Wastewater Treatment Lecture 2

Wastewater Engineering – Physical and Chemical properties

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Fall 2025

Water: The Lifeblood of Our Planet

Solid (Ice)

In its solid state, water becomes ice, a crystalline structure with a lower density than its liquid form. Ice is crucial for various natural processes, including glaciers and permafrost.

Liquid (Water)

The liquid state of water, commonly referred to simply as "water", is the most familiar form. It covers approximately 71% of the Earth's surface, playing a vital role in all life forms.

Gaseous (Vapor)

Water vapor, or steam, is the gaseous state of water. It is invisible to the naked eye and is present in the atmosphere, influencing weather patterns and contributing to the water cycle.

Water Quality: Defining the Essence of Our Source

Physical

Physical properties encompass aspects such as temperature, color, turbidity, and odour. These characteristics provide initial insights into the water's overall quality.

Chemical

Chemical properties encompass the presence of dissolved substances like minerals, salts, and pollutants. Chemical analysis is crucial for understanding the potential impacts of water on human health and the environment.

Biological

Biological parameters focus on the presence of microorganisms, including bacteria, viruses, and algae. The presence of these organisms indicates the water's suitability for various uses, particularly for drinking water.

Water Analysis: Unlocking the Secrets of Purity

1

1. Raw Water

Analysis of raw water helps identify the nature and levels of impurities, guiding the selection of appropriate treatment methods.

2

2. Treated Water

Water analysis after treatment verifies the effectiveness of purification processes and ensures that the final water meets established quality standards.

3

3. Monitoring

Regular water analysis helps monitor the overall quality of water sources and identify any potential changes or contamination risks.

Essential Water Quality Requirements for Domestic Use

Colorless

Water should be clear and free from any noticeable color, ensuring aesthetic appeal and suggesting purity.

Tasteless

It should be free from any unpleasant tastes or odours, ensuring palatability and promoting consumer acceptance.

Bacteriologically Safe

Water must be free from harmful bacteria and pathogens that can cause illness, safeguarding public health.

Mineral Content

The mineral content should be within acceptable limits, ensuring the water is not excessively hard or contaminated with harmful substances.

Environmental Water Quality: Parameters to Consider

1

Physical Properties

Physical parameters include color, odor, temperature, turbidity, and the presence of solids, oils, and grease.

2

Chemical Properties

Chemical parameters include pH, conductivity, dissolved oxygen levels, nitrates, phosphates, and various pollutants like pesticides and heavy metals.

3

Biological Properties

Biological parameters assess the presence of microorganisms, including coliforms, fecal coliforms, specific pathogens, and viruses.

Physical Parameters: First Insights into Water Quality

1

Temperature

The temperature of water, measured using thermometers, affects its density, viscosity, and other properties.

2

Color

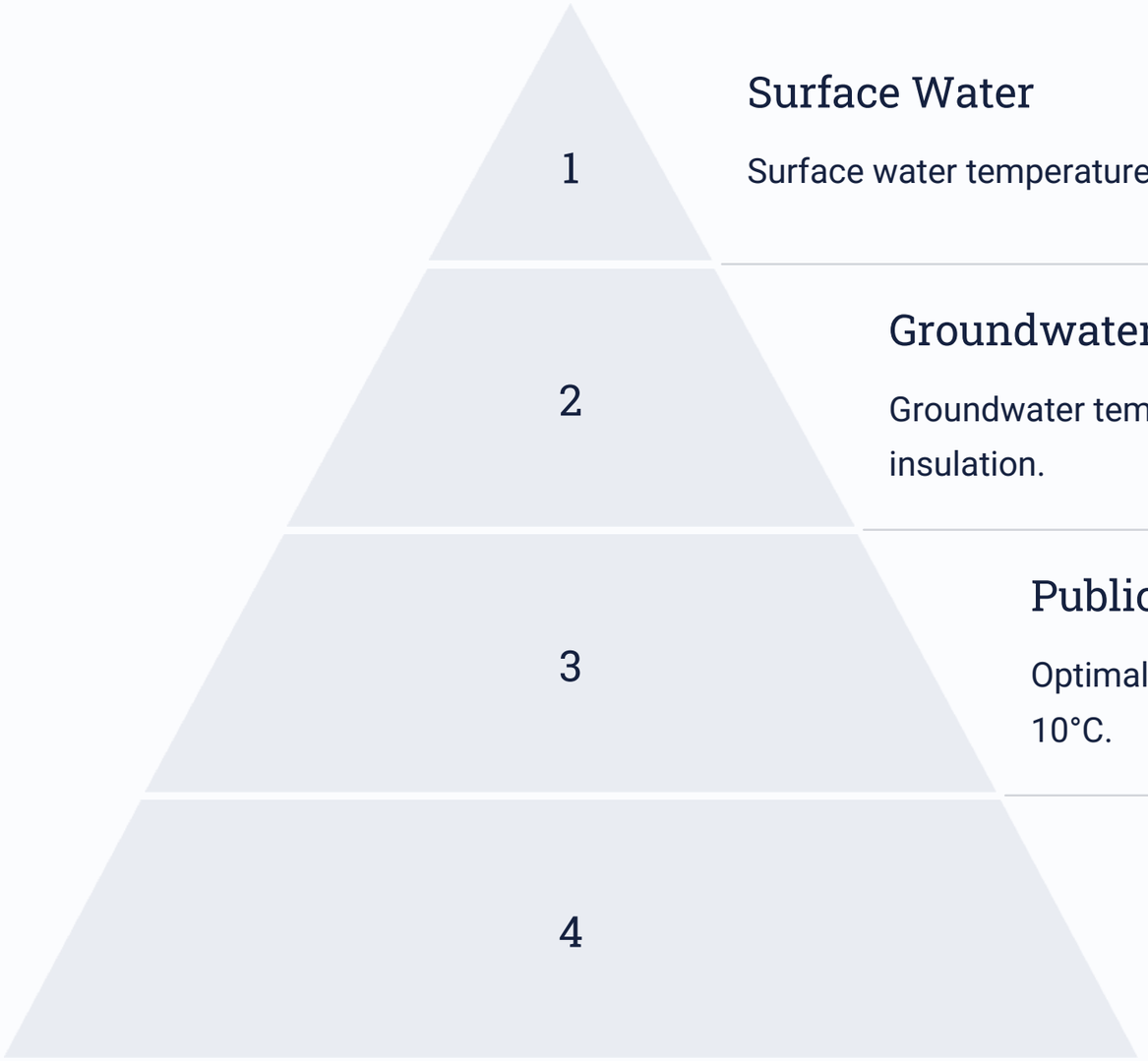
The color of water, often due to organic matter, is assessed by comparing it to standard color solutions. Acceptable color limits are typically established for domestic water.

3

Odor

Odor, which can be caused by various substances, is assessed through sensory evaluation techniques. The absence of objectionable odors is essential for water quality.

Temperature: A Key Indicator of Water Quality



Surface Water

Surface water temperatures are generally similar to atmospheric temperatures.

Groundwater

Groundwater temperatures can differ from atmospheric temperatures due to the earth's insulation.

Public Supply

Optimal temperature ranges for public water supplies are between 4.4°C and 10°C.

Unfit for Consumption

Temperatures exceeding 35°C are generally considered unfit for drinking due to taste and potential health risks.

Color: Assessing the Visual Purity of Water

1

Suspended Matter Removal

Before assessing color, suspended matter is removed through processes like centrifugation.

2

Color Comparison

The color of the water is compared with standard color solutions, using a scale such as the platinum-cobalt scale.

3

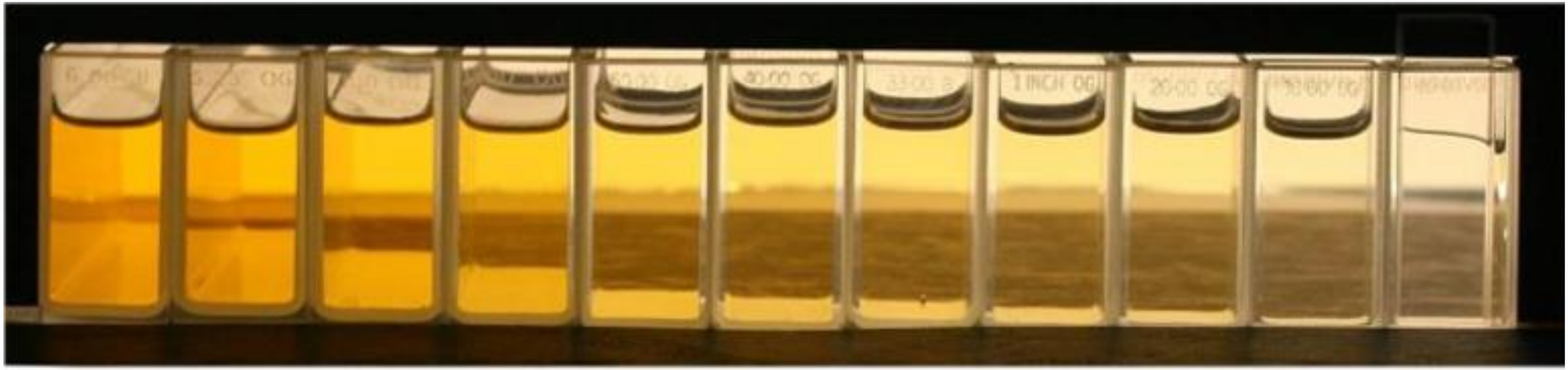
Acceptable Limits

The permissible color for domestic water is typically 20 PPM on the platinum-cobalt scale.

4

Aesthetic Concern

While color is primarily an aesthetic concern, it can sometimes indicate the presence of certain impurities.


6"
5.25"
100mm
3"
50mm
40mm
33mm
1"
20mm
10mm
1mm

Odor and Taste: Unveiling the Sensory Attributes of Water

1

Sensory Evaluation

Odor and Taste is assessed through the use of sensory evaluation techniques, where trained individuals evaluate the water's smell.

2

Ingestion Safety

Sensory evaluation is only used on water samples that are deemed safe for human ingestion.

3

No Objectionable Odor

The goal of water quality standards is to ensure the absence of any objectionable odors and tastes in water intended for consumption.

Understanding Odour in Water

Odour Measurement

Odour is assessed using a device called an OSMOscope, which measures the Threshold Odor Number (TON).

TON Interpretation

TON represents the dilution ratio at which the odor becomes detectable. A higher TON indicates a stronger odor.

Turbidity: A Measure of Water Clarity

Suspended Matter

Turbidity is caused by suspended particles, such as clay, silt, and algae.

Light Scattering

Turbidimeters measure light scattering, indicating the amount of suspended matter.

Visual and Direct Methods

Turbidity can be measured visually or using instruments with direct readings.

الجدول ٢ ــ الخصائص الفيزيائية لمياه الشرب

الخاصية	الحد الأقصى المسموح به
اللون	١٥ TCU
الطعم	مستساغ
الرائحة	مقبولة
العكارة	٥ NTU
درجة الحرارة للمصدر المائي	٢٥ درجة مئوية

المصدر مؤسسة المواصفات والمقاييس

Chemical Properties

1. pH
2. Electrical Conductivity (EC)
3. Total Dissolved Solids (TDS)
4. Hardness
5. Minor or trace elements
6. Salinity
7. Alkalinity

Electrical Conductivity (EC)

Measurement

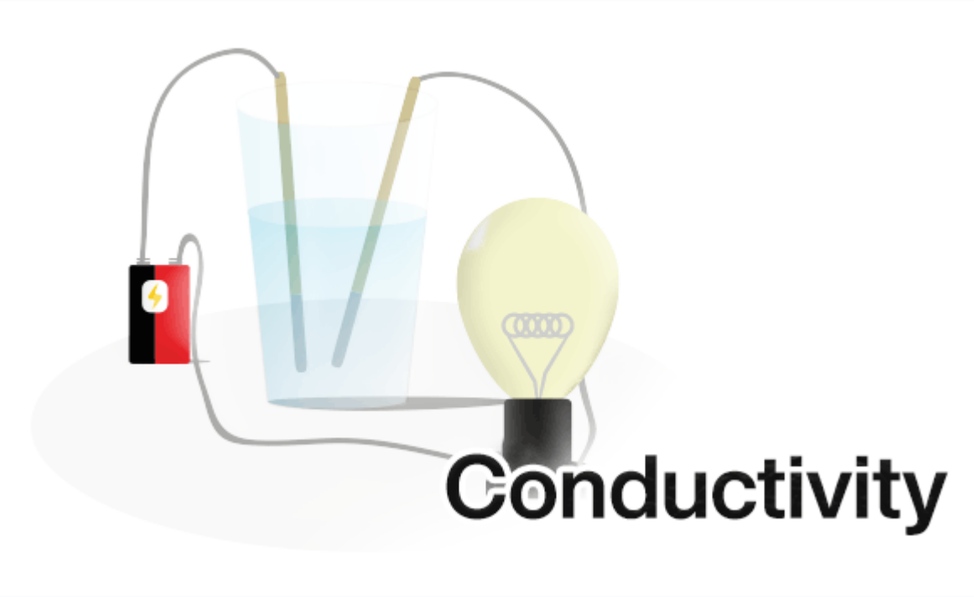
EC is measured using conductivity meters, which determine the resistance of water to electrical flow.

Temperature Dependence

EC is directly proportional to temperature, meaning higher temperatures lead to increased conductivity.

Unit of Measurement

EC is typically expressed in milliSiemens per centimeter (mS/cm) or microSiemens per centimeter (µS/cm).
Pure water is less conductive



Water Type	Conductivity (µS/cm)
totally pure water	0.055
typical deionized water	0.1
distilled water	0.5-3.0
reverse osmosis water	50-100
domestic "tap" water	500-800
potable water	1,055 max
sea water	56,000
brackish water	100,000

Understanding EC

Dissolved Ions

The presence of dissolved ions, such as salts and minerals, makes water conductive.

Current Flow

These ions facilitate the flow of electrical current through the water.

Measurement

Conductivity meters detect the ease with which current flows through water, providing an indication of its dissolved ion content.

pH of Water

1

Hydrogen Ion Concentration

pH reflects the concentration of hydrogen ions (H+) in water.

2

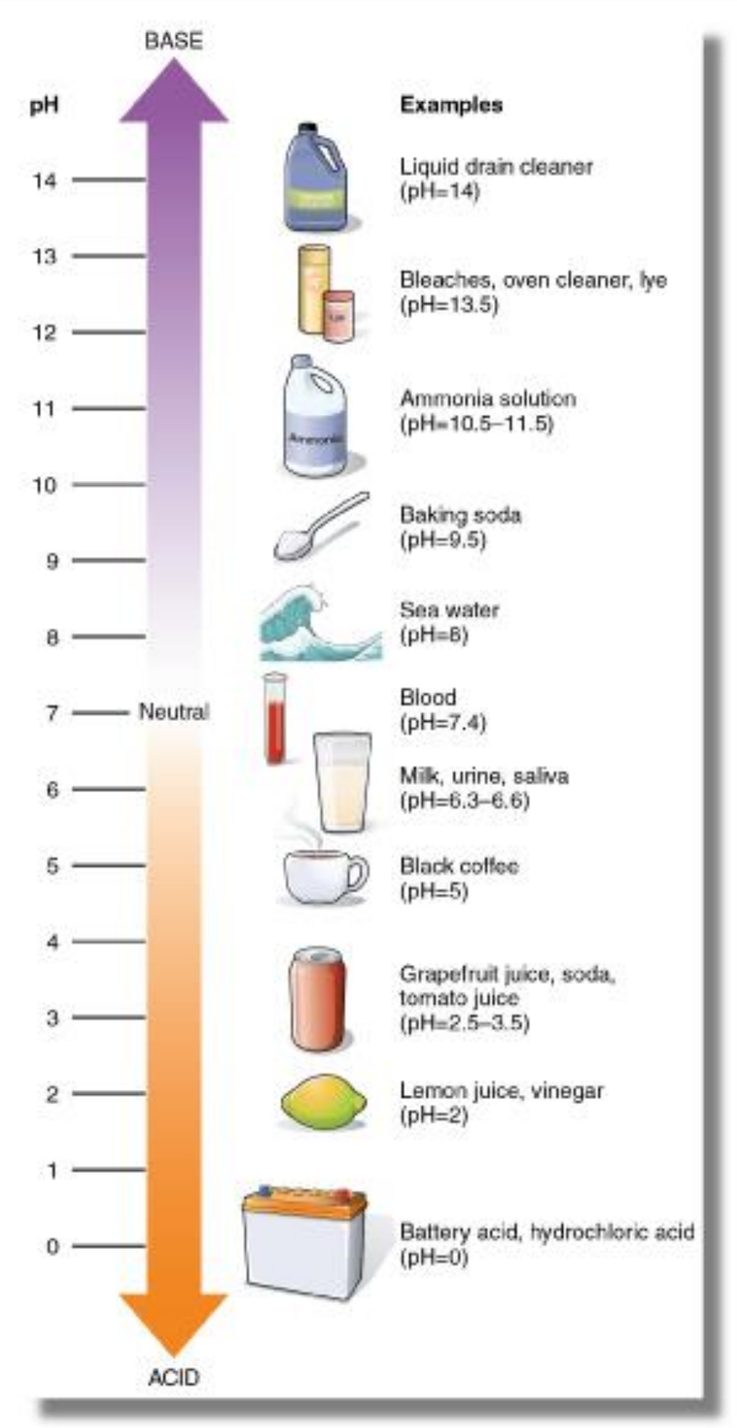
pH Scale

The pH scale ranges from 0 to 14, with 7 representing neutral, below 7 being acidic, and above 7 being alkaline.

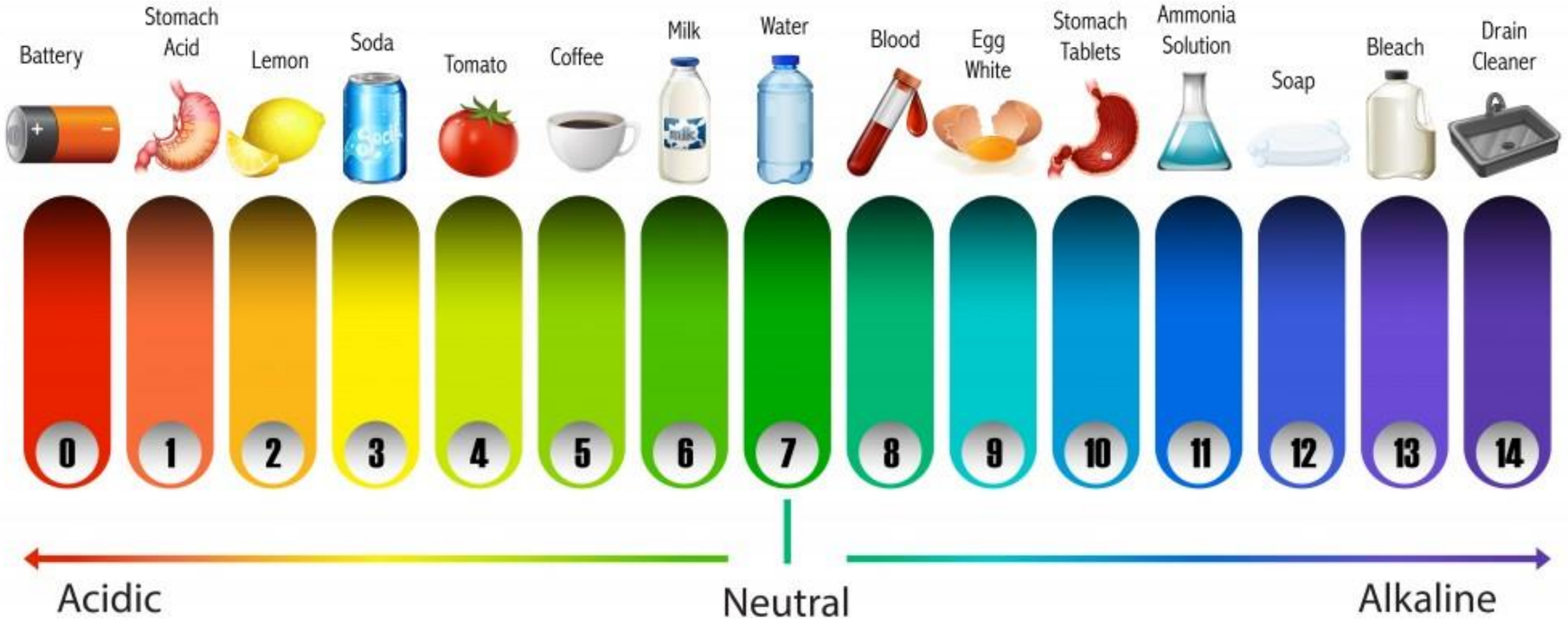
3

Measurement

pH meters are used to measure the hydrogen ion concentration and determine the pH value of water.



The pH Scale


Battery
Stomach Acid
Lemon
Soda
Tomato
Coffee
Milk
Water
Blood
Egg White
Stomach Tablets
Ammonia Solution
Soap
Bleach
Drain Cleaner
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Acidic
Neutral
Alkaline

Understanding pH

Acidity

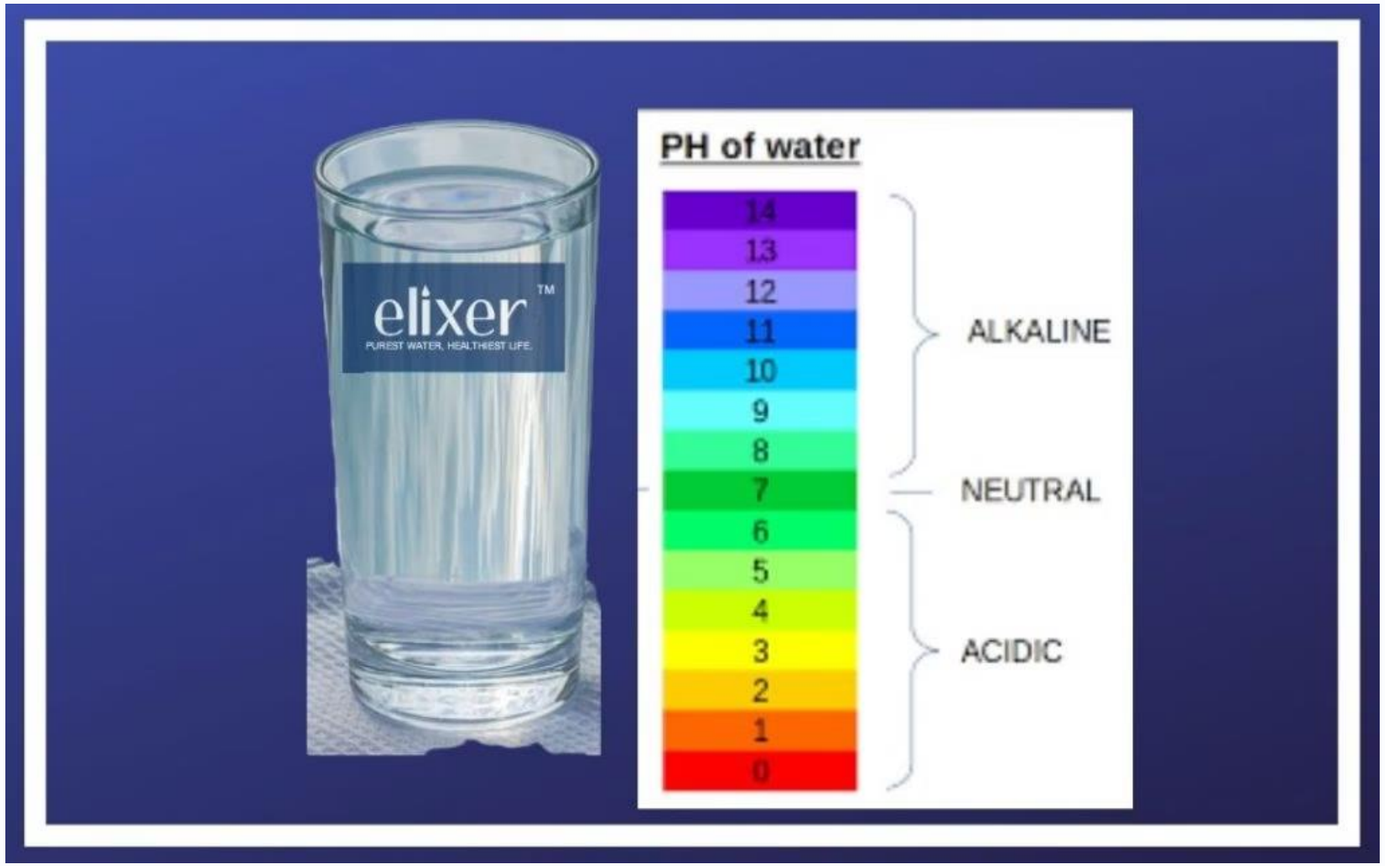
Water with a pH below 7 is considered acidic, indicating a higher concentration of hydrogen ions.

Alkalinity

Water with a pH above 7 is considered alkaline, indicating a lower concentration of hydrogen ions.

Neutrality

Water with a pH of 7 is considered neutral, meaning there is an equal balance of hydrogen and hydroxide ions.



Total Dissolved Solids (TDS)

1

Dissolved Substances

TDS represents the total amount of dissolved minerals, salts, and organic matter in water.

2

Concentration

TDS is expressed in parts per million (ppm) or milligrams per litre (mg/L), indicating the mass of dissolved substances per unit volume of water.

3

Water Quality

TDS levels influence the suitability of water for drinking, irrigation, and other uses.

Classification of Dissolved constituents:

1. Basis of concentrations- mg/L
2. Charges (positive or negative)
3. Level of Toxicity (toxic or non-toxic)

Based on Concentrations

1 Major Ions

These ions have a concentration greater than 10 mg/L, including bicarbonate, calcium, magnesium, chloride, sodium, sulphate, and silicon.

2 Minor Ions

These ions have a concentration ranging from 0.1-10 mg/L, including carbonate, fluoride, nitrate, potassium, iron, strontium, and boron.

3 Trace Elements

Trace elements have a concentration less than 0.1 mg/L, including aluminium, arsenic, barium, bromide, cadmium, chromium, cobalt, copper, lead, zinc, nickel, phosphate, silver, tin, and vanadium.

Based on Ionic Charges

Cations

Positively charged ions, such as calcium, magnesium, sodium, and potassium, are important for maintaining water balance and supporting life processes.

Anions

Negatively charged ions, such as bicarbonate, carbonate, chloride, sulphate, nitrate, and phosphate, contribute to water's alkalinity and nutrient content.

Major Cations in Water

Calcium (Ca)

Calcium plays a vital role in water hardness and is essential for various biological processes, including bone health.

Magnesium (Mg)

Magnesium is another key contributor to water hardness and is involved in numerous enzymatic reactions within organisms.

Sodium (Na)

Sodium contributes to water's salinity and can influence its taste and palatability.

Potassium (K)

Potassium is an essential nutrient for plant growth and plays a role in regulating water balance in organisms.

Major Anions in Water

Anion	Chemical Formula	Significance
Bicarbonate	HCO3-	Contributes to water's alkalinity and acts as a buffer against pH changes.
Carbonate	CO_3^{2-}	Involved in the formation of calcium carbonate, which can cause scaling in pipes and water systems.
Chloride	Cl-	Contributes to water's salinity and can affect its taste and corrosivity.
Sulphate	SO_4^{2-}	Can cause a bitter taste in water and contribute to scaling in pipes.
Nitrate	NO3-	An essential nutrient for plant growth, but excessive levels can be harmful to human health.
Phosphate	PO_4^{3-}	A vital nutrient for plant growth and can contribute to eutrophication in water bodies.

Trace Elements in Water

Essential Nutrients

Some trace elements, like iron and zinc, are crucial for human health and growth.

Toxicity

Excessive levels of trace elements like arsenic and lead can be toxic and pose serious health risks.

Balance

Maintaining proper balance of trace elements is essential for ecological health and human well-being.

Minor and Trace Elements

Iron (Fe)

Can cause staining and taste issues.

Copper (Cu)

Essential for some organisms, but high levels can be toxic.

Zinc (Zn)

Important for growth and development, but excess can be harmful.

Hardness of Water

1

Definition

Water hardness is defined as the content of metallic ions that react with soaps, forming a residue.

2

Measurement

Hardness is expressed as the total concentration of calcium and magnesium in parts per million (ppm).

3

Types

Softwater, with low mineral content, and hardwater, with high mineral content, have different properties and effects.

Water Hardness

1 Calcium and Magnesium

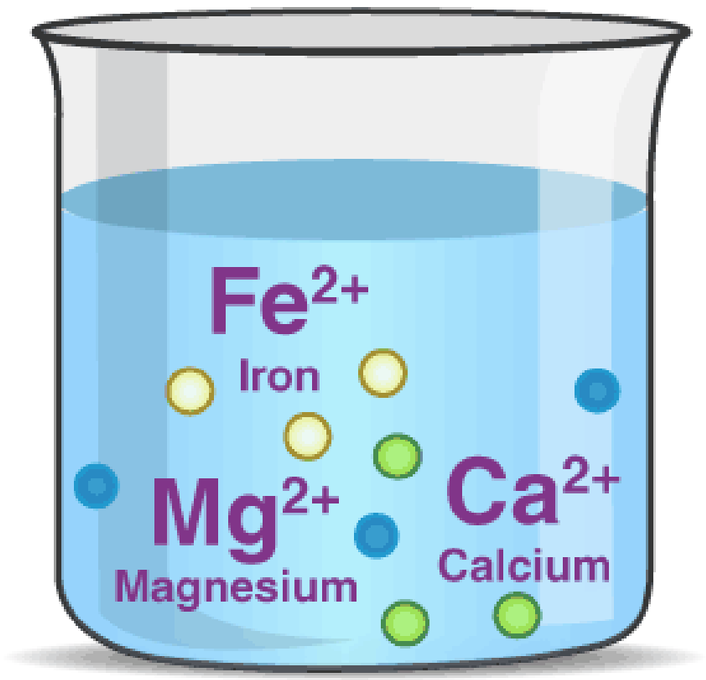
Hardness is primarily caused by the presence of dissolved calcium and magnesium ions.

2 Scale Formation

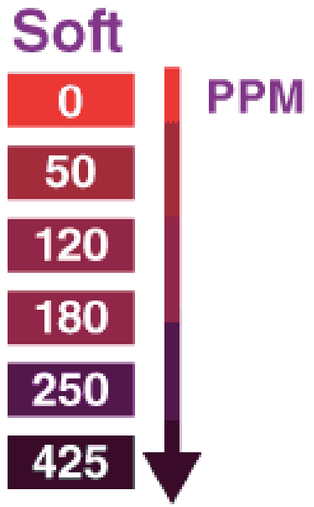
Hard water can lead to scale buildup in pipes and appliances, reducing efficiency and increasing maintenance costs.

3 Soap Lather

Hard water reacts with soap to form a scum, making it difficult to lather.



Hard water



Salinity of Water

Cause

Salinity is primarily caused by the presence of sodium and chloride ions in water.

1

Seawater

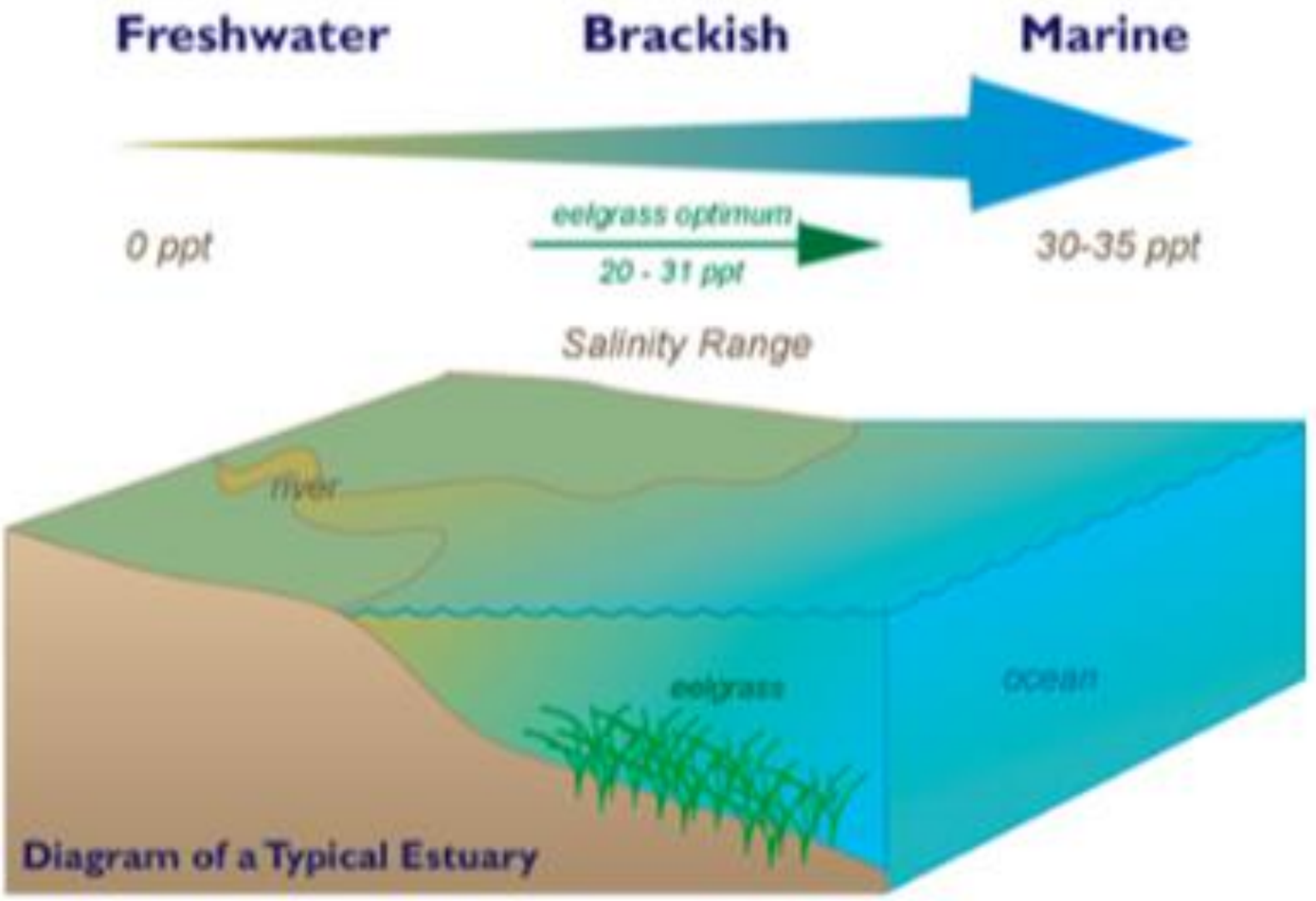
2

Seawater typically contains around 35,000 ppm or mg/L of dissolved salts, making it significantly saline.

Freshwater

3

Freshwater sources have much lower salinity levels, making them suitable for drinking and agriculture.


Freshwater
Brackish
Marine
0 ppt
eelgrass optimum
20 - 31 ppt
30-35 ppt
Salinity Range
river
eelgrass
ocean
Diagram of a Typical Estuary