Determination of water quality

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Water Quality

- The quality of the water you consume or use in municipal or industrial processes must meet specific parameters.
- For instance, **the EPA has set legal limits on more than 90 different contaminants that can be found in water**.
- These limits are necessary to ensure that drinking water remains free from contaminants that could cause health issues or the development of waterborne diseases.
- When it comes to industrial facilities, there are times when water must be treated to ensure that the quality is at an acceptable level for a wide range of essential processes.
- There are three water quality parameters that help to measure the quality of water, which include **physical parameters, chemical parameters, and biological parameters**.
- The physical parameters include color, taste, odor, temperature, turbidity, solids, and electrical conductivity.
- On the other hand, chemical parameters can include pH, acidity, alkalinity, chlorine, hardness, dissolved oxygen, and biological oxygen demand.
- The third type of parameter involves biological parameters, which include bacteria, algae, and viruses.

Water quality parameters matter because of the different requirements that applications can have.

- The following water properties are important in determining water quality:
- **Temperature:** Water temperature is important to fish and aquatic plants. Temperature can affect the level of oxygen, as well as the ability of organisms to resist certain pollutants.
- **Acidity – pH:** The measurement of pH is a measure of the amount of hydrogen ions (H+) present in a substance such as water. Knowing the amount of hydrogen in a substance allows us to judge whether it is acidic, neutral, or basic.
- **Dissolved Oxygen:** A small amount of oxygen, about ten molecules of oxygen per million molecules of water, is dissolved in water. Fish and microscopic organisms need dissolved oxygen to survive.

... The following water properties are important in determining water quality:

- **Turbidity:** Turbidity makes the water cloudy or opaque. Turbidity is the amount of particulate matter (such as clay, silt, plankton, or microscopic organisms) suspended in water.
- **Specific Conductance:** Specific conductance measures the capacity of water to conduct an electrical current. It depends on the amount of dissolved solids, such as salt, in the water.
- **Hardness:** The amount of dissolved calcium and magnesium in water determines its “hardness.” Water hardness varies throughout the United States.
- **Suspended Sediment:** Suspended sediment is the amount of soil circulating in water. The amount depends in part on the speed of the water flow. Fast-flowing water can pick up and hold, or suspend, more soil than calm water

Dissolved Oxygen

- The stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis.
- Running water, because of its churning, dissolves more oxygen than still water, such as that in a reservoir behind a dam.
- Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen.
- Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process.
- Other sources of oxygen-consuming waste include stormwater runoff from farmland or urban streets, feedlots, and failing septic systems.
- Oxygen is measured in its dissolved form as dissolved oxygen (DO).
- If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

… Dissolved Oxygen

- DO levels fluctuate seasonally and over a 24-hour period.
- They vary with water temperature and altitude. Cold water holds more oxygen than warm water and water holds less oxygen at higher altitudes.
- Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content.
- Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset.
- In contrast to lakes, where DO levels are most likely to vary vertically in the water column, the DO in rivers and streams changes more horizontally along the course of the waterway.
- This is especially true in smaller, shallower streams. In larger, deeper rivers, some vertical stratification of dissolved oxygen might occur.
- DO is measured either in milligrams per liter (mg/L) or "percent saturation." Milligrams per liter is the amount of oxygen in a liter of water.
- Percent saturation is the amount of oxygen in a liter of water relative to the total amount of oxygen that the water can hold at that temperature.

Dissolved oxygen is measured primarily either by using some variation of the Winkler method or by using a meter and probe.

- **Winkler method:** The Winkler method involves filling a sample bottle completely with water (no air is left to bias the test).
- The dissolved oxygen is then "fixed" using a series of reagents that form an acid compound that is titrated.
- Titration involves the drop-by-drop addition of a reagent that neutralizes the acid compound and causes a change in the color of the solution.
- The point at which the color changes is the "endpoint" and is equivalent to the amount of oxygen dissolved in the sample.
- **Meter and Probe:** A dissolved oxygen meter is an electronic device that converts signals from a probe that is placed in the water into units of DO in milligrams per liter.
- The probe is filled with a salt solution and has a selectively permeable membrane that allows DO to pass from the stream water into the salt solution.
- The DO that has diffused into the salt solution changes the electric potential of the salt solution and this change is sent by electric cable to the meter, which converts the signal to milligrams per liter on a scale that the volunteer can read.

Chemical Oxygen Demand (COD)

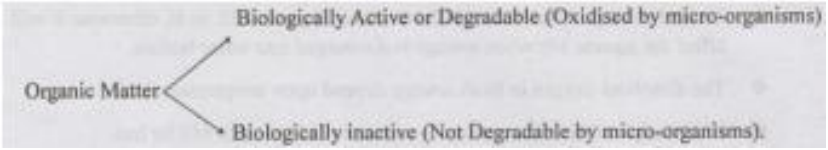
- Oxygen Demand: Oxygen required for oxidation of both inorganic as well as organic matter.
  - BOD - Biochemical Oxygen Demand.
  - COD - Chemical Oxygen Demand
- Chemical Oxygen Demand (COD): COD is an indicative measurement of the amount of oxygen that can be consumed by reactions in a measured solution.
- It is an indicator of the contents of reducing substances in the water, which are organic, nitrite, sulfide, ferrous salts, etc., and the organic is dominant.
- COD is commonly expressed in mass of oxygen consumed over volume of solution.
- The principle of COD detection is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic conditions .
- COD test - Oxidation using potassium dichromate. COD is determined using a method based upon the reduction of (orange) potassium dichromate to (green) chromium salts at high temperature, followed by absorbance measurement using a dedicated colorimeter.

… Chemical Oxygen Demand (COD)

- The International Organization for Standardization describes a standard method for measuring COD in ISO 6060.
- Potassium dichromate is a strong oxidizing agent under acidic conditions.
- Acidity is usually achieved by the addition of sulfuric acid.
- In the process of oxidizing the organic substances found in the water sample, potassium dichromate is reduced, forming Cr^{3+} .
- The amount of Cr^{3+} is determined (through titration with Ferrous Ammonium Sulphate and the oxygen used in oxidising the waste water is determined) after oxidization is complete and is used as an indirect measure of the organic contents of the water sample.
- One of the main limitations of the COD test is its inability to differentiate between biodegradable and biologically inert organic matter on its own.

What is biochemical oxygen demand?

- .**Biochemical oxygen demand (BOD):** It is an important measure of water quality.
- It is a measure of the amount of oxygen needed (in mg l^{-1}) by bacteria and other microorganisms to fully oxidize the organic matter present in a water sample.
- It is also called the biological oxygen demand.
- The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic water pollution.



- * Biologically Active → The organic matter which can be oxidised by microorganisms is called biologically active (under aerobic conditions at standard temperature).
- The oxygen consumed by the bacteria for decomposition of organic matter in sewage is BOD. Practically it is not feasible to determine the ultimate BOD. Hence BOD at 20°C during 5 days is taken which is 68% of the total BOD.
- BOD_{5d} =0.68 BOD
- BOD_5 = 5 day BOD
- BOD_u = Ultimate BOD.

… *Biochemical oxygen demand*

- The oxygen demand during the first 20 days is due to oxidation of organic matter in sewage and is called Carbonaceous BOD or first stage demand (CBOD).
- The latter oxygen demand occurs due to biological oxidation of ammonia and is called as second stage BOD or nitrogenous BOD (NBOD).
- **Why COD values are higher than BOD values?**
- In COD test, the oxygen required by chemicals for oxidation of both biologically active and biologically inactive organic matter is measured.
- But in BOD, the oxygen required by microorganisms for oxidation of biologically active organic matter only is measured.
- Microorganisms cannot act on biologically inactive organic matter and hence COD > BOD