Experiment 11
Determination of Biochemical oxygen demand



Introduction:

The biochemical oxygen demand determination is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic organisms in a water body to break the organic materials present in the given water sample at certain temperature over a specific period of time.
BOD of water or polluted water is the amount of oxygen required for the biological decomposition of dissolved organic matter to occur under standard condition at a standardized time and temperature. Usually, the time is taken as 5 days and the temperature is 20°C.
The test measures the molecular oxygen utilized during a specified incubation period for the biochemical degradation of organic material (carbonaceous demand) and the oxygen used to oxidize inorganic material such as sulfides and ferrous ion. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand).

Environmental significance:

BOD is the principle test to give an idea of the biodegradability of any sample and strength of the waste. Hence the amount of pollution can be easily measured by it. Efficiency of any treatment plant can be judged by considering influent BOD and the effluent BOD and so also the organic loading on the unit.

Application of the test to organic waste discharges allows calculation of the effect of the discharges on the oxygen resources of the receiving water. Data from BOD tests are used for the development of engineering criteria for the design of wastewater treatment plants. Ordinary domestic sewage may have a BOD of 200 mg/L. Any effluent to be discharged into natural bodies of water should have BOD less than 30 mg/L. This is important parameter to assess the pollution of surface waters and ground waters where contamination occurred due to disposal of domestic and industrial effluents. Drinking water usually has a BOD of less than 1 mg/L. But, when BOD value reaches 5 mg/L, the water is doubtful in purity. The determination of BOD is used in studies to measure the self-purification capacity of streams and serves regulatory authorities as a means of checking on the quality of effluents discharged to stream waters.
The determination of the BOD of wastes is useful in the design of treatment facilities. It is the only parameter, to give an idea of the biodegradability of any sample and self-purification capacity of rivers and streams. The BOD test is among the most important method in sanitary analysis to determine the polluting power, or strength of sewage, industrial wastes or polluted water. It serves as a measure of the amount of clean diluting water required for the successful disposal of sewage by dilution.

Guideline:

According to Bangladesh Environment Conservation Rules (2023), drinking water standard for biochemical oxygen demand (BOD) is 2 mg/L (at 20°C). For wastewater effluent allowable concentration of BOD is set at a maximum of 30 mg/L depending on discharge point of the effluent (e.g., inland water, irrigation land, public sewer etc.)

Principle:

The sample is filled in an airtight bottle and incubated at specific temperature for 5 days. The dissolved oxygen (DO) content of the sample is determined before and after five days of incubation at 20°C and the BOD is calculated from the difference between initial and final DO. The initial DO is determined shortly after the dilution is made; all oxygen uptake occurring after this measurement is included in the BOD measurement.

Since the oxygen demand of typical waste is sever hundred milligrams per liter, and since the saturated value of DO for water at 20^{u}C is only 9.1 mg/L, it is usually necessary to dilute the sample to keep final DO above zero. If during the five days of experiment, the DO drops to zero, then the test is invalid since more oxygen would have been removed had more been available.

The five-day BOD of a diluted sample is given by,

$$\mathbf{BOD_5} = [DO_i - DO_f] \times D.F. \qquad \mathbf{11.1}$$

Here,

$$\textbf{Dilution factor (D.F.)} = \frac{(\text{Volume of waste water} + \text{Volume of dilution water})}{\text{Volume of waste water}}$$

In some cases, it becomes necessary to seed the dilution water with microorganisms to ensure that there is an adequate bacterial population to carry out the biodegradation. In such cases, two sets of BOD bottles must be prepared, one for just the seeded dilution water (called the "blank") and the other for the mixture of wastewater and dilution wader. The changes in DO in both are measured. The oxygen demand of waste water (BOD_w) is then determined from the following relationship:

$$\mathbf{BOD_m \times V_m} = BOD_w \times V_w + BOD_d \times V_d \qquad \mathbf{11.2}$$

Where, BOD_m, is the BOD of the mixture of wastewater and dilution water and BOD_d is the BOD of the dilution water alone; V_w and V_d are the volumes of wastewater and dilution water respectively in the mixture and $V_m = V_w + V_d$.

Sample handling and preservation:

Preservation of sample is not practical. Because biological activity will continue after a sample has been taken, changes may occur during handling and storage.

If Analysis is to be carried out within two hours of collection, cool storage is not necessary. If analysis cannot be started with in the two hours of sample collection to reduce the change in sample, keep all samples at 4° C.

Do not allow samples to freeze. Do not open sample bottle before analysis. Begin analysis within six hours of sample collection.

Apparatus:

1. BOD bottle
2. Beaker (250 ml)
3. Measuring cylinder
4. Dropper
5. Stirrer

Reagents:

1. Manganous sulfate solution
2. Alkaline potassium iodide solution
3. 0.025N sodium thiosulfate
4. Starch solution (indicator)
5. Concentrated sulfuric acid.

Procedure:

Fill two BOD bottles with sample (or diluted sample); the bottles should be completely filled. Determine initial DO (DO_i) in one bottle immediately after filling with sample (or diluted sample). Keep the other bottle in dark at 20°C and after particular days (usually 5-days) determine DO (DO_f) in the sample (or diluted sample). Dissolved oxygen (DO) is determined according to the following procedure:

1. Add 1 mL of manganous sulfate solution to the BOD bottle by means of pipette, dipping in end of the pipette just below the surface of the water.
2. Add 1 mL of alkaline potassium iodide solution to the BOD bottle in a similar manner.
3. Insert the stopper and mix by inverting the bottle several times.
4. Allow the "precipitates" to settle halfway and mix again.
5. Again allow the "precipitates" to settle halfway.
6. Add 1 mL of concentrated sulfuric acid. Immediately insert the stopper and mix as before.
7. Allow the solution to stand at least 5 minutes.
8. Withdraw 100 mL of solution into an Erlenmeyer flask and immediately add 0.025N sodium thiosulfate drop by drop from a burette until the yellow color almost disappears.
9. Add about 1 mL of starch solution and continue the addition of the thiosulfate solution until the blue color just disappears. Record the ml. of thiosulfate solution used (disregard any return of the blue color).

Calculation:

Dissolved oxygen, DO (mg/L)

= mL of 0.025N sodium thiosulfate added x Multiplying Factor (M.F.)

Calculate BOD of the sample according to Eq. – 11.1 or Eq. – 11.2.

Assignment:

1. In a BOD test on a diluted wastewater sample (1:20 dilution, but not seeded), the initial DO is 8.2 mg/L and final DO after 5 days is 3.2 mg/L. If the reaction rate constant is 0,2/day, calculate: (a) 5-day BOD of the wastewater, (b) Ultimate carbonaceous BOD of the wastewater, (c) Remaining Oxygen demand after 5-days.
2. A test bottle containing just seeded dilution water has its DO level drop by 0.6 mg/L in a 5-day test, A 300 mL BOD bottle filled with 40 mL of wastewater and the rest with seeded dilution water experiences a drop of 7.1 mg/L in the same period (5-day), Calculate the BOD_5 of the wastewater.

DATA SHEET

Experiment Name :
Experiment Date :

Student's Name :
Student's ID :
Year/ Semester :
Section :
Group :

Table

Sample No	Source of Sample	Temperature of Sample (°C)	BOD (mg/L)

Signature of the course teacher and date