UNIVERSITI TEKNOLOGI MALAYSIA
COLLEGE OF SCIENCE & TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

ENVIRONMENTAL ENGINEERING LABORATORY

BIOCHEMICAL OXYGEN DEMAND (BOD)

INTRODUCTION

The level of pollution (industrial or domestic wastewater) is measured with a BOD (Biochemical Oxygen Demand) test. BOD is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. It is usually performed over a 5-day period at 20°C. It is used in water quality management and assessment, ecology and environmental science. A BOD of 10 mgL^{-1} represents a liter of a sample requires 10 mg of oxygen for bacteria to successfully undergo oxidization. Most pristine rivers will have a 5-day BOD below 1 mgL^{-1}. Moderately polluted rivers may have a BOD value in the range of 2 to 8 mgL^{-1}. Municipal sewage that is efficiently treated would have a value of about 20 mgL^{-1}. Untreated sewage varies, but averages around 600 mgL^{-1}.

The BOD test is carried out by diluting the sample with de-ionized water saturated with oxygen, inoculating it with a fixed aliquot of seed, measuring the dissolved oxygen and sealing the sample (to prevent further oxygen dissolving in). The sample is kept at 20 °C in the dark to prevent photosynthesis (and thereby the addition of oxygen) for five days, and the dissolved oxygen is measured again. The difference between the final dissolved oxygen (DO) and initial DO is the BOD. In Malaysia, the BOD test is typically prepared at 30° C.

Example

A BOD test was conducted for three (3) samples collected from a river. The samples have an initial dissolved oxygen value of 7 mgL^{-1}. At the end of incubation period (5 days), the dissolved oxygen values were 0, 3, and 7 mgL^{-1}. Determine the BOD values for each sample.

Case 1: No result, unless BOD is assumed above 7 mgL^{-1}.

Case 2: $BOD_5 = 7 - 3 = 4\ mgL^{-1}$.

Case 3: $BOD_5 = 7 - 7 = 0\ mgL^{-1}$.

BOD_5 is defined as BOD of a sample incubated for 5 days. If BOD value is above 7 mgL^{-1}, then the sample should be diluted. For example (in second case), if 1 mL sample is diluted to become 100 mL with dilution water (dilution is 100 times the original) the dilution factor, P = 1/100 = 0.01, therefore the BOD is:

$$(7 - 3) \times 100 = (7 - 3) / 0.01 = 400 \text{ mg/L}$$

First order reaction is used to explain the BOD kinetics;

$$dL_t / dt = -k L_t$$

Where L_t is oxygen equivalent for organic matter at time t, k is a constant with unit t^{-1} (per day). Integration of the equation results;

$$L_t / L_o = exp\ (-k\ t)$$

Or,

$$log\ L_t - log\ L_o = -k\ t$$

$$L_t / L_o = 10^{-kt}$$

$$L_t = L_o\ (1 - 10^{-kt})$$

Where L_o is oxygen equivalent for organic matter in the sample at time = 0 and this value is also known as ultimate BOD. As a result, BOD transferred is;

$$BOD_t = L_o - L_t$$

$$BOD_t = L_o\ (1 - 10^{-kt})$$

The constant, k for a wastewater can be estimated by plotting $(time/BOD_t)^{1/3}$ versus time. From the graph, k = 2.61 B/A where B is the slope of the linear graph and A is intersection at $(time/BOD_t)^{1/3}$ axis.

OBJECTIVE

To estimate the constant, k for a wastewater sample.

PROCEDURE

1. Prepare seeded dilution water by adding 1 ml of the following prepared solutions **per litre**: phosphate buffer, $MgSO_4$, $CaCl_2$, FeCl and settled sewage (the seed) to distilled water that has been saturated with oxygen by aerating at room temperatures.
2. Determine sample (wastewater) pH using pH meter. Neutralize sample by adding NaOH or H_2SO_4 and record the volume added.

3. Remove additional chlorine in sample by adding Na_2SO_3 solution if required.
4. Dilute sample with seeded dilution water (prepared in step 1 above) in 1.5 litre volumetric flasks. (Example: 1/50 the dilution is equivalent to 30 ml of sample in 1.5 litre volumetric flasks). (Note* It is always good practice to use volumetric flasks for accurate reading; however you can use 1.5 litre cylinder for this experiment).
5. Transfer to numbered BOD bottles (5 bottles). Determine zero day (initial) dissolved oxygen on all five (5) bottles using calibrated dissolved oxygen meter.
6. Incubate bottles for 5 days at 30°C.
7. Determine residual dissolved oxygen after incubation period of one day, two days, three days etc (each day only one (1) bottle is determined for its dissolved oxygen).
8. Determine zero day (initial) and after 5 days incubation period dissolved oxygen for prepared seeded dilution water as well.

RESULTS

1. Determine BOD_1, BOD_2, BOD_3, etc.
2. Plot the graph of $(t/BOD_t)^{1/3}$ versus t and determine k value.

BIOCHEMICAL OXYGEN DEMAND (BOD)

1.0 Data

Sample pH reading: _____

Volume of NaOH or HCL added: _____ mL.

Bil	DO_0 (mgL^{-1})	Time, t (day)	DO_t (mgL^{-1})	$BOD_t = (DO_0 - DO_t) / P$ mgL^{-1}

2.0 Plot the graph of $(t/BOD_t)^{1/3}$ versus t.

3.0 Determine value k by using the graph in (2) above. Given k = 2.61 (B/A), where;

A: intersection at the $(time/BOD_t)^{1/3}$ axis

B: slope of the linear graph

4.0 List factors which may affect the experiment.

5.0 Discussion and conclusion from the experimental results.