

Chapter 12: Environmental Chemistry - Water

All Lectures Uploaded on YouTube:

<https://tinyurl.com/fkm9-chemistry>

The collage features a purple banner with white text: 'Class 9 Chemistry', 'All 19 Chapters', 'All Lectures Playlist', and 'Full Book'. To the right, there is a book cover for 'Model Textbook of CHEMISTRY Grade 9' from the Federal Board, based on the National Curriculum of Pakistan 2022-23. The book cover includes images of laboratory glassware and two young people, a girl in a lab coat and a boy in a tuxedo. Below the book cover is a photograph of a person's gloved hand holding a clear glass sphere over a body of water.

Introduction to Water Quality and Issues

Water comes from various sources (groundwater, lakes, rivers, etc.), and its quality varies. Poor water quality can cause health issues and environmental harm.

- Wastewater disposal: Often dumped into open gutters → flows into rivers/oceans → spreads diseases, harms aquatic life.
- Need for treatment: Both public and private water sources need treatment to ensure safety. Wastewater must be treated before release.



12.1. Properties of Water

- Water is the only substance naturally found in three states on Earth: solid (ice), liquid (water), gas (water vapor).

- Pure water: colorless, odorless, tasteless, boils at 100°C, freezes at 0°C at sea level.

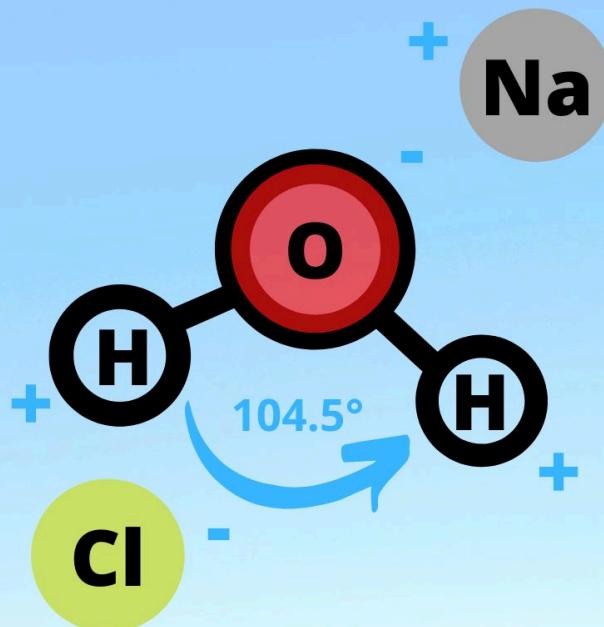
12.1.1. Water as a Solvent

Water dissolves many substances:

- Rainwater absorbs gases from air (O_2 , N_2 , CO_2 , HNO_3 during thunderstorms).

Water: The Universal Solvent

- Water dissolves more substances than any other liquid.
- The bent molecule shape makes it polar. It gives the oxygen atom a partial positive charge and the hydrogen atoms partial positive charges.
- The partial charges attract parts of polar molecules to dissolve them.
- Water does not dissolve nonpolar molecules.



- Groundwater dissolves minerals from rocks/soil and organic matter from decaying plants/animals.

12.1.2. Quality of Water from Natural Resources

Natural water contains dissolved substances that can be beneficial or harmful.

12.1.3. Disadvantages of Natural Substances in Water

| Substance | Effect |
|------------------|---|
| Dissolved Oxygen | Essential for aquatic life, but depletion causes death. |

| | |
|-------------------------------|--|
| Metal Compounds | Necessary in trace amounts, but high concentrations toxic. |
| Plastics | Pollute water, harm aquatic life and ecosystems. |
| Wastewater | Contains pathogens, bacteria, viruses → diseases. |
| Harmful Microbes | Cause waterborne diseases (cholera, dysentery, diarrhea). |
| Nitrates (fertilizers) | Health risks, especially to infants (blue baby syndrome). |
| Phosphates | Cause eutrophication → algal blooms → oxygen depletion in water. |
| Detergents | Damage fish mucous membranes and gills, increase phosphate levels. |

12.1.4. Benefits of Natural Substances in Water

Some natural substances are essential for life:

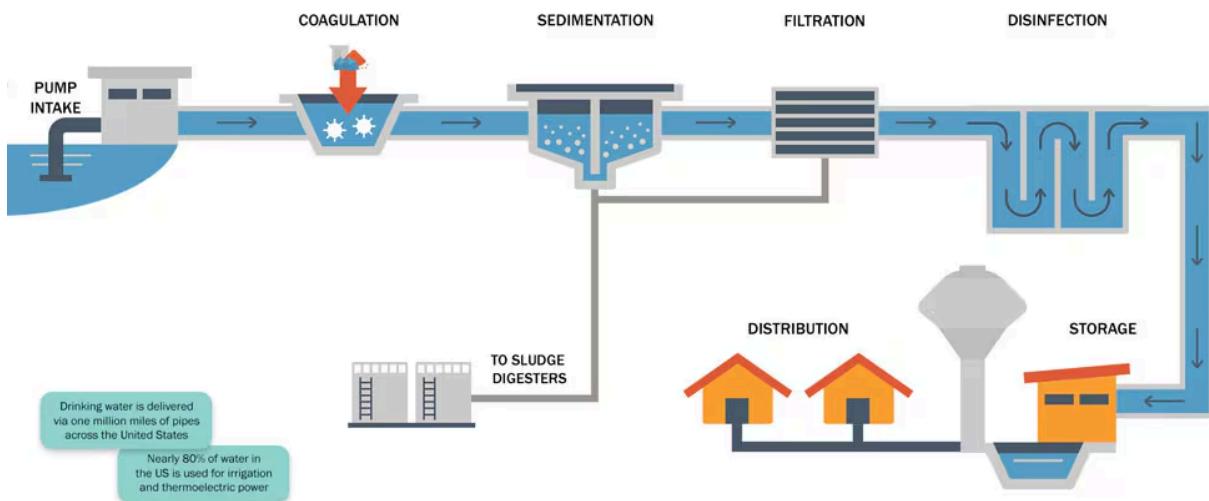
1. Dissolved Oxygen: Supports respiration of aquatic organisms.
2. Essential Minerals:
 - o Iron: Needed for hemoglobin production.
 - o Zinc, Copper, Manganese: Activate enzymes for biological processes.



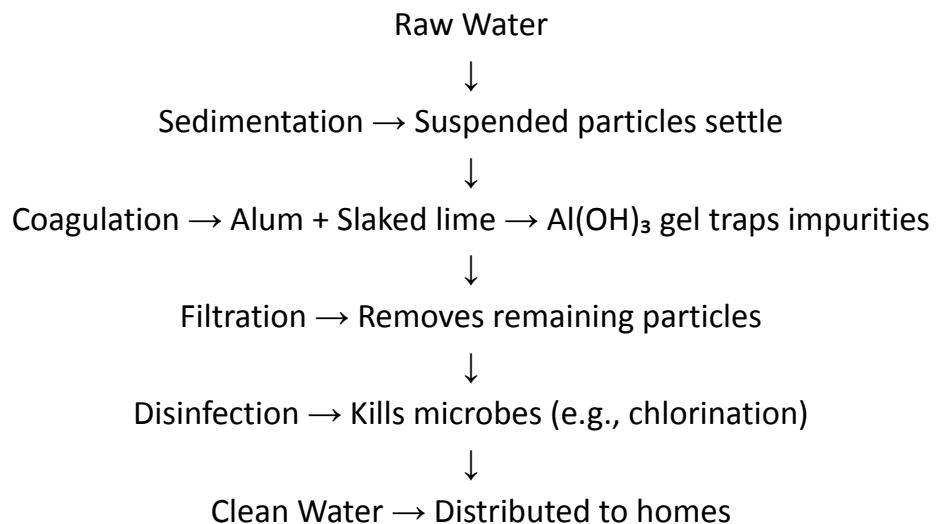
12.2. Treatment of Domestic Water Supply

Process to make raw water safe for drinking and domestic use.

Stages in Municipal Water Purification:



Flowchart of Water Treatment Process:



Detailed Steps:

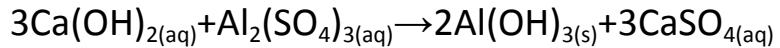
1. Sedimentation:

Water stands in the reservoir → suspended matter settles.

2. Coagulation:

Chemicals added (alum + slaked lime) → form aluminum hydroxide gel → traps fine particles.

Chemical Reaction:



3. Filtration:

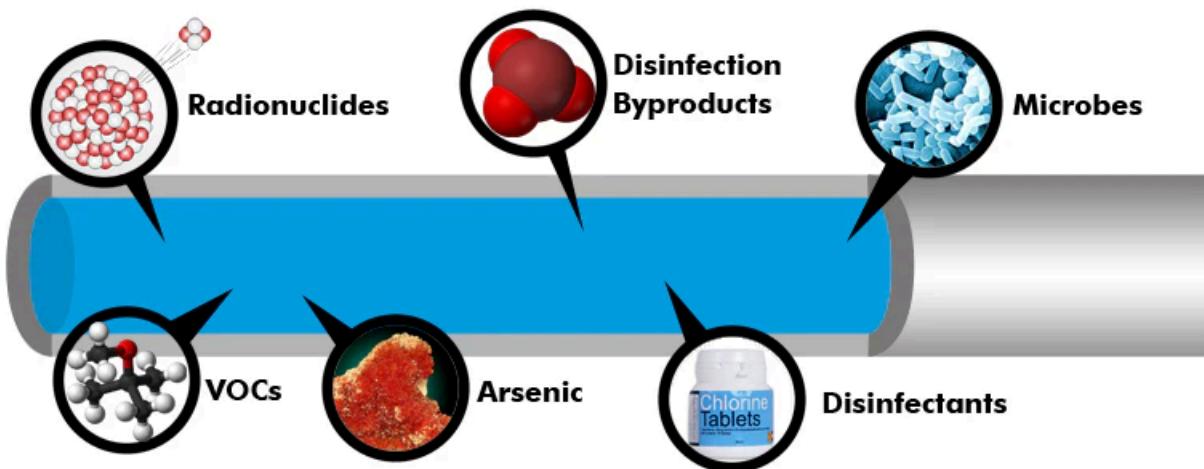
Removes remaining impurities.

4. Disinfection:

Chlorine or other disinfectants kill pathogens.

5. Environmental Impacts of Poor Water Management

- Eutrophication: Excess nutrients (nitrates, phosphates) → algae overgrowth → oxygen depletion → dead zones.
- Bioaccumulation: Plastics and toxins enter the food chain → affect humans.
- Disease spread: Pathogens in untreated wastewater cause outbreaks.



Water Contaminants & Effects

| Contaminant Type | Source | Impact |
|---------------------|--------------------------|---|
| Metals (Fe, Zn, Cu) | Natural rocks, pollution | Essential in trace amounts, toxic in excess |
| Nitrates | Fertilizers, runoff | Health risks, eutrophication |

| | | |
|-------------------|-------------------------|---------------------------------------|
| Phosphates | Detergents, fertilizers | Algal blooms, oxygen depletion |
| Pathogens | Wastewater | Waterborne diseases |
| Plastics | Human waste | Ecosystem damage, enters food chain |
| Detergents | Household use | Damages aquatic life, adds phosphates |

Coagulation to Chlorination

After sedimentation and coagulation with alum and slaked lime, the process continues:

Filtration:

- Water passes through sand and gravel layers.
- Sometimes activated charcoal is used to remove color, odor, and organic compounds.

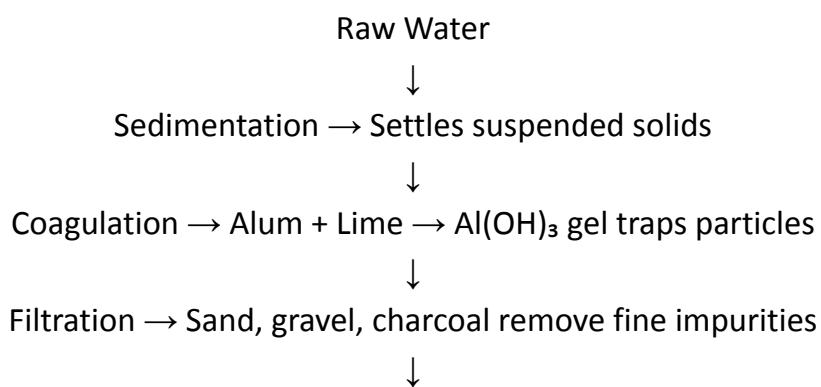
Chlorination:

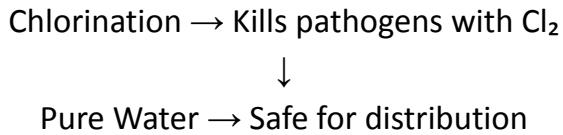
- Chlorine (Cl_2) is added to kill remaining bacteria.
- Chlorine reacts with water to form hypochlorous acid (HClO), a strong disinfectant.

Chemical Reaction:



Final Flowchart:





Types of Purified Water

12.2.1. Distilled Water

Process: Boiling → condensation of steam → impurities left behind.

Properties:

- pH = 7 (neutral)
- Very low electrical conductivity
- Free from minerals, contaminants, bacteria

Uses in Chemistry:

- Preparing chemical reagents
- Calibrating pH meters and sensors

· Health Note: Not ideal for long-term drinking → lacks essential minerals → can cause mineral deficiencies.

12.2.2. Tap Water

Source: Municipal supply from rivers, lakes, reservoirs, groundwater.

Treatment: Meets safety standards through purification.

Uses in Lab:

- Cleaning glassware
- General solvent for demonstrations
- Not used for precise experiments due to dissolved minerals.

DISTILLED WATER vs TAP WATER

What's the Difference?



VS



DISTILLED WATER

- purified by distillation
- no minerals
- flat taste
- used in laboratories, appliances

TAP WATER

- from municipal source
- contains minerals
- may contain contaminants
- used for drinking

12.3. Water Pollution

Causes of Pollution

As water moves through the environment, it dissolves minerals and pollutants from:

Natural sources: Minerals from rocks and soil.

Human activities:

- Household waste
- Agricultural runoff (fertilizers, pesticides)
- Industrial discharge
- Oil spills
- Detergents, soaps



- Septic tanks
- Petroleum and gas production

Household Waste and Its Impact

| Waste Type | Examples | Impact on Water |
|------------------------------------|------------------------|--|
| Human & Livestock Waste | Feces, urine | Pathogens → cholera, typhoid, hepatitis |
| Soaps & Detergents | Cleaning agents | Eutrophication, toxic to fish, long persistence |
| Paints & Oils | Solvents, hydrocarbons | Toxic to aquatic life, hard to remove |
| Food & Vegetable Waste | Organic matter | Decomposes → uses up oxygen → kills aquatic life |
| Garbage | Plastics, packaging | Physical pollution, enters food chain |

Specific Harm from Detergents:

- Stronger cleaning power than soap but persists in water.
- Removes protective mucus from fish → exposes to bacteria/parasites.
- Damages fish gills.
- Contains phosphates → algal blooms → oxygen depletion.

Benefits of Water Treatment

| Benefit | Explanation |
|---------------------------|--|
| Prevents Epidemics | Removes pathogens causing cholera, typhoid, hepatitis, polio |

| | |
|--|--|
| Removes Heavy Metals | Arsenic (As), Chromium (Cr), Lead (Pb) → cause cancer, neurological issues |
| Improves Taste & Appearance | Removes odors, colors, suspended particles |
| Protects Aquatic Life | Reduces toxins entering rivers/lakes |
| Safe for Daily Use | Makes water potable and suitable for domestic purposes |

Diseases from Contaminated Water

- Cholera – Bacterial infection from *Vibrio cholerae*
- Typhoid – *Salmonella typhi*
- Hepatitis – Viral infection affecting liver
- Dysentery – Severe diarrhea with blood
- Polio – Poliovirus
- Botulism – Rare but serious illness from toxic materials

12.4. Waterborne Diseases

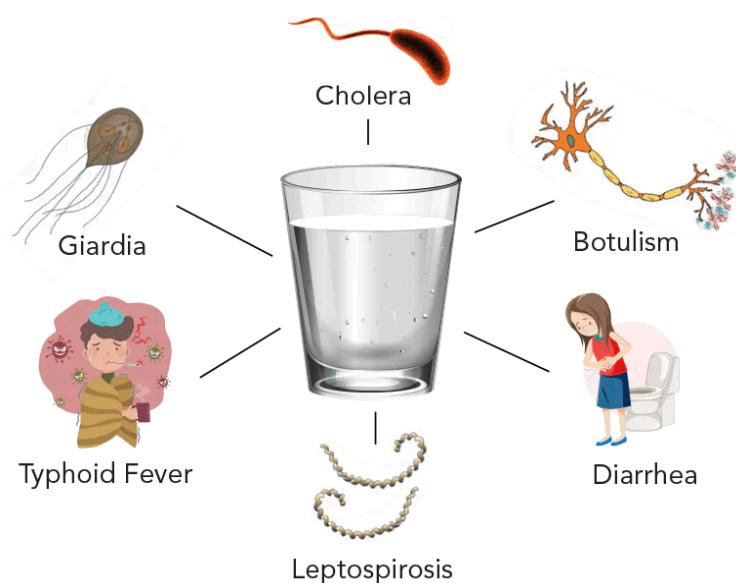
Waterborne diseases are caused by pathogens (bacteria, viruses, parasites) in contaminated water due to poor sanitation and waste disposal.

Common Waterborne Diseases:

| Disease | Caused by | Transmission | Symptoms |
|------------------|--------------------------------------|-----------------------------------|--|
| Dysentery | Parasite (Entamoeba) | Fecal contamination of water/food | Abdominal cramps, diarrhea, mucus/blood in stool |
| Typhoid | Bacteria (<i>Salmonella typhi</i>) | Polluted water, contaminated food | Continuous high fever (101– 104°F), |

| | | | |
|------------------------|-------------------------------------|--|---|
| | | | irregular pulse, weakness |
| Hepatitis Virus | (Hepatitis A & E) | Polluted water, poor sanitation | Liver inflammation, jaundice, fatigue, loss of appetite |
| Jaundice | Often a symptom of liver issues | Result of hepatitis or bile obstruction | Yellow skin/eyes, weakness, fatigue, loss of appetite |
| Cholera | Bacteria (<i>Vibrio cholerae</i>) | Contaminated water | Severe diarrhea, dehydration |

- 2.668 million people die yearly worldwide due to unclean water, poor sanitation, and hygiene.
- Chlorination kills bacteria but is less effective against viruses (e.g., hepatitis viruses).
- Swimming pools use aeration and chlorination to control pathogens.



12.5 Ways To Deal With The Negative Effects Of Water Pollution

| Problem | Cause | Solution |
|---------------------------------|--------------------------------|---|
| Low Oxygen in Water | Nutrient runoff → algal blooms | Control nutrient flow; treat sewage/industrial waste |
| Heavy Metal Accumulation | Industrial waste | Prevent industrial wastewater from entering waterways |
| Waterborne Diseases | Harmful microbes in water | Treat wastewater; ensure sanitation; provide clean drinking water |

Detailed Actions:

1. **Control nutrient runoff** to prevent eutrophication.
2. **Treat industrial and domestic wastewater** before discharge.
3. **Promote sanitation and hygiene** to reduce pathogen spread.
4. **Regulate and monitor illegal dumping** and groundwater extraction.

12.6. Water Scarcity in Pakistan

Causes of Water Scarcity:

- Population Growth: Increased demand for agriculture, industry, and households.
- Climate Change: Irregular rainfall, reduced water availability.



- Over-extraction of Groundwater: Depletes aquifers.
- Inefficient Irrigation: Flood irrigation causes evaporation and uneven distribution.

Solutions to Water Scarcity:

- Effective water management (e.g., drip irrigation)
- Infrastructure development (dams, reservoirs, pipelines)
- Policy reforms for sustainable use
- Public awareness on water conservation
- Regulations to control groundwater extraction and prevent illegal drilling

12.7. Fertilizers and Their Impact

What Are Fertilizers?

Substances that provide essential nutrients for plant growth: Nitrogen (N), Phosphorus (P), Potassium (K) → NPK fertilizers.

Common Fertilizers:

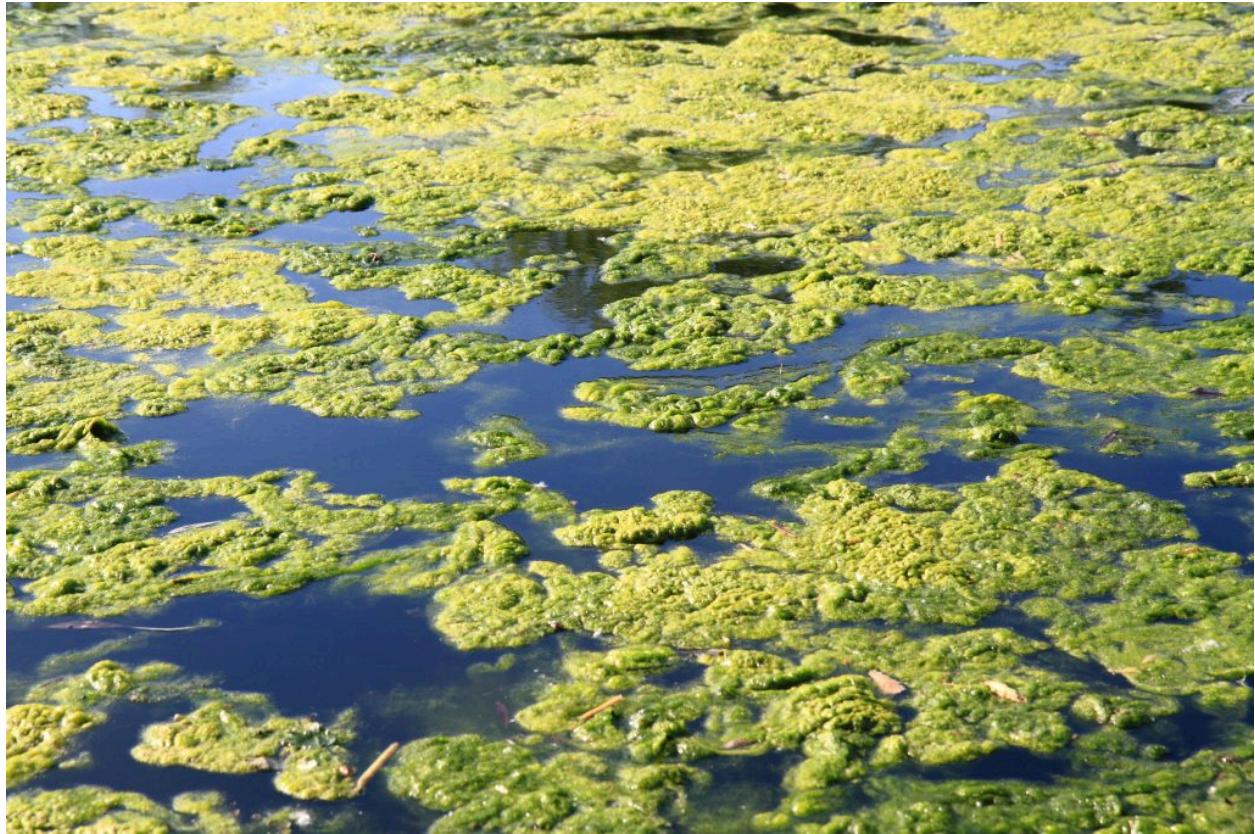
- Urea (Nitrogen)
- Potassium nitrate
- Ammonium salts (e.g., di-ammonium phosphate, superphosphate)

Benefits:

- Increase crop yields
- Provide nutrients in water-soluble form for easy plant uptake

Environmental Risks:

- Nutrient runoff into water bodies → eutrophication → algal blooms → oxygen depletion → harms aquatic life.



Nutrient Management:

- Applying fertilizers at the right time and in the right amount
- Reduces nutrient loss and environmental damage



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