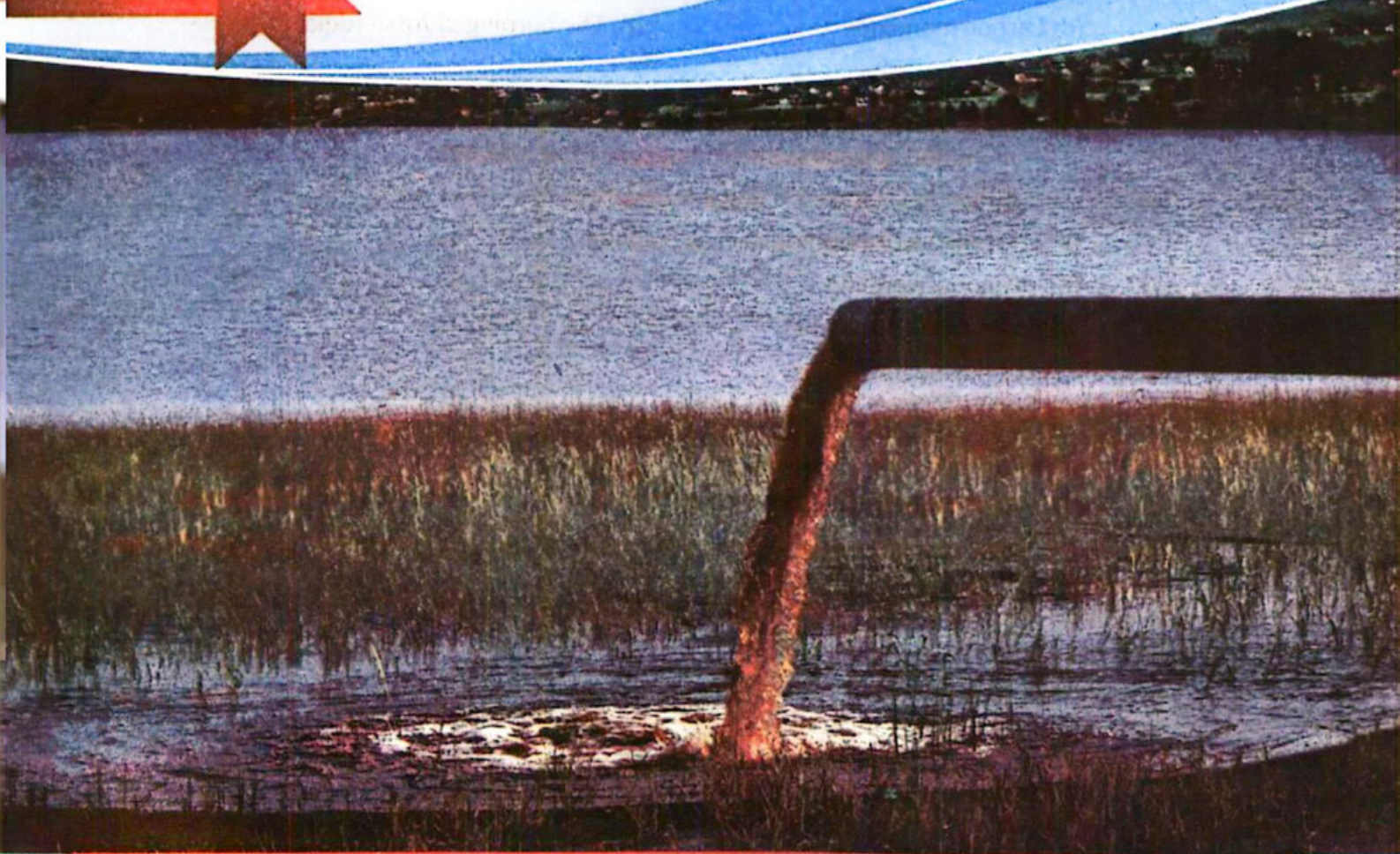




ENVIRONMENTAL CHEMISTRY-WATER

Student Learning Outcomes (SLOs)

After completing this lesson, the student will be able to:

- Investigate chemical tests for the presence of water using anhydrous copper(II) sulphate.
- Explain how to test the purity of water using melting point and boiling point.
- Distinguish between distilled water and tap water with their applications in practical chemistry.
- State that water from natural sources may contain useful and harmful substances. (Some examples include:
 - (a) Dissolved oxygen (b) Metal compounds (c) Plastics (d) Sewage (e) Harmful microbes (f) Nitrates from fertilizers (g) Phosphates from fertilizers and detergents)
- Recognize that some naturally occurring substances in water are beneficial. (some examples include:
 - (a) Dissolved oxygen for aquatic life (b) Some metal compounds provide essential minerals for life)
- Recognize that some naturally occurring substances in water are potentially harmful (some example include:..

- (a) Some metal compounds that are toxic (b) Some plastics that harm aquatic life (c) Sewage that contains harmful microbes which cause disease (d) Nitrates and phosphates that lead to de-oxygenation of water and damage to aquatic life. Details of the eutrophication process are not required)
- Explain the treatment of domestic water supply (some examples include: .
 - (a) Sedimentation and filtration to remove solids (b) Use of carbon to remove tastes and colours (c) Chlorination to kill microbes
 - Describe various water-borne diseases and the steps that can be taken to avoid them.
 - Identify the negative effects of water pollutants on life and the ways to avoid them.
 - Explain water scarcity as an important issue faced by Pakistan and the ways in which can be resolved.
 - Fertilizers: State that urea, ammonium salts, and nitrates are used as fertilizers.
 - Explain the use of NPK fertilizers to provide the elements nitrogen, phosphorous, and potassium for improved plant growth.

INTRODUCTION

Where does the water in your kitchen and bathroom come from? Because water comes from different sources, its quality varies. Do you drink water that has a colour, a bad taste or an unpleasant smell? When you wake up in the morning, what do you do? You brush your teeth, take a shower, flush the toilet, etc. What happens to the water flowing out of the drain? Can you reuse this water? Sewage is often poured into open gutters and allowed to flow directly into streams, rivers and oceans. This practice spreads diseases and also threatens aquatic life. How? This will become clear in this chapter. The presence of disease-causing bacteria affects water quality. Water from both public and private sources often requires treatment to ensure it is clean and safe to drink. Wastewater should also undergo treatment to remove unwanted substances before entering lakes, rivers or oceans. Otherwise, it would also affect marine life and, through the food chain, humans.

12.1 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.

Activity 12.1

Detection of water with anhydrous(II) copper sulphate

Objective:

The objective of this activity is to demonstrate the ability of anhydrous copper(II) sulphate to detect the presence of water by observing its reaction and colour change.

Materials Required:

Anhydrous copper (II) sulphate (in powder form), a dry test tube or small beaker , a pipette or pipette, spatula.

Procedure:**Step 1:**

Take a small amount of anhydrous copper(II) sulphate powder with spatula and place it in a dry test tube or beaker.

Step 2:

Observe the initial state and the appearance of anhydrous copper(II) sulphate powder before adding water. It should be a white or off-white crystalline.

Step 3:

Carefully add a few drops of water to the anhydrous copper(II) sulphate powder in the container using a dropper or pipette.

Step 4:

Observe the reaction. When water comes into contact with anhydrous copper(II) sulphate, a chemical reaction occurs in it. Copper(II) sulphate reacts with water to form hydrated copper(II) sulphate, which is blue in colour.

Step 5:

Observe and note the colour change that occurs. A white anhydrous copper (II)sulphate powder should turn light blue when reacted with water. This colour change confirms the presence of water.

Interpretation of results:

Anhydrous copper(II) sulphate is a white crystalline solid. It does not contain water molecules. However, it has ability to absorb water from the surrounding environment through a process called hydration. When water is added to anhydrous copper(II) sulphate, it undergoes chemical reaction. It reacts with water forming hydrated copper (II) sulphate, which has a distinct blue colour. The appearance of blue colour indicates the presence of water in it.

Safety Precautions:

Copper sulphate is a toxic compound, so handle it carefully. Perform this activity under the adult supervision. Wear gloves and safety goggles, and wash your hands, when the activity is over.

Activity 12.2**Testing the purity of water by determining its melting point.****Materials needed:**

beaker, thermometer, bunsen burner or spirit lamp, ice cubes, tripod stand.

Procedure:

1. Make ice cubes of sample water using refrigerator.
2. Fill the glass with ice cubes.
3. Hang the thermometer on the ice cubes, making sure that its bulb is completely

immersed in ice and does not touch the bottom of the beaker.

4. Place the beaker on the heat source using the stand.
5. Gradually heat the ice cubes.
6. Record the temperature at which the ice begins to melt.
7. Record your observations.

Interpretation of results:

The melting point of pure water is 0°C . Impurities in water affect its melting point. Compare the observed melting point with the expected value.

Activity 12.3

Testing the purity of water by determining its boiling point.

Materials needed:

beaker, thermometer, bunsen burner or spirit lamp, water sample, tripod stand, a glass rod.

Procedure:

1. Fill the beaker with sample water and place it over the tripod stand.
2. Hang the thermometer in the water, making sure that its bulb is completely submerged in water and does not touch the bottom of the beaker.
3. Gradually heat water, constantly stirring water with a glass rod.
4. Record the temperature at which the water begins to boil.
5. Record your observations.

Interpretation of results:

The boiling point of pure water is 100°C . Impurities in water affect its boiling point. Compare the observed boiling point with the expected value.

12.1.1 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.

12.1.2 Quality of Water from Natural Resources

Water from natural resources such as lakes, streams, and underground rivers can contain many dissolved substances that can be beneficial or harmful.

12.1.3 Disadvantages of Natural Substances Found in Water:

1. **Dissolved oxygen:** Where do fish and other marine life get their oxygen? Water contains dissolved oxygen. This oxygen is responsible for the survival of aquatic organisms.
2. **Metal compounds:** Natural water can contain metals such as iron, sodium, potassium, magnesium, calcium, manganese, zinc and copper. Some of these metals are necessary

for biological processes, their excessive concentration can be poisonous for aquatic organisms and humans.

3. **Plastics:** Plastic waste can pollute water bodies. This is a serious threat to aquatic life and ecosystem.
4. **Wastewater:** Wastewater can enter natural water supplies. Wastewater carries pathogens, bacteria, viruses and other harmful substances. These pollutants pose a serious threat to humans and aquatic life.
5. **Harmful Microbes:** Natural water sources can contain harmful microbes such as bacteria, viruses and parasites that can cause waterborne diseases such as diarrhea, dysentery, cholera and stomach upsets.
6. **Nitrates from fertilizers:** Fertilizers add nitrates to water bodies through agricultural runoff. High concentrations of nitrates in drinking water cause health risks, especially for young children.
7. **Phosphates from fertilizers and detergents:** Phosphates in fertilizers and detergents can enter water bodies through runoff. High concentrations of phosphate can cause eutrophication. This can cause harmful algae blooms and oxygen caps in water bodies. Detergents used in water systems can destroy the outer mucous membranes that protect fish from bacteria and parasites. In addition, detergents can also damage their gills.

12.1.4 Benefits of Natural Substances Found in Water:

Some naturally occurring substances are useful and necessary for life. For example,

1. **Dissolved oxygen:** Existence of aquatic life depends on dissolved oxygen. This oxygen supports the respiration process of aquatic organisms.
2. **Essential minerals:** Metal compounds in natural water can provide essential minerals needed for various biological processes. For example, iron is necessary for the production of hemoglobin in the blood, which carries oxygen to the cells of our body. Metals like zinc, copper, and manganese activate enzyme activity the proper functioning of biological systems.

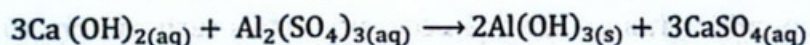
12.2 TREATMENT OF DOMESTIC WATER SUPPLY

The treatment of domestic water supply involves several processes to ensure that water is safe for human use.

RAW WATER TREATMENT

Raw water is treated in a municipal water purification plant, to make it fit for drinking and domestic purposes. 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.

1. **Filtration:** The water is then filtered through sand and gravel. Sometimes it is filtered through charcoal to remove coloured and odorous compounds.
2. **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 12.1: Flow sheet diagram for water purification plant

12.2.1 Distilled Water

Water purified by distillation is called distilled water.

The process of distillation involves heating water to boiling point, collecting the vapors, and condensing it back into the liquid. The impurities are left behind. Distilled water is free of any contaminants. The electrical conductivity of distilled water is very low. The pH of distilled water is 7.

Uses in chemistry:

1. Distilled water is usually used in laboratories to prepare chemical reagents and solutions.
2. Distilled water is used in the calibration of sensors in analytical instruments, e.g. pH meter.

DO YOU KNOW?

Long-term drinking of distilled water can cause mineral deficiency because it lacks essential minerals found in natural water sources. For drinking purposes, it is better to use treated tap water, bottled water or natural spring water.

12.2.2 Tap water:

Water supplied through the municipal water system to households and for commercial purposes is called tap water. It comes from various sources, including, streams, rivers, lakes, reservoirs, and groundwater. It undergoes processes to meet safety standards to make it safe for people.

Applications in Chemistry Laboratory

1. Tap water is used as a solvent for general purposes, such as cleaning glassware, equipment, etc.
2. It is also used for educational and simple demonstration as a readily available solvent.

12.3 WATER POLLUTION

Water is very good at dissolving substances. As water from rain and snow flows over rocks and through soil, it dissolves minerals. The freshwater 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 pollute the

surface and groundwater. Human activities such as household waste, agricultural waste, livestock waste, pesticides, oil leaks, detergents, septic tanks, petroleum, and natural gas production may result in contamination of water bodies. We will discuss household waste and industrial waste in this unit. You will learn about other types of waste in higher grades.

Household Wastes

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

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, Cr and Pb which can cause long term neurological problems, kidney diseases, nausea, dizziness, and cancer.
- It also improves the flavor and appearance.

12.4 WATERBORNE DISEASES

Human wastes are dumped on the ground or into the nearest stream. Human waste contains infectious microorganisms, which spread diseases like typhoid fever, dysentery, and hepatitis. Chemical and bacterial contents in livestock waste can pollute surface and groundwater causing the above-mentioned diseases. 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. Water in swimming pools is purified from pathogenic organisms by aeration and chlorination.

Some waterborne diseases are given below.

Dysentery

Dysentery is also an intestinal disease. It is caused by a parasite, entamoeba. This infection is transmitted by fecal contamination of water or food by the encysted organism. Patients have mild to severe abdominal cramps, diarrhea, chocolate-colored stool with mucous and sometimes blood.

DO YOU KNOW?

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

Jaundice

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

Hepatitis

Hepatitis is an acute inflammation of the liver. It is caused by viruses and is classified as Hepatitis A, B, C, D, and E. Hepatitis A and E spread 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.

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.

CONCEPT ASSESSMENT EXERCISE 12.1

1. List some water borne diseases.
2. List sources of water borne diseases.
3. List steps used in raw water treatment

12.5 WAYS TO DEAL WITH THE NEGATIVE EFFECTS OF WATER POLLUTION

Water pollution affects life in many ways. Here are some ways to deal with them as follows.

1. Some pollutants reduce oxygen levels in water bodies and make the survival of aquatic life difficult. To prevent this, it is important to control nutrient flow and properly treat sewage and industrial waste that encourage excessive algae growth.
2. Heavy metals present in polluted water, can accumulate in the tissues of aquatic organisms. These metals also harm human health if people consume them as food. Preventing industrial wastewater from entering waterways can minimize emissions of such pollutants.
3. Water-borne diseases like hepatitis, cholera, dysentery, etc. are caused by harmful microbes. Ensuring proper treatment of domestic and industrial wastewater, compliance with good sanitary and hygiene requirements, and providing access to clean drinking water are crucial in preventing water-borne diseases.

12.6 WATER SCARCITY IN PAKISTAN

Water scarcity is a major problem in Pakistan. This is mainly due to the following factors.

1. Population Growth:

The population of Pakistan is growing rapidly, which increases the demand for water in agriculture, industry, and homes.

2. Climate change:

Climate change has caused irregular rainfall patterns, which affects water availability. The country's water resources are also declining due to excessive extraction of water from groundwater aquifers and insufficient irrigation practices.

3. Inadequate water supply:

Traditional flood irrigation methods are widely used in Pakistan. This has resulted in significant water losses through evaporation and inadequate water distribution.

To solve the problem of water scarcity in Pakistan, the following are necessary:

- Effective water management practices.
- Development of infrastructure.
- Policy reforms.
- Public awareness of responsible water use and its promotion.
- Strict regulations and monitoring systems to control groundwater and prevent illegal drilling are essential.

12.7 FERTILIZERS

Fertilizers are substances that provide essential elements for plant growth. These elements are essential to enhance crop yields. Fertilizers mainly provide three main nutrients, nitrogen (N), phosphorus (P), and potassium (K), hence known as NPK fertilizers. Urea, potassium nitrate, and ammonium salts such as di-ammonium phosphate (superphosphate) are important fertilizers. Fertilizers dissolve in water. So they provide nutrients to the plants in a readily available form. It is important to give fertilizers at the right time and in the right amount. This practice is called nutrient management. It optimizes the intake of nutrients by plants and reduces the loss of nutrients. This practice can minimize environmental problems such as nutrient runoff into water bodies.

KEY POINTS

- Hepatitis a viral disease occasionally spreads through drinking polluted water.
- Unclean water supplies, poor sanitation and poor hygiene kill 2,668,000 people worldwide each year.
- Anhydrous copper(II) sulphate is used to detect water, on absorbing water it turns blue.
- Water from natural resources contains useful and harmful substances.
- Nitrates and phosphates present in water damage aquatic life.
- Sewage contains harmful microbes which cause diseases.
- Sedimentation, filtration, and chlorination are major steps in the treatment of domestic water supply.
- Urea, ammonium salts, and nitrates are used as fertilizers.

- NPK fertilizers provide the elements nitrogen, phosphorous, and potassium for plant growth.
- **References for additional information**
- Chemistry Kelter, Carr, Scott.
- Environmental Chemistry, Barid, Colin.
- Environmental Science, Richard Wright, R.T. Wright.

REVIEW QUESTIONS

1. Encircle the correct answer.

- Which of the followings is not a water borne disease?

a) hepatitis	b) typhoid
c) dysentery	d) anemia
- Which human activity results in contamination of water bodies?

a) livestock waste	b) pesticides
c) septic tanks	d) all of these
- pH of distilled water is

a) 7	b) Less than 7
c) Greater than 7	d) None of these
- Anhydrous copper (II) sulphate is _____ solid.

a) blue	b) white
c) yellow	d) None of these

2. Give short answer.

- 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?
- How does tap water differ from distilled water?
 - Why are municipal water supplies treated with aluminium sulphate?
 - What are some health effects of biological contamination of water?
 - Identify the negative effects of water pollutants on life.
 - Water scarcity is an important issue in Pakistan. Give your comments on it.
 - What are fertilizers?

THINK TANK

9. Public health depends on water quality. Give arguments.
10. How chemistry helps maintain a clean swimming pool? Explain.
11. It is advisable to wash hands well with soap after using bathrooms. Evaluate it.

PROJECT

Create a chart showing water pollution model. (Watch YouTube - Kansal creation)