Chapter 20

Water

20.1 Water

Water is essential for all. All living organisms contain of water in them and they need water to support their life everyday.

Testing for water has two main uses in chemistry:

- It checks if products are pure and free from unwanted moisture
- It acts as proof that a chemical reaction has taken place

Test for Water

Testing water is important for food and pharmaceutical industries because the presence of water can affect the product quality and safety.

The color of hydrated copper(II) sulphate ($CuSO_4.5H_2O$) is blue. When we heat hydrated copper(II) sulphate ($CuSO_4.5H_2O$) it loses water by evaporation and its color becomes white because anhydroys copper(II) sulphate ($CuSO_4$) is white in color. To reconfirm, we again add drop of water on anhydrous copper(II) sulphate and its color again turns to blue.

$$CuSO_4.5H_2O \rightleftharpoons CuSO_4 + 5H_2O$$

Blue white

$CuSO_4 + 5H_2O \rightleftharpoons CuSO_4 . 5H_2O$

White blue

It is a very sensitive test and can detect even a small amount of water.

20.2 Purity of Water

Boiling point of pure water is 100°C and freezing point of pure water is 0°C at standard temperature and pressure. But impurities in water will change both these physical constants (boiling and freezing points).

1. The purity of water can be checked by determining its boiling point at STP. If it boils at 100°C, it is pure water. The presence of impurities in water will slightly increase its boiling point.
2. The purity of water can be checked by determining its melting point at STP. For this purpose, cool water until it freezes. Observe and record the temperature at which the ice begins to melt. If its melting point is 0°C, it is pure water. A melting point below 0°C suggests the presence of impurities in the sample.

At standard conditions the impurities present in water raise the boiling point but lowers the melting point. These values will change at high altitudes because of low pressure.

20.3 Difference between distilled water and tap water

Tap Water:

- Water which is supplied to our homes, shops and offices comes through taps, it is called tap water.
- Sources: This water may come from rivers, lakes and ponds or from underground sources.

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

- Tap water contains minerals like salts of calcium and magnesium depending upon the source from where it is obtained.
- It is a conductor of electricity due to the presence of free ions from dissolved minerals
- It also contains chlorine and fluoride salt which are mixed with it during treatment.
- Its pH has the range of 6.5 to 8.5 depending upon its source.

Distilled Water:

- Water obtained after the process of distillation is called distilled water.
- Process of distillation: The process involves heating water to get steam and then condensing this steam back into liquid water. This process effectively removes all the dissolved minerals, microorganisms and contaminants from water leaving behind only pure water.
- Use: The purity of distilled water makes it ideal for use in the laboratories, medical procedures and pharmaceutical industry. Its purity ensures accurate scientific measurements, sterilization of medical equipments and to prevent corrosion.
- Distilled water contains only water molecules without any bacteria, ions, gases or other contaminants.
- Its pH is 7.
- It is safe to drink but it may not have the necessary minerals needed for the body.
- It is also a bad conductor of electricity due to absence of ions.

20.4 Substances present in water obtained from natural sources

Water from natural sources such as rivers, lakes and aquifers contains a number of substances which may be useful or harmful for our health.

Useful Substances

- **Dissolved Oxygen**

Oxygen enters the natural water from the atmosphere through the process of diffusion. It is also produced by aquatic plants and algae in the process called photosynthesis.

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

This absorbed oxygen is used by the aquatic organisms including fish to breathe and survive. The health and diversity of an ecosystem directly depends upon the amount of dissolved oxygen in a water body.

Harmful substances and their effects on the quality of water

- **Harmful Microbes**

Human activities such as human and animal wastes, landfills, agricultural runoff, waste water from industries and sewage water from water treatment plants or from faulty septic tanks are polluting vital sources of water i.e ground water and surface water. It also enters harmful microorganisms like bacteria, viruses and parasites enter into natural water. Diseases caused by bacteria are dysentery, typhoid, hepatitis and cholera.

- **Heavy metals and their compounds**

Heavy metals like lead, mercury, cadmium and chromium and their compounds can enter in natural water i.e rivers and other water bodies through many routes. Waste water from factories, mining operations and use of fertilizers and pesticides can contaminate both ground and surface water with heavy metals and their compounds.

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

Heavy metals and their compounds damage vital organs like liver and kidney and it may lead to neurological problems. Arsenic and cadmium are known to increase the risk of certain cancers.

- **Plastics**

Very small particles of plastics called microplastics are present in both tap and bottled water. These tiny particles can enter water through wastewater, rainwater through plastic debris, and by degradation of plastic waste. Plastic tiny particles have been found in some human organs like lungs and blood. These particles can disturb the immune and reproductive systems.

- **Nitrates and Phosphates**

Nitrates and phosphates enter natural waters through weathering of rocks and through human activities such as agriculture fertilizers, detergents and industrial wastewater. They are essential nutrients for plant and animal life. However, if amounts of these compounds exceed a limit they can affect the quality of water and cause eutrophication.

Eutrophication is a process where excess nutrients (phosphorus and nitrogen) enter a water body, causing an overgrowth of algae. This thick layer of algae uses up the dissolved oxygen in the water, which suffocates and kills aquatic life..

20.5 Treatment of Domestic Water Supply

Three types of impurities are mostly present in water obtained from natural sources.

1. Dissolved impurities
2. Suspended impurities
3. Microorganisms

In order to remove these impurities different methods are applied which include sedimentation, filtration, distillation and treatment with liquid chlorine etc.

a) Sedimentation

Natural water contains large insoluble impurities like soil, sand, and plant pieces. These are removed using sedimentation, where water sits undisturbed in a tank for a few hours so gravity can pull the heavy particles to the bottom, leaving cleaner water at the top.

b) Filtration

Filtration is used to remove smaller suspended particles that do not settle down during sedimentation. In this process, water is passed through layers of sand and gravel filters, which trap the tiny solid impurities and let clean water pass through.

c) Chlorination

It is method of sterilization. For this purpose all harmful bacteria and other microbes, must be killed. Mostly a small amount of liquid chlorine is added which has the power to kill all these germs.

d) Removal of odours

To remove bad tastes and odors, water is passed through powdered activated charcoal, which absorbs organic compounds. Odors can also be removed by mixing the water with air in a process called aeration.

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

20.6 Effects of Pollutants Present in Water

Water pollution affects human health, ecosystems, aquatic organisms and industries that are dependent on good water quality.

How to Control the Negative effects of Pollutants

Harms of water pollutants:

- Water Pollutants can disrupt aquatic ecosystems through eutrophication and destruction of habitats.
- Polluted water can also lower crop yields.
- It contaminate food sources.

Steps to remove effects of water pollutants:

1. **Treat Wastewater:** Clean sewage and industrial chemical waste before releasing it into rivers.
2. **Recycle Plastics:** Reuse and recycle plastic items to reduce waste production.
3. **Keep Drains Clean:** Never pour oils, grease, or chemical cleaners down the sink drain.
4. **Reduce Agri-Chemicals:** Limit the use of chemical fertilizers and pesticides on farms.
5. **Public Awareness:** Run public campaigns to educate people about the dangers of water pollution.
6. **Enforce Strict Laws:** Implement and strictly enforce government laws against water pollution.

Water-borne Diseases

The World Health Organization (WHO) estimates that 80% of all sickness and diseases in the world are caused by polluted water and poor sanitation. Every year, nearly 500 million people suffer from these water-borne diseases. Common diseases caused by drinking contaminated water include cholera, typhoid, malaria, nausea, leprosy, and liver diseases like viral hepatitis. Additionally, millions of babies and children in developing countries suffer from a water-related eye disease called trachoma, which often leads to permanent blindness.

Prevention of water-borne diseases

Water-borne diseases can be avoided if we strictly follow the following instructions:

1. **Clean Water:** Drink water after removing dirt and impurities.
2. **Boil Water:** Always boil water before drinking to kill harmful germs.
3. **Wash Hands:** Keep your hands and body clean to stop diseases from spreading.
4. **Good Toilets:** Use proper sanitation and toilets to keep waste away from clean water.

20.7 Water Scarcity in Pakistan

The world is divided into different zones based on how much rain they get each year. Pakistan is located in a semi-arid region, which means it naturally receives very low rainfall. In northern Pakistan and Punjab, the annual rainfall is between 250 and 600 mm, mostly arriving during the monsoon season. In southern Pakistan, rain is very rare and scarce, dropping below 200 mm per year.

Pakistan is currently facing a severe water shortage crisis. This crisis is caused by six major factors: less rainfall, a growing population, wasteful flood irrigation in farming, climate change, drying underground water (depleting aquifers), and poor water management. If this current situation continues, Pakistan will face very serious challenges and severe water shortages in the coming years.

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

The problem can be addressed by taking a number of steps which are as follows:

1. Collecting rain water especially during monsoon season by constructing water reservoirs and other water storage facilities.

2. Using better crop irrigation techniques.

3. Taking appropriate measures to face effects of climate change.

4. Effective management of water resources.

20.8 Elements Essential for Plant Growth

Plants need nutrients from the soil for a healthy growth. The elements essential for the plant growth can be classified as micro-nutrients and macro-nutrients.

Micro-nutrients (Trace elements)

Definition: The nutrients which are required in a very small amount for the growth of plants are called micro-nutrients.

Examples: boron, copper, iron, manganese, zinc, molybdenum and chlorine.

Health and Toxicity Risks: Only minute amounts of these elements are needed for healthy plant growth and it may be dangerous to add too much quantity because they are poisonous in larger quantities.

Required Quantity Per Acre: These are generally required in quantities ranging from 6 grams to 200 grams per acre.

Macro-nutrients

Definition of Macro-nutrients: The nutrients which are required in large amounts for the growth and development of plants are called macro-nutrients.

Examples: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, carbon, hydrogen, and oxygen**.**

Required Quantity Per Acre: These elements are needed in bulk, generally ranging from 5 kg to 200 kg per acre for healthy crop growth.

20.9 Fertilizers

Fertilizers are the substances added to the soil to make up the deficiency of essential elements like nitrogen, phosphorus and potassium (NPK) required for the proper growth of plants. Fertilizers enhance the natural fertility of the soil and provide the chemical elements taken up from soil by the previous crops.

Essential Qualities of a Good Fertilizer

Not every compound can be a fertilizer. A good fertilizer must meet three simple conditions:

Water Soluble: It must easily dissolve in water so plant roots can absorb it quickly.

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

Stable: It must stay stable during storage, meaning it shouldn't absorb moisture or turn into hard, stony lumps over time.

Cheap: It must be cheap and low-cost to manufacture for farmers.

The essential requisites (requirement) of a good fertilizer are:

1. The nutrient elements present in it must be readily available to the plants.
2. It must be fairly soluble in water so that it thoroughly mixes with the soil.
3. It should not be injurious to plants. It should be inexpensive.
4. It must be stable so that it is available for a longer time to the growing plants.
5. It should not alter the pH of the soil.
6. By rain or water, it should be converted into a form, which the plant can absorb easily.

20.10 Classification of Fertilizers

Fertilizers are classified according to the nature of the elements like nitrogen, phosphorus and potassium which they provide to the soil. This classification gives the following types of fertilizers.

(i) Nitrogenous fertilizers

(ii) Phosphatic fertilizers

(iii) Potassium fertilizers

Nitrogenous Fertilizers

Nitrogen fertilizers supply essential nitrogen to plants and soil. Plants need nitrogen during their early growth stage to develop strong stems and leaves.It is the main part of proteins, gives a healthy green color to leaves, and improves both the yield (crop amount) and quality of the plants.Common types include urea, ammonia, ammonium sulfate, calcium cyanamide, ammonium nitrate, ammonium phosphate, and ammonium chloride.

Urea is a high quality nitrogenous fertilizer. It contains about 46% nitrogen and is the most concentrated solid nitrogen fertilizer. It is the most widely used nitrogen fertilizer in Pakistan.

Ammonium nitrate is a useful fertilizer for many crops except paddy rice because the microbial bacteria in flooded fields decompose it to nitrogen gas. It is also used in combination with limestone. It is hygroscope in nature.

Phosphatic Fertilizers

Phosphatic fertilizers provide essential phosphorus to plants and soil.It boosts early growth, speeds up seed and fruit formation in later stages, and helps plants fight diseases (increases resistance).Different phosphorus fertilizers have different formulas, so they dissolve in water at different rates.The two most important water-soluble examples are:

- Super phosphate (Calcium super phosphate): $Ca(H_2PO_4)_2$
- Triple phosphate (Diammonium phosphate / DAP): $(NH_4)_2HPO_4$

Potassium Fertilizers

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved

Potassium fertilizers supply essential potassium to plants and soil. It helps plants make starch, sugar, and fiber. It also builds strong roots, helps plants fight diseases, and helps seeds, fruits, and grains ripen.These are especially useful for tobacco, coffee, potato, and corn. Three common examples are:

- Potassium chloride
- Potassium sulphate
- Potassium nitrate

www.sirumais.com

www.sirumais.com

© 2026 Sir Umais | www.sirumais.com |All Rights Reserved