AI 3010 WASTE AND BY PRODUCT UTILIZATION

UNIT II NOTES

Dissolved oxygen

Dissolved Oxygen (DO) is a water quality parameter that is very important in secondary treatment processes. DO levels represent the amount of oxygen that is dissolved and dispersed throughout a water sample. Bacteria and microorganisms use dissolved oxygen to break down organic material, therefore reducing concentrations of DO. In wastewater treatment, microorganisms are added in flocs to aerobically digest and remove organic matter.1 As a result, efficient treatment relies on microorganism health and dissolved oxygen concentration.

Sources:

In nature, DO levels are higher in streams with choppy, turbulent water, at colder temperatures, and during the day when aquatic plants release oxygen. Common sinks for DO in the environment include microbiological degradation of organic compounds and algae blooms.

In wastewater treatment, DO levels decrease as Biological Oxygen Demand (BOD) and microorganism activity increase. If DO concentrations are too low, microorganisms will die off and treatment efficiency will therefore decrease. Aeration and bubbler systems are needed to keep DO levels around 2 mg/L and to evenly distribute DO throughout the flocs that contain microorganisms.

aquatic life relies heavily on enough oxygen to survive just like you and me. If dissolved oxygen levels drop too low there can be a large loss of fish and plant population. Therefore, dissolved oxygen measurements can provide a great insight into water quality, especially when paired with pH, temperature, and other probe measurements.
As a rule of thumb, according to the Environmental Protection Agency (EPA), dissolved oxygen levels approaching 3 mg/L are in the danger zone for supporting common aquatic life, and then levels below 1 mg/L cannot support any aquatic life.
Dissolved oxygen levels vary for each organism, but levels around 8-9 mg/L will support all life (fish or plants) and approach the oxygen saturation level of water. This high level of dissolved oxygen should be closely monitored in hydroponic setups, as large changes can have detrimental effects on the plants.

Generally, dissolved oxygen will naturally balance itself in moving waterways full of fish and plant life. Since natural aeration, agitation (wind, animal movement) increase dissolved oxygen levels, one should pay closer attention if these elements do not exist like in a basement hydroponic tank. Other factors that affect dissolved oxygen include temperature, pressure, and salt concentration (salinity).

1. Temperature – as temperature rises, DO levels decrease
2. Pressure – as pressure decreases, DO levels decrease
3. Salinity – as the salt content increases, DO levels decrease

These 3 factors define the oxygen saturation level of a particular water system. In most cases, the dissolved oxygen level will not increase, naturally, beyond 13-14 mg/L but as stated above 8-9 mg/L is a high-quality water condition.

BOD – Biochemical Oxygen Demand

It is applied to determine the aerobic destructibility of organic substances.

BOD is the biological method used for the measurement of the total amount of dissolved oxygen (DO) used by microbes in the biological process of metabolizing organic molecules present in water.

The total amount of oxygen gas present in the water is called dissolved oxygen (DO). The non-compound oxygen present in water may either be a by-product of the photosynthesis of the aquatic plants or the dissolved atmospheric oxygen gas.

In some water bodies, organic matter is a great source of BOD. These organic matters include sewage and other pollutants present in the water bodies. The greater the BOD, the lower is the dissolved oxygen available for aerobic animals such as fishes and other **aquatic** organisms.

The BOD is accordingly a reliable measure of the organic pollution of water bodies. The main reason for treating wastewater prior to its discharge into a water resource is to reduce its BOD level (the demand for oxygen).

Importance of BOD

1. BOD measures the amount of oxygen consumed by microorganisms for the process of decomposition of the organic matters in the water bodies.

2. It indicates the amount of organic pollution present in an aquatic ecosystem.
3. BOD is calculated in sewage treatment or wastewater treatment to find the destruction of organic wastes by aerobic microbes
4. It determines the amount of organic matter present in soils, sewages, sediment, garbage, sludge, etc.
5. The biochemical oxygen demand also determines the rate of respiration in living beings.
6. BOD is also used in the medicinal & pharmaceutical industries to test the oxygen consumption of cell cultures.

Biochemical oxygen demand, or BOD, measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD also measures the chemical oxidation of inorganic matter (i.e., the extraction of oxygen from water via chemical reaction). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20 C). The rate of oxygen consumption in a stream is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water.

BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food-processing plants; failing septic systems; and urban stormwater runoff.

THE SIGNIFICANCE OF BOD IN WASTEWATER TREATMENT

Regulations concerning permissible BOD levels for wastewater disposal in industries and municipalities vary from state to state. BOD is listed as a conventional pollutant under the U.S. Clean Water Act. Typical maximum values range from 10 mg/L for direct environmental disposal and 300 mg/L for disposal to sewer systems.

Knowing BOD value helps municipal authorities determine their biological water quality and industries to assess the impact effluent disposal will have on the immediate environment.

APPLICATIONS OF BIOLOGICAL OXYGEN DEMAND IN WASTEWATER TREATMENT

Wastewater treatment plants use BOD value as an index to ascertain the overall degree of organic pollution in a water source. A BOD test is typically carried out over a standard 5-day incubation period at 20°C (68°F) for the most accurate results.

Generally, a higher BOD value indicates a higher level of water pollution, while a lower BOD value indicates less polluted, or cleaner water.

BENEFITS OF BOD REMOVAL WASTEWATER TREATMENT

Municipalities can use a BOD test to detect water contamination in their public supply to ensure that it is safe for human consumption. Industries need to know their BOD value to determine when treated wastewater is safe for reuse or disposal.

How to Reduce BOD in Wastewater

Several techniques are used for BOD removal in wastewater prior to reuse or safe disposal. Three common BOD reduction methods for wastewater treatment are:

- Wastewater clarification
- Wastewater separation (Coagulation & Flocculation)
- Anaerobic microbial decomposition

Wastewater clarification and separation BOD reduction methods are part of the primary phase of wastewater treatment while anaerobic microbial decomposition is part of the second phase of treatment.

WASTEWATER CLARIFICATION

Wastewater clarification removes organic solids (primary sludge) from the water by utilizing the force of gravity – in other words, the heavier particles settle to the bottom and are removed first. Wastewater clarification is often followed by a chemical separation process.

WASTEWATER SEPARATION (COAGULATION AND FLOCCULATION)

Wastewater separation removes any colloidal solids suspended in wastewater by *coagulation and flocculation*.

In coagulation, a non-toxic agglomerating agent such as Ferric Chloride (F_eCl) or alum is added to the wastewater causing the suspended particles to come together to form *clumps* which can easily be removed from the water by filtration.

Flocculation uses a chemical polymer (flocculating agent) to precipitate organic particles out of the water by coalescing to form larger particles or *flocs.* These larger particles can then be deposited into a sedimentation tank for further treatment prior to disposal.

Removal of organic matter from wastewater using coagulants and flocculants eliminates the 'food' necessary for microbes to thrive, thus reducing the competition for dissolved oxygen with marine life.

ANAEROBIC MICROBIAL DECOMPOSITION

Anaerobic microbial decomposition introduces microorganisms or bacteria cultures into wastewater in the absence of air to break down the organic particles present. The product of an anaerobic digestion process is the generation of biogas.

Anaerobic decomposition is a highly beneficial method because the biofuel generated from the process can be utilized as an alternative energy source for power, heating, and drying applications

Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is a test that measures the amount of oxygen required to chemically oxidize the organic material and inorganic nutrients, such as Ammonia or Nitrate, present in water. The earliest methods for quantification of COD were developed ~150 years ago and involved recording colour changes of a permanganate solution mixed when mixed with a water samples. There was, however, significant variability between samples using this compound. The use of the dichromate procedure was pioneered and perfected for wastewater in 1949. COD is measured via a laboratory assay in which a sample is incubated with a strong chemical oxidant for a specified time interval and at constant temperature (usually 2 h at 150°C). The most commonly used oxidant is potassium dichromate, which is used in combination with boiling **sulphuric acid**. It is important to note that the chemical oxidant is not specific to organic or inorganic compounds, hence both these sources of oxygen demand are measured in a COD assay. Furthermore, it does not measure the oxygen-consuming potential associated with certain dissolved organic compounds such as acetate. Thus, measurements are not directly comparable to Biochemical Oxygen Demand (BOD) but can be used to compliment (though is sometimes used as surrogate measure).

Why is it Important?

COD is an important water quality parameter and is used in a wide range of applications, including:

- to confirm wastewater discharge and the waste treatment procedure meets criteria set by regulators (see Table 2);
- to quantify the biodegradable fraction of wastewater effluent - ratio between BOD and COD;
- COD or BOD measurements are also used as an indicator of the size of a wastewater treatment plant required for a specific location.

COD can be used to:

- Determine concentrations of oxidisable pollutants in wastewater
- Analyse the effectiveness of wastewater treatment solutions
- Determine the effect of wastewater disposal on the environment.
- As an index for determining overall water quality.

COD measures the amount of oxygen necessary to break down the organic substances that are pollutants in water. A higher COD in a sample indicates that it contains higher levels of oxidisable material. If this is the case, then the water will have reduced dissolved oxygen levels. Where this happens, the effects can be environmentally damaging to higher aquatic lifeforms. The aim of wastewater treatment, therefore, is to reduce levels of COD in water.

Monitoring COD levels enables wastewater management companies and facilities to decide on the best methods for water treatment. Without this detailed analysis and information, it can be challenging if not completely impossible to take the correct action.

How is COD measured?

There are different methods that can be used when it comes to measuring COD. These include online testing and offline laboratory methods using **environmental analysers.**

The principle behind the COD testing method is that, under acidic conditions, a strong oxidising agent will oxidise almost any organic compound to carbon dioxide. COD analysis will measure the equivalent amount of oxygen that is required to chemically oxidise organic compounds in water.

Modern methods of COD testing involve the use of highly accurate scientific instruments known as **environmental analysers.**. This mixes, heats, cools and then analyses COD samples. The device automates the COD analysis process, making it more streamlined. The COD-200 also offers turbidity detection for added accuracy. In COD analysis, the presence of turbidity can cause deviations of up to 30% from the real sample value due to interference with a sample's measured absorbance. This capability allows the end user to confidently analyse samples knowing that the turbidity level is adequate for COD analysis.

COD Analysis Process

The COD analysis process is rapid when compared with traditional methods such as biochemical oxygen demand (BOD). To measure COD in a sample you must use a strong oxidant under acidic conditions.

Typical oxidants include:

- Potassium dichromate
- Potassium iodate
- Potassium permanganate
- Ceric sulphate

The basic requirements of any effective COD method should be to:

- Reduce the chloride concentration to a level at which chloride interference is insignificant – chloride interference occurs where there is the presence of chlorine in concentrations greater than 0.02 M

- Not alter the organic content of the sample to a significant extent – ensuring there's no increase or decrease in COD

- Make the method suitable for routine use – inexpensive with simplified processes.

COD analysis takes place in two stages:

1. Digestion – oxidising the organic substances in the sample

2. Determination – measuring COD using either the titrimetric or colourimetric method.

You first achieve digestion by creating a reaction, which requires acid, heat and a catalyst.
You then measure chemical oxygen demand by one of these methods:

- Titrimetric analysis involves treating the sample solution with a suitable reagent to react quantitatively with it.

- Colourimetric analysis involves the use of a colour reagent and then observing measurable colour changes in the sample solution.

Analysis of Oxygen Demand

Along with COD, there are other forms of measurable oxygen demand. The most common of these is biochemical oxygen demand (BOD).

Chemical oxygen demand is broadly similar to biochemical oxygen demand in that they are both used to calculate the oxygen demand of a water sample. The key difference between the two is that chemical oxygen demand measures everything that can be oxidized, whereas biochemical oxygen demand only measures the oxygen demanded by organisms.

BOD measures the amount of dissolved oxygen that aerobic biological organisms require to break down organic material. It is the traditional test for establishing the concentration of organic matter in wastewater and it works on the principle that if sufficient oxygen is available then aerobic microorganisms in water will continue to decompose until all the waste is consumed.

However, COD analysis is an increasingly popular alternative to BOD because it's faster, and it can test wastewater that is too toxic for BOD. The BOD test takes five days, but modern COD testing methods mean that this method can be used as a real-time analyser, enabling wastewater operatives to monitor and adjust parameters during processes. Additionally, only organic compounds are consumed during BOD testing, which gives lower concentration results than COD testing.

What are the advantages and disadvantages of Chemical Oxygen Demand

COD's chief advantages are that it is a relatively rapid testing method which complies with APHA and ISO standards. Speed matters, but accuracy can't be compromised. COD analysers combination of speed and precision are it's key advantage in a wide-range of contexts.

COD will normally be higher than BOD because more organic compounds can be chemically oxidised than biologically oxidised. This includes a range of chemicals that are toxic to biological life. This makes COD tests highly useful when it comes to testing industrial sewage as these will not be captured by BOD testing.

One potential disadvantage to this method is that it cannot differentiate between inorganic and organic carbons and that it can receive interference from halides, nitrates and peroxide. In certain circumstances, results may vary in warmer conditions or at room temperature so it is important to monitor temperature when measuring COD.