Estimation of Biological Oxygen Demand (BOD)

Introduction:

The biological oxygen demand (BOD) is an empherical test in which, standardized laboratory procedures are used to determine the relative oxygen requirements of wastewaters, effluents and polluted waters. The test has its widest application in measuring waste loadings to treatment plants and evaluating the BOD - removal efficiency of such treatment systems.

This test measures the molecular oxygen utilized, expressed in terms of mg/l during a specified incubation period for the biological degradation of organic material (carbonaceous compound) and inorganic material such as sulfides and ferrous iron. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen (Nitrogenous demand).

BOD Principle:

The method consists of filling with samples to overflowing in an airtight bottle of specified size and incubating it at the specified temperature (20^0C) for 5 days. Dissolved oxygen is measured initially and after incubation. The BOD is computed from the difference between initial and final DO. Because the initial DO is determined immediately after the dilution is made, all oxygen uptake, including that occurring during the first 15 min is included in the BOD measurement.

Principle of Dissolved Oxygen Estimation by Winkler's Or Iodometric Method:

It is based on the addition of divalent manganese solution, followed by a strong alkali to a glass-stoppered bottle. DO rapidly oxidizes an equivalent amount of the dispersed divalent manganous hydroxide precipitate to hydroxides of higher valency states. In the presence of iodide ions in an acidic solution, the oxidized manganese reverse to the divalent state, with the liberation of iodine equivalent to the original DO content. The iodine is then titrated against standard sodium thiosulphate, using starch indicator.

End point – Blue to colourless.

Apparatus and Reagents required:

1. Incubation Bottles:

250-300 ml capacity

2. BOD Incubator:

3. Phosphate Buffer Solution:

Dissolve 8.5 g of KH_2PO_4, 21.75 g of K_2HPO_4, 33.4 g of $Na_2HPO_4.7H_2O$ and 1.7 g of NH_4Cl in about 500 ml distilled water and dilute to 1 litre. Adjust the pH to 7.2. Discard reagent, if there is any sign of biological growth in the stock bottle.

4. Magnesium Sulfate Solution:

Dissolve 22.5 g of $MgSO_4.7H_2O$ in distilled water and dilute to 1 litre.

5. Calcium Chloride Solution:

Dissolve 27.5 g $CaCl_2$ in distilled water and dilute to 1 litre.

6. Ferric Chloride Solution:

Dissolve 0.25 g $FeCl_3.6H_2O$ in distilled water and dilute to 1 litre.

7. Manganous Sulfate Solution:

Dissolve 480 g of $MnSO_4.4H_2O$ or 400 g of $MnSO_4.2H_2O$ or 364 g of $MnSO_4.H_2O$ in distilled water and dilute to 1 litre.

8. Alkaline Iodide Solution:

Dissolve 500 g of NaOH in 500 ml distilled water and 365 g of KI in 450 ml distilled water and mix the two solutions.

9. Concentration Sulphuric Acid:

10. Starch:

Dissolve 2 g of soluble starch and 0.2 g of salicylic acid as a preservative in 100 ml distilled water.

11. Standard Sodium Thiosulfate (0.025 N):

Dissolve 6.205 g of $Na_2S_2O_3.5H_2O$ in 1000 ml distilled water.

Procedure:

A. Preparation of Dilution Water:

Place desired volume of water in a suitable bottle and 1 ml each of phosphate buffer, $MgSO_4$, $CaCl_2$ and $FeCl_3$ solutions per litre of water. Before using, bring dilution water temperature to 20^0C. Saturate with dissolved oxygen by shaking in a partially filled bottle or by aerating with organic free filtered air.

B. Dilution Technique of Sample:

Dilutions that result in a residual dissolved oxygen of at least 1 mg/l and a dissolved oxygen uptake of at least 2 mg/l after 5 days incubation to produce the most reliable results. Make several dilutions of samples to obtain dissolved oxygen uptake in this range. In absence of prior knowledge about sample, use 0-1 % dilution for strong industrial wastes, 1-5 % for raw and settled waste water, 5-25 % for biologically treated

effluent and 25-100 % for polluted river waters. Prepare dilutions either in graduated cylinders and then transfer to BOD bottles or prepare directly in BOD bottles.

C. Determination of Initial Dissolved Oxygen:

To the sample taken in BOD bottle, add 1 ml $MnSO_4$ and 1 ml alkaline iodide solution. Shake well and wait for precipitate to settle. Add concentration H_2SO_4 to dissolve the precipitate. Take 100 ml of sample in conical flask and titrate against std. $Na_2S_2O_3$ with starch as indicator. End point is colourless solution.

d. Incubation:

Incubate the samples at 20 ± 1^0C in BOD bottles for 5 days. The bottles should be labeled properly.

E. Determination of Final Dissolved Oxygen:

Estimate the dissolved oxygen content of the BOD samples after 5 days of incubation following above procedure.

Calculation:

$$\text{mg./l of } O_2 = \frac{A \times V \times N \times 1000 \times 22.4}{B \times (A - L) \times 4 \times 0.698}$$

Where, A= Volume of DO bottle or BOD bottle

V = Volume of standard $Na_2S_2O_3$ rundown

N = Normality of $Na_2S_2O_3$ solution

B = Volume of sample taken for titration

L = Reagents volume ($MnSO_4$ and Alkaline iodide)

$$\text{Biological Oxygen Demand, } BOD_5 \text{ (mg/l)} = \frac{D_1 - D_2}{P}$$

Where, D_1 = Initial level of DO

D_2 = Level of DO after 5 days incubation

P = Dilution factor

Result: