella paratyphi, and salmonella enteritidis. It is characterized by continuous fever between 101°F to 104°F and irregular pulse.



Self-Assessment Exercise 15.6

1. List some water borne diseases.
2. List sources of water borne diseases.
3. List steps used in sewage water treatment.
4. List steps used in raw water treatment.
5. Write effects produced by industrial wastes.
6. Write names of six household wastes.

SKILLS



Activity 15.5

To test water quality by checking its colour, odour, hardness and conductivity
Carry out the following:

Obtain water samples from nearest water body and carry out the following.

- Note its colour and odour.
- Check hardness as described in activity 15.4.
- Determine boiling point of water.
- Check the electrical conductivity of water.



- Good quality water is colourless, odorless and tasteless. It produces good lather with soap. Pure water has least conductivity. Pure water boils at 100°C

To purify impure water by distillation

.Perform this activity in the laboratory.

You will need:

- A round bottom flask with side arm, thermometer, a glass condenser, a conical flask.
- Tripod stand, plastic tubes, stand, Bunsen burner.
- Sample of impure water.

Carry out the following:

1. Place water sample in the round bottom flask and place it on the tripod stand.
2. Fix thermometer on the mouth of the flask.

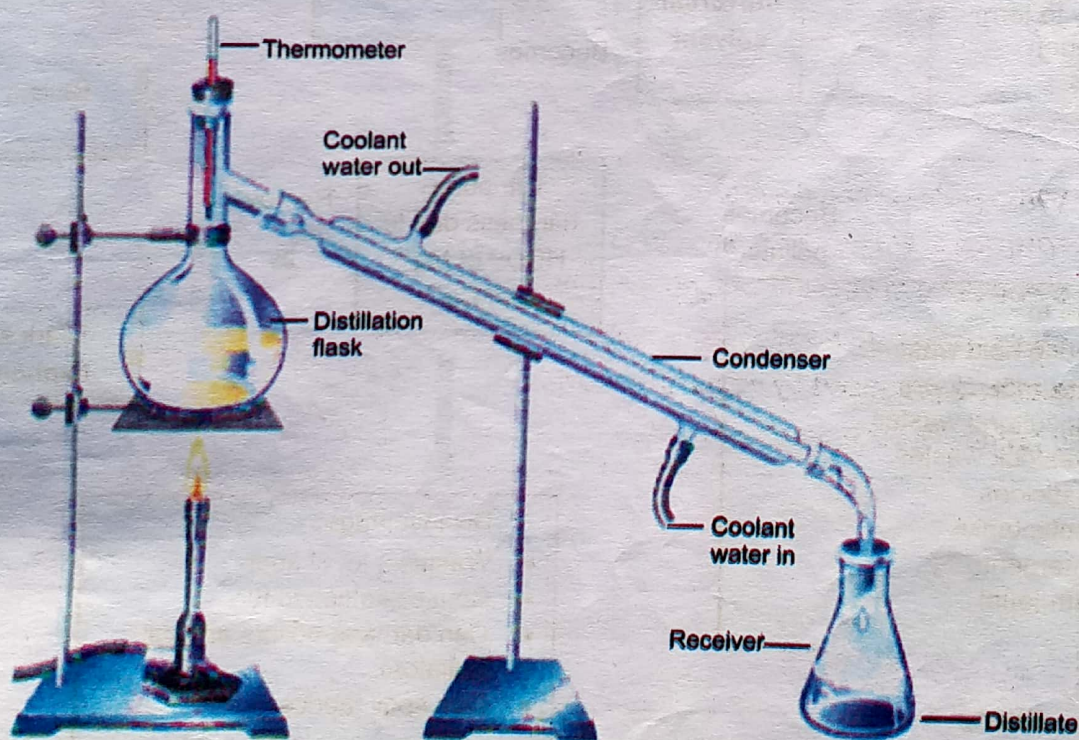


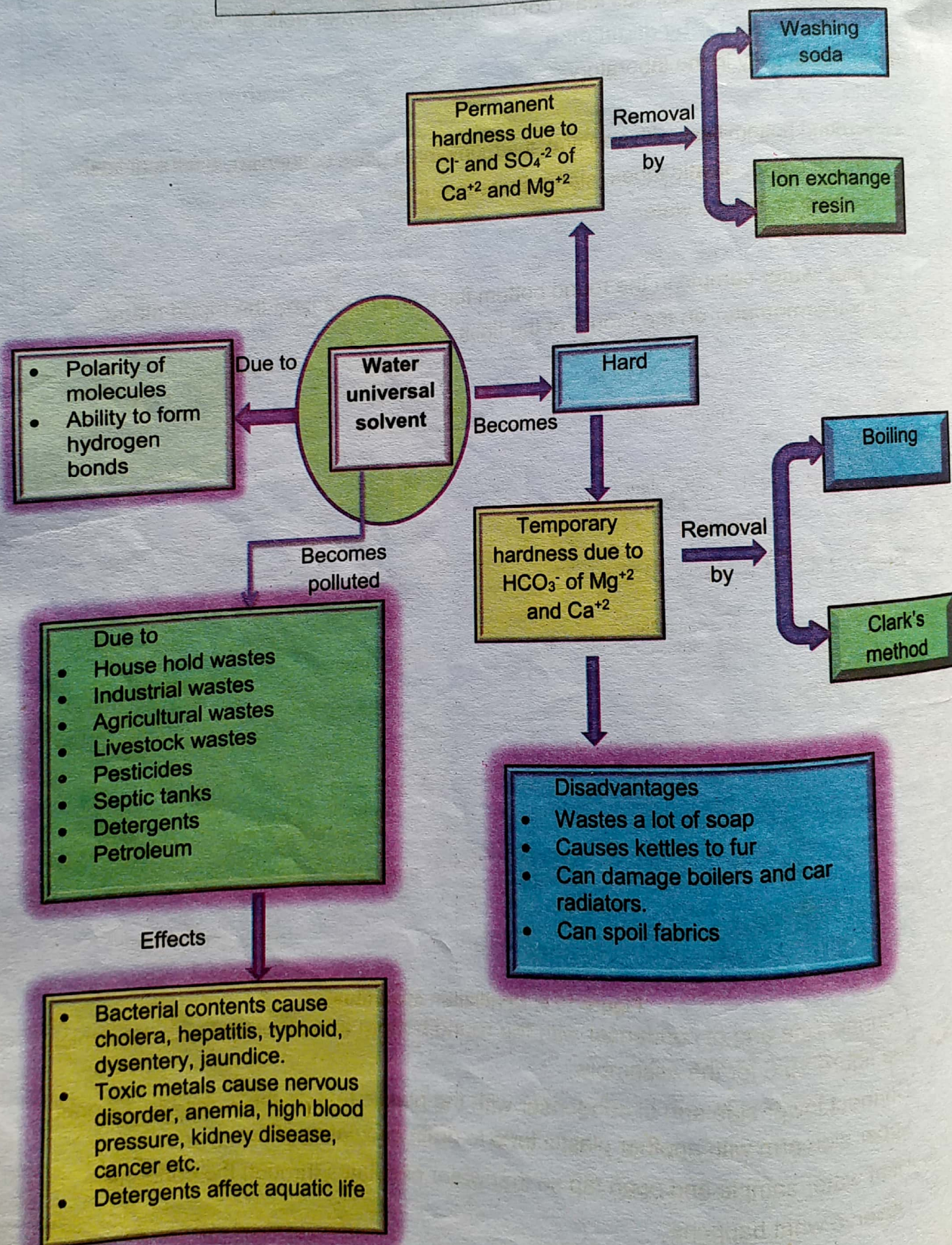
Figure 15.6: Distillation apparatus

Connect one end of condenser with the round bottom and other end with the conical flask. See figure 15.6 for the assembly.

3. Connect lower side arm of condenser with the plastic tube to the water tap. Connect upper side arm with another plastic tube to drain circulating water.
4. Heat water sample and open tap so that water circulates through the condenser.
5. Observe what happens.



Concepts in brief





Key Points

- ❖ An enormous amount of water is found on the Earth, but the fresh water available to man is only 0.2% of the total.
- ❖ Water that easily gives lather with soap and does not form scum is called soft water.
- ❖ Water that gives little lather or forms scum with soap is called hard water.
- ❖ Temporary hardness is the one which can be removed by boiling.
- ❖ Permanent hardness is the one which cannot be removed by boiling.
- ❖ Hard water hampers cleaning action of soap.
- ❖ Hepatitis a viral disease occasionally spreads through drinking water.
- ❖ Unclean water supplies, poor sanitation and poor hygiene kill 2,668,000 people worldwide each year.

References for additional informations.

- ❖ Chemistry Kelter, Carr, Scott.
- ❖ Environmental Chemistry, Barid, Colin.
- ❖ Environmental Science, Richard Wright, R.T. Wright.



Review Questions

Q.1. Select the correct answer.

- i) Percentage of sodium chloride in sea water is
a) 0.02 b) 3.4 c) 97 d) 2
- ii) The density of water is maximum at
a) 0°C b) 4°C c) 100°C d) -4°C
- iii) Which salt does not cause the water to become hard?
a) calcium hydrogen carbonate
b) magnesium hydrogen carbonate
c) magnesium sulphate.
d) Sodium chloride.



- iv) Which salt causes temporary hardness in water?
- magnesium sulphate
 - calcium sulphate
 - both calcium sulphate and magnesium sulphate
 - ☒ magnesium hydrogen carbonate
- v) Heating calcium hydrogen carbonate produces
- CO_2
 - H_2O
 - CaCO_3
 - ☒ all of these
- vi) Which of the followings is not a water born disease?
- hepatitis
 - typhoid
 - dysentery
 - ☒ anemia
- vii) Which human activity results in contamination of water bodies?
- livestock waste
 - pesticides
 - septic tanks
 - ☒ all of these
- viii) Which is used to remove permanent hardness in water?
- slaked lime
 - ☒ washing soda
 - boiling water
 - all of these

2. Give short answers.

- List the impurities present in rain water
- List toxic substances present in household wastes.
- In what ways, industrial wastes pollute water.
- What is water pollution?
- List some waterborne diseases
- What are pathogenic microorganisms?

3. What is hard water? Why is it sometimes undesirable?

4. List two ways in which lakes and streams become polluted.

5. Give chemical equations for the

- reaction of slaked lime with alum.
- carbonated rain water with lime stone.
- reaction that occurs when temporary hard water is boiled.
- Ca^{+2} ions interact with sodiumzeolite.

6. How can buildings made of limestone be affected by acid rain?

7. Make a list of main methods of softening hard water. In each case write a chemical equation to summarize the chemical reactions involved.

8. List some disadvantages of water hardness.



9. What are the Earth's four main water sources? Pg#127
10. How does hard water differ from soft water?
11. What is the purpose of coagulation in water treatment?
12. Explain how hard water hampers the cleansing action of soap.
13. Why are municipal water supplies treated with aluminium sulphate and slaked lime?
14. What are some health effects of biological contamination of water?
15. Write a word and balanced chemical equation to show the effect of heat on magnesium hydrogen carbonate in an aqueous solution.

**Think-Tank**

16. Why is it cooler near a lake than inland during summer?
17. Evaluate the option, ion exchange resins can be used to remove temporary hardness.
18. Public health depends on water quality. Give arguments.
19. Hard water causes kettles to fur. This fur can be removed by using an acid. Justify.
20. The following chemical equation is about a calcium compound.
$$\text{Comp A} + \text{Ca}(\text{OH})_2 \rightarrow \text{Comp B} + \text{H}_2\text{O}$$
$$\text{Comp B} + \text{H}_2\text{CO}_3 \rightarrow \text{Comp C}$$
 - a) Name and give the formula of
 - i. Compound A
 - ii. Compound C
 - b) Describe with the aid of a balanced chemical equation. What happens when compound C is heated?
 - c) Compound C is soluble in water. Write a balanced chemical equation to show what happens when its aqueous solution is treated with washing soda?
21. How chemistry helps maintain a clean swimming pool? Explain.
22. It is advisable to wash hands well with soap after using bathrooms, evaluate it.
23. Differentiate between raw water treatment and sewage treatment process.
24. Evaluate the advantages of waste water treatments.
25. Water born diseases are no longer common in developed countries. Defend this statement.