ENVIRONMENTAL ENGINEERING

Chapter 2 : Water & Wastewaster Quality Management (Part 1)

Physical, Chemical Parameters

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Chapter Description

- Topic
  - Physical Parameters
  - Chemical Parameters
  - Biochemical Parameters

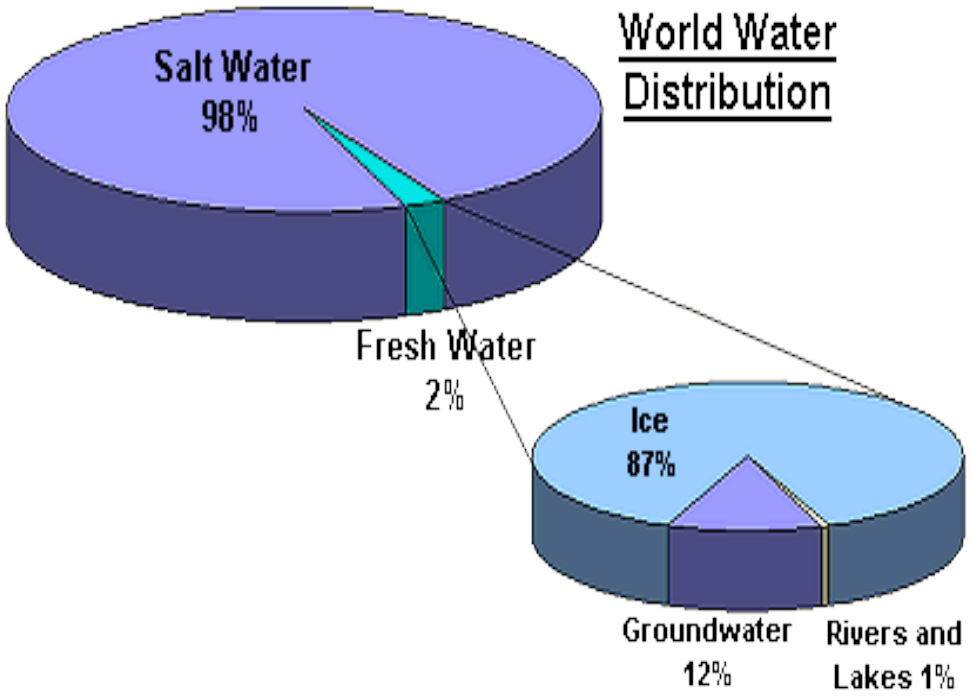
- Expected Outcomes
  - Explanation of the physical, chemical and biochemical wastewater quality parameters such as suspended solids, turbidity, alkalinity, hardness, BOD, microorganisms and nutrient
  - Select the content of environmental quality Act 1974 practices in Malaysia related to water

- References

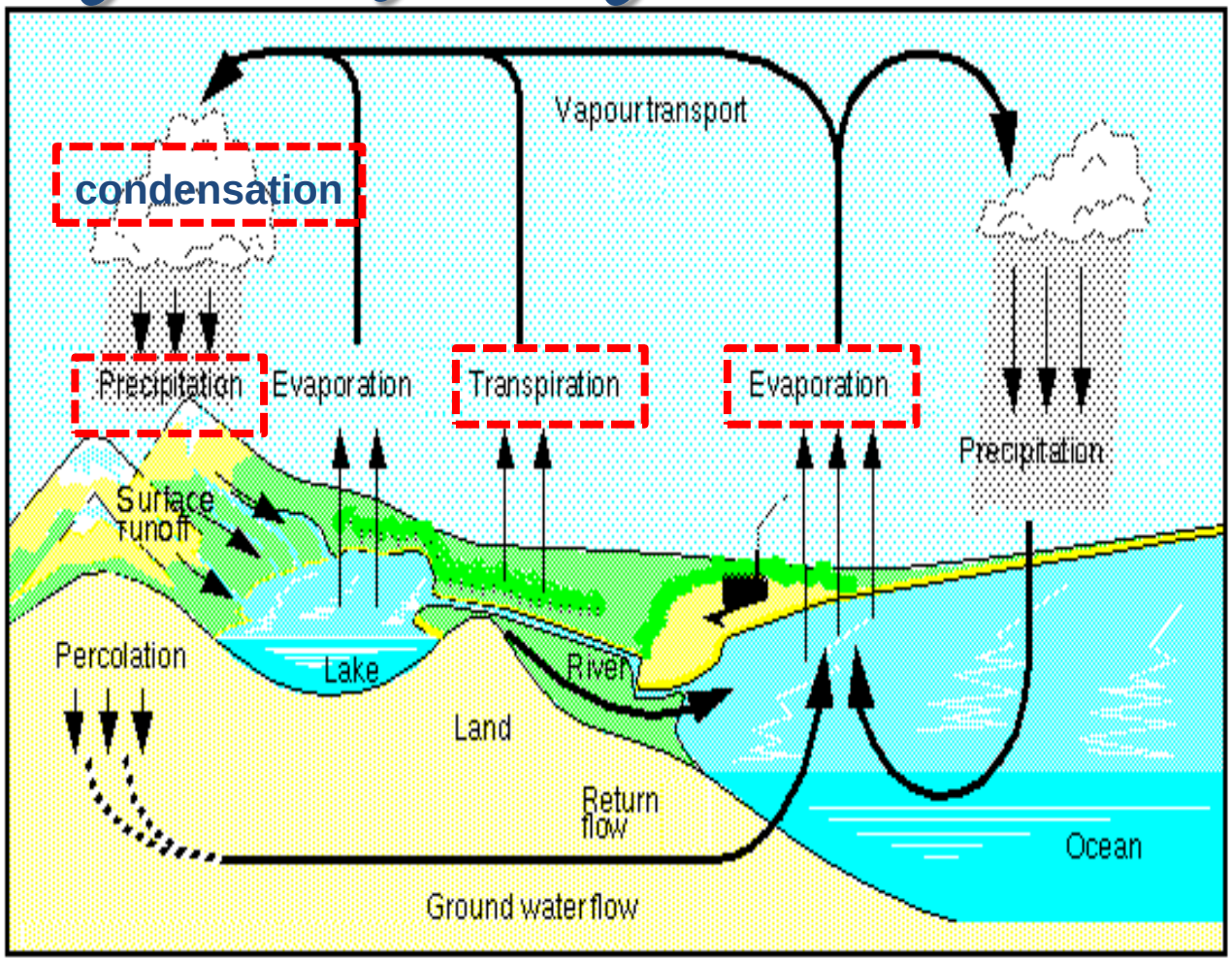
  - Peavy, H.S., Rowe, D.R. and Tchobanoglous, G., Environmental Engineering, McGraw Hill, 1985.
  - Mackenze, I.D., Introduction to Environmental Engineering, 4th Edition, Davis A. Cornell, Mc Graw Hill, 2008.
  - Sawyer, C.N. Chemistry for Environmental Engineerin. 4th Edition, McGraw Hill, 1994.
  - Martin, T.A. and David, W.H. Fundamental of Environmental Engineering. 2003.
  - Environmental Quality Act 1974 (Subsidiary Legislation), International Law Book, Service June 2002.

Overview

- Approximately, 98 % of water on the earth is salt water.
- The remaining 2 % → 87 % of fresh water is locked in glaciers and polar ice caps.
- 12 % in the ground.
- And leaving only 1 % of fresh water available for human use from lakes and river.



Hydrologic cycle



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

1. Evaporation : A change in phase in the atmosphere that occurs when substances change from a liquid to a gaseous or vapor form.

2. Transpiration : A process whereby plants give off water vapor through the pores of their leaves.

3. Condensation : transition from vapor phase to liquid phase

4. Precipitation : is any product of the condensation of atmospheric water vapour that falls under gravity including rain, snow, sleet or hail.

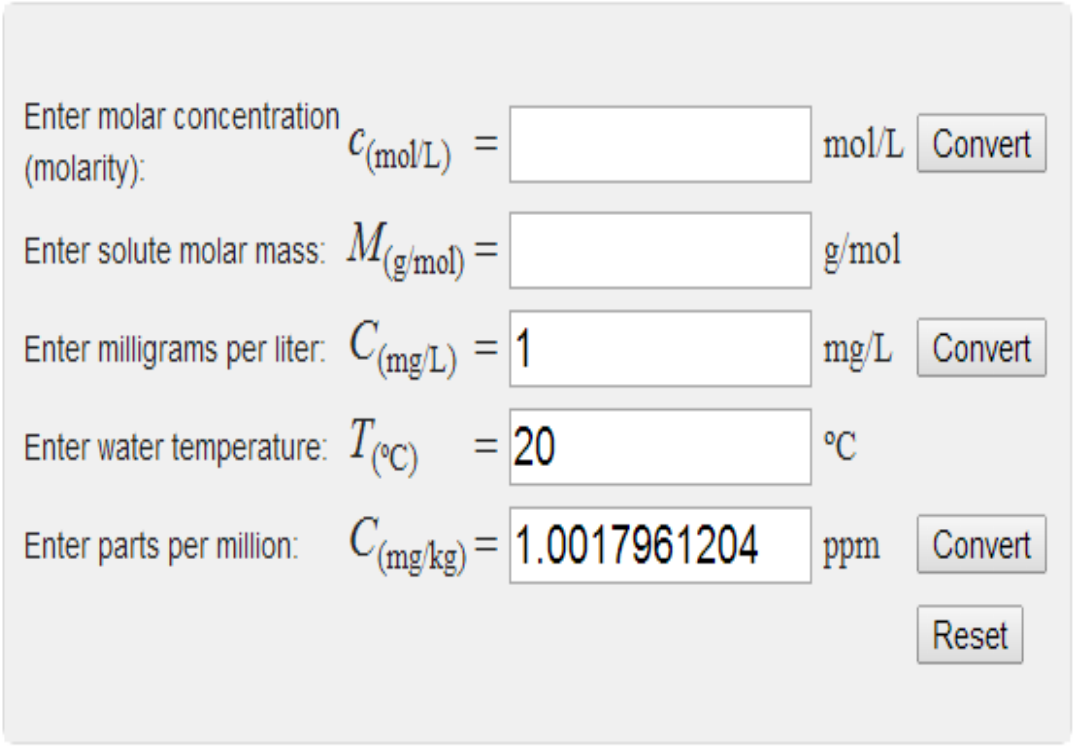
Measurement of Water Quality

- Standard Methods for the Examination of Water and Wastewater
- Water quality parameter concentration:
  - Weight of solute per weight of solution (wt per wt)
  - Parts per million (ppm) solution = 1 mg solute per kg (10^6 mg)
  - Part per thousand (ppt) solution = 1 g solute per kg (*i.e.* salinity)
- Weight per volume solution (wt /v)
- In the laboratory it is easier to measure volume of water using volumetric containers
- Unit : mg/L = ppm
- 1 liter of water = 1 kg (distilled water 3.89°C)

Salinity is the saltiness or dissolved salt content of a body of water or in soil.

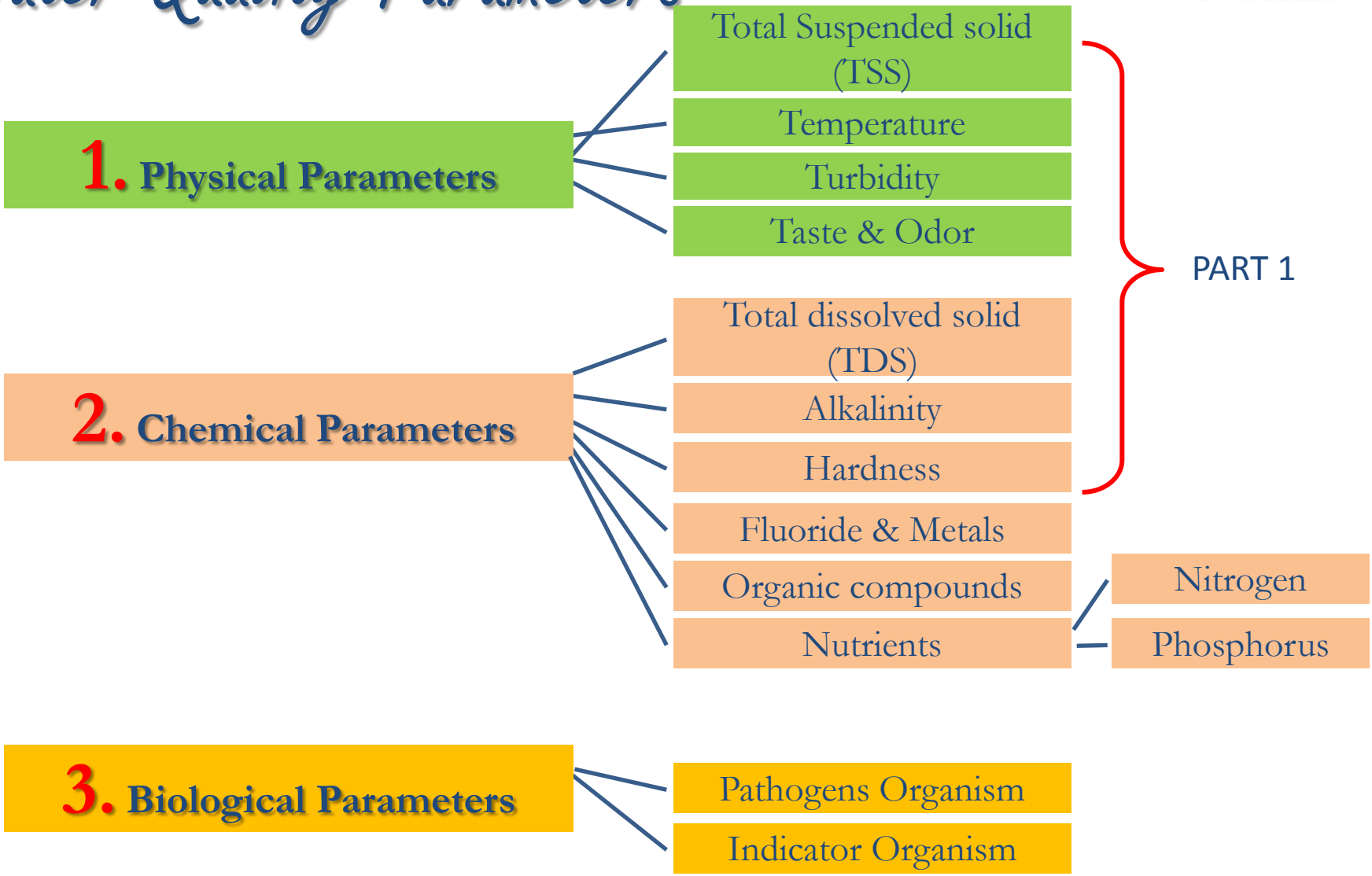
Moles per liter (mol/L) to milligarms per liter (mg/L) to ppm conversion calculator

Water solution, molar concentration (molarity) to milligrams per liter to parts per million (ppm) converter.



Source:http://www.rapidtables.com/math/number/PPM.htm

Water Quality Parameters



PHYSICAL PARAMETERS

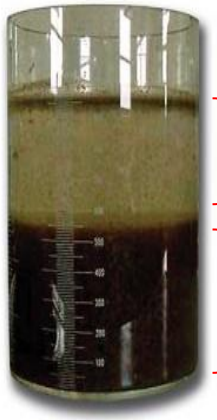
Physical Parameters

1 – Total Suspended Solids (TSS)

- Solid suspended in water may consists of inorganic or organic particles or immiscible liquids.
- **Causes:**
  - Inorganic – clay, silt, soil.
  - Organic – plant fibers, biological solids (bacteria, *etc.*)
  - Immiscible liquids – oils and greases (constituents of wastewater).
- **Impact:** unpleasant smell & may cause disease (cause by live suspended solids).

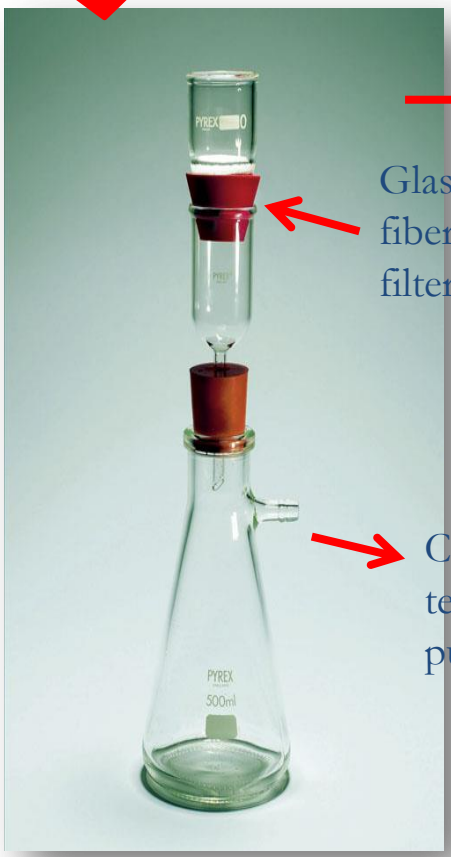
Natural contaminants and are common in surface water.

Measurement: Filtration

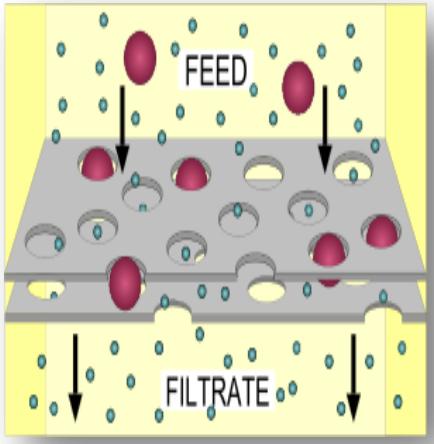


Dissolved solid

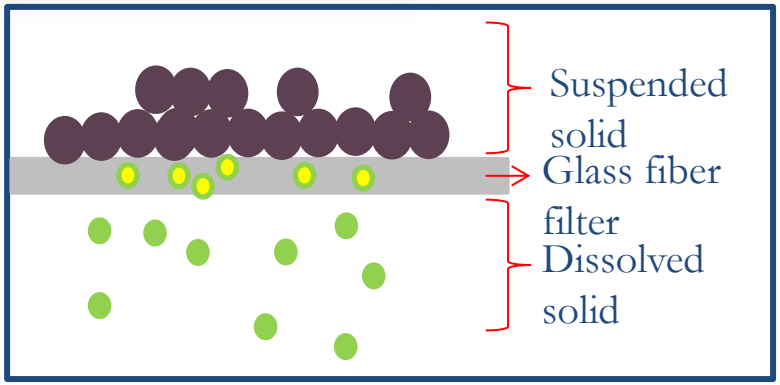
Suspended solid



Water sample is filtered through a glass fiber filter.



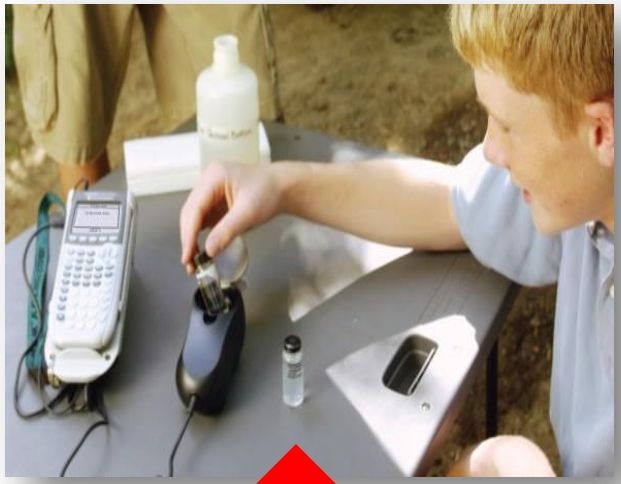
- **Unfilterable residues:** suspended solids –retained on the filter
- **Filterable residues:** dissolved solid- pass through the filter along with water



- The filtrate is dried using temperature at 180^{O}C (TDS).
- The residue on the filter is dried at 103 – 105^{O}C (TSS)

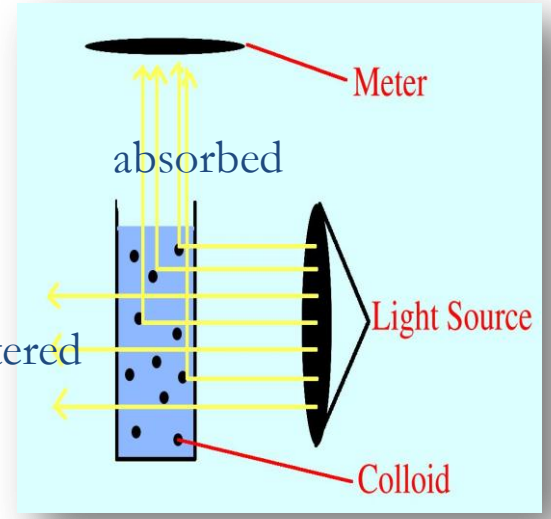
2 – Turbidity

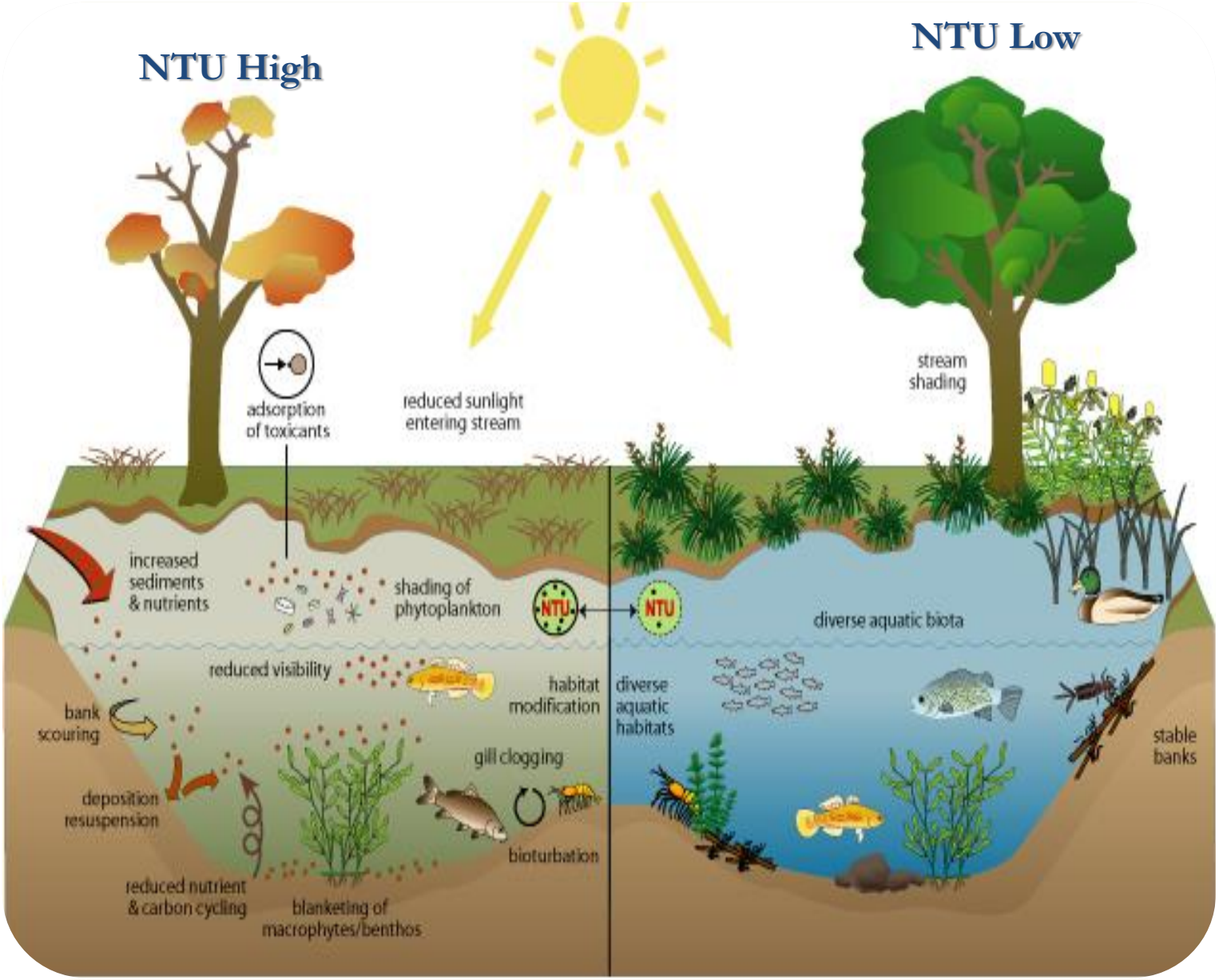
- Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material in water.
- For potable water supplies measurement.
- **Causes:** Is caused by suspended substances in the water such as clay, silt, fine organic materials, planktons *etc.*
- **Impact:** Give unpleasant apparent, interfere light penetration.



Turbidity meter reading

Turbidity measurement is an optical measurement - suspended matter disperse light percentage.
Unit NTU (nephelometry turbidity units).





Turbidity, WetlandInfo, Department of Environment and Heritage Protection, Queensland.

3 – Color

- Pure water is colorless
- However, dissolved solids that remain after removal of suspended will affect the color – **true color**
- The yellowish-brown color cause by leaves, weeds, wood.
- Reddish cause by iron oxides & brown or black cause by manganese oxides.
- Not aesthetically acceptable to the general public (consumers tend to choose clear, non colored water).
- Measurement: by spectrophotometer
- compare color with standardized colored materials.

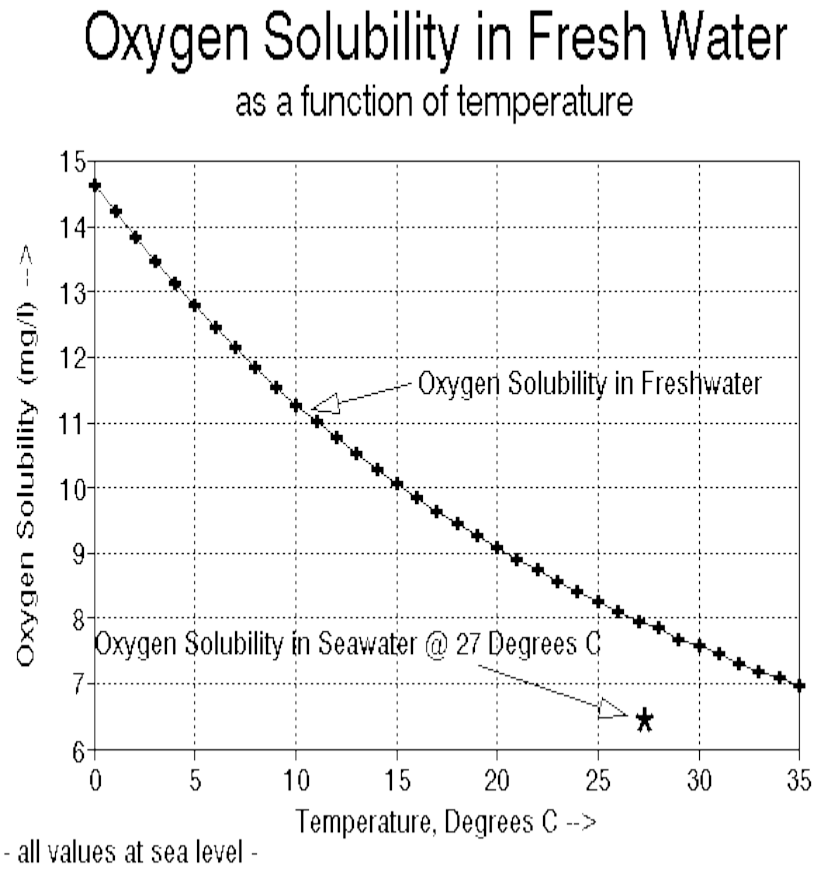
4 - Taste and Odor

- **Source:** Many mineral substances that produce taste but no odor.
  - Inorganic: taste (no odor) *e.g.*: metallic salts: salty and bitter.
  - Organic : taste + odor
- Minerals, metals, salts, biological reactions and constituents of wastewater.
- **Impact:** Consumers find taste and odor aesthetically displeasing.
- **Measurement:** Quantitative test, employ human sense.

Algae bloom

5 - Temperature

- Temperature of surface water governs to a large extent the biological species present and their rates of activity.
- **Impact:**
  - Cooler water usually have a wider diversity of biological species.
  - At lower temp the rate of biological activity (growth, reproduction, *etc.*) is slower, temp increased, biological activity increases.
  - Most chemical reactions involving dissolution of solids are accelerated by increased temperatures.
  - The solubility of gases decreased at high temperature.
  - The viscosity of water increases with decreasing temperature.



Source:http://www.marietta.edu/~mcshaffd/aquatic/sextant/chem.htm

CHEMICAL PARAMETERS

Chemical Parameters

Chemistry of Solutions:

The equivalence of an element or radical is defined as the number of hydrogen atoms that the element or radical can hold in combination or can replace in reaction.

An equivalent (equiv) of an element or radical is its gram molecular mass divided by its equivalence.

A milliequivalent (meq) is the molecular mass expressed milligrams (mg) divided by the equivalent.

1- Total Dissolved Solids (TDS)

Sources:

-Dissolved substance may be organic or inorganic (includes minerals, metals and gases).

Impact:

-Produce aesthetically displeasing color, taste, odor and might be carcinogenic.

-Not all dissolved substances are undesirable in water. (*e.g.*: mineral water).

Bottled mineral water usually contains higher TDS levels than tap water.

A carcinogen is any substance, radionuclide, or radiation that is an agent directly involved in causing cancer. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes

Source:https://upload.wikimedia.org/wikipedia/commons/4/49/AMDK_2tang%28Botol%2C_Cup%29.jpg

- **Measurement:**
  - Ions balance – common ions (summed in equivalent basis) to represents approximate TDS
  - As a check, the sum of the anions should be equal to the sum of cations because the electroneutrality must be preserved.

2. Alkalinity

- Defined as the quantity of ions in water that will react to neutralize hydrogen ions (neutralize acids).
- **Sources:**
  - Constituents of alkalinity in natural water include CO_3^{2-} (carbonate), HCO_3^-(bicarbonate), OH^-(hydroxide) *etc.*
  - Resultant from dissolution of mineral substances in soil and atmosphere.
  - Originate from CO_2, a constituent of the atmosphere and a product of microbial decomposition of organic material.

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \quad dissolved\ CO_2\ and\ carbonic\ acid$$

$$H_2CO_3 \longleftrightarrow H^+ + HCO_3^-\ bicarbonate$$

$$HCO_3^- \longleftrightarrow H^+ + CO_3^{2-}\ carbonate$$

$$CO_3^{2-} + H_2O \longleftrightarrow HCO_3^- + OH\hbar ydroxide$$

- **Impact:**
  - Utilization of the bicarbonate ion as a carbon source by algae can drive the reaction to the right (carbonate) and result in substantial of OH^-
  - Heavy algal growths often has high pH values (9 to 10).
  - Relative quantities of the alkalinity species are pH dependent
  - Give a bitter taste to water.
  - Reaction between alkaline constituent and cation (+ve ion) produces precipitation in pipe.

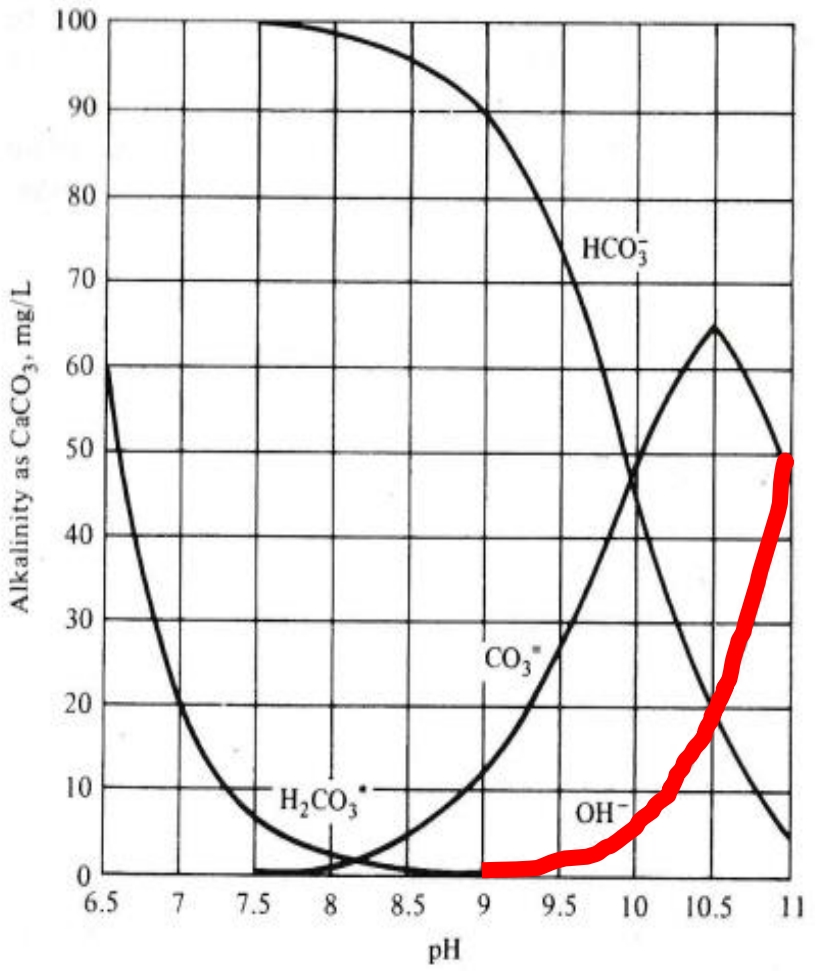


Figure 2.3: Alkalinity species vs. pH

$$CO_2 + H_2O \leftrightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

$$HCO_3^- \rightarrow H^+ + CO_3^{2-}$$

$$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$$

- **Measurement:**
  - Measure by titrating water with an acid and determining the hydrogen equivalent.
  - Alkalinity expressed as 'mg/L as $CaCO_3$'.
  - *E.g.* : 0.02 *N* H_2SO_4 is used, 1mL of acid will neutralize 1 mg of alkalinity as $CaCO_3$.
  - H^+ from the acid react with the alkalinity according to the following equations:

$$H^+ + OH^- \Leftrightarrow H_2O$$

$$CO_3^{2-} + H^+ \Leftrightarrow HCO_3^-$$

$$HCO_3^- + H^+ \Leftrightarrow H_2CO_3$$

3. Hardness

- Defined as concentration of multivalent metallic cations in solution.
- At supersaturated conditions, the hardness cations will react with anions in the water to form a solid precipitate.
- Classified as *carbonate hardness* and *noncarbonate hardness*.
- **Sources:**
  - Calcium, magnesium, iron, manganese.
- **Impacts:**
  - Hard water used in soap consumption will bring economic loss to the water user.
  - Precipitate form on hardware- boiler scale: may cause economic loss through fouling of water heaters and hot water pipes
  - Precipitate in pipe – temperature and pH increased.

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To be continued…

Author Information

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