

**Lab #3: Oxygen Demand (COD
and BOD)**

Experiment #3

**CVG 2132: Fundamentals of
Environmental Engineering**

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1.0 Theory & Objectives

This lab's primary purpose is to determine the required amount of oxygen needed to oxidize all the organic constituents within a sample fully. This will be done through the measurement of oxygen demand.

Oxygen demand can be broken into two types of measurements: chemical oxygen demand (COD) and biological oxygen demand (BOD). Although they have distinct differences in how the oxygen demand is measured, they share a correlation that is determined based on the water sample's biodegradability. If the sample has a high biodegradability, the lower the COD to BOD ratio will be. COD also represents the total oxygen demand of a given water sample when all the organic matter is chemically oxidized, so in turn, the COD should always be greater or equal to the BOD when comparing the two [1]. Again, the process of oxygen demand is a critical stage of the water treatment process. Organic constituents that are within drinking water can bring a multitude of negatives to environmental and human health. Health hazards, environmental hazards, and plant/animal health hazards are all causes of polluted drinking water [2]. If the amount of oxygen needed to oxidize the organic material can be found, it is a massive advantage in cleaning polluted water.

To start off, COD is a measurement of the amount of organic matter that is chemically oxidized. It is typically measured in a spectrophotometer (see figure #), which is the process of detecting the presence of a colored species through the absorbance of a particular wavelength of light [1]. The sample is placed into the spectrophotometer and has light pass through it. Before the light passes through the sample, a monochromator is used to remove undesired wavelengths while allowing the desired wavelength through, followed by a slit that focuses the light into the sample. The light gets somewhat absorbed by the sample, but the light that passes through is then passed into a photodetector that detects the light intensity and converts it into an electric pulse. It then passes through an amplifier due to the light source be a bit weak when going through the photodetector. Finally, the increased signal is then converted into a numerical reading as it reaches the detector [1].

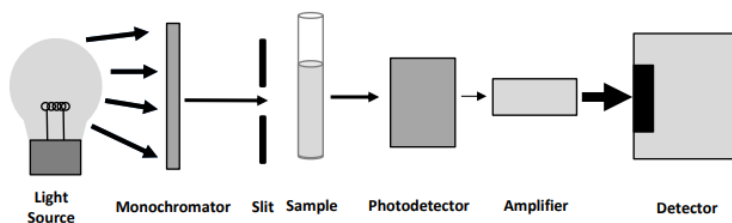


Figure 1: Spectrophotometer Schematic Diagram [1]

For the general method of measuring the COD, a prefilled vial of sulfuric acid and potassium dichromate has a water sample added. The vial is then refluxed, which is the process of heating the sample without loss of vapors. This lets the sulfuric acid and potassium dichromate react, which in turn oxidizes the organic material in the sample. As COD concentration increases through the reflux, the dichromate ions get reduced to the chromic ion (Cr^{3+}), which makes the sample clearer. This makes the sample absorb less light, signifying that the more significant the COD concentration, the light absorbance readings will decrease [1]. Once the sample is ready for the spectrophotometer, a blank is used to set a zero factor that eliminates background interference. Finally, to determine the water sample concentration, a calibration curve is used [1].

The biological oxygen demand is also another way of measuring the organic material within a water sample. To determine the BOD of a sample, the amount of dissolved oxygen (DO) used by microorganisms for cellular respiration must be measured [1]. Dark incubation conditions used to prevent algae photosynthesis, constant temperature, and specific incubation time are all standard test conditions used. The testing process starts with adding a small amount of the water sample into a 300 ml BOD bottle. This is followed by adding oxygen saturated dilution water to dilute the sample. The dilution water contains nutrients such as nitrogen, phosphorus, and some trace metals, which promote biological growth. The initial DO concentrations are recorded before sealing the BOD bottle and placing it in an incubator for five days at 20°C . Once the five-day time frame has been completed, the bottle is taken out, and their final DO concentrations are recorded. Of course, interferences such as inorganic materials, presence of chlorine, and inconsistent heat can significantly affect the results. These should be considered when conducting the lab [1].

By taking the procedures and reasons for measuring the oxygen demand, this lab's goal is to successfully determine the amount of oxidized organic material within a given sample. Due to the health risks that come with organic material in water, it is essential to understand how COD and BOD processes can help treat said water. By conducting this investigation, the presence of organic constituents, its risks, and how to measure them once they're oxidized can help bring awareness to communities and the population.

2.0 Materials

Refer to Lab Manual: Kinsley, C., Dr. (2020). CVG 21332 Laboratory Manual 2020. Ottawa, Ontario: UOttawa. (Page 43)

3.0 Methods

Refer to Lab Manual: Kinsley, C., Dr. (2020). CVG 21332 Laboratory Manual 2020. Ottawa, Ontario: UOttawa. (Page 43 to 47)

4.0 Results/Data

4.1 Raw Data from Lab 2 (Group 19)

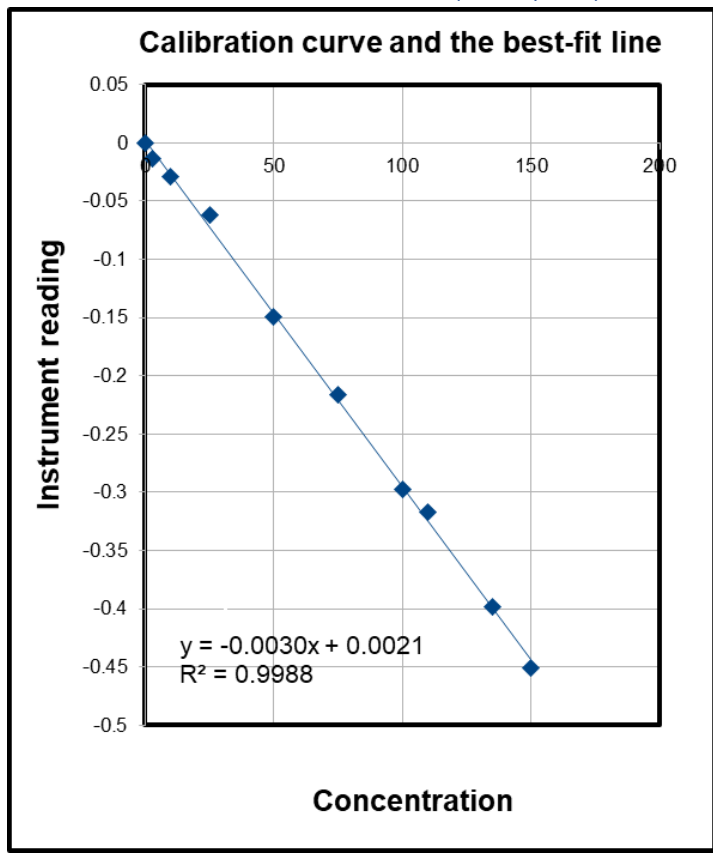


Figure 2: Calibration curve of Absorbance vs. Concentration

5.0 Calculations

5.1.0 Concentration with calibration curve

<p>Sample A</p> $y = -0.0030(-0.1248) + 0.0021$ $= 0.0025$	<p>Sample B</p> $y = -0.0030(-0.3051) + 0.0021$ $= 0.0030$ $1/5 = x/0.0030$ $X = 0.0006$
<p>Sample C</p> $y = -0.0030(-0.2678) + 0.0021$ $= 0.0030$ $1/5 = x/0.0030$ $X = 0.0006$	<p>Sample D</p> $y = -0.0030(-0.1736) + 0.0021$ $= 0.0026$ $1/500 = x/0.0026$ $X = 0.000005$

Figure 3: Concentration using the calibration curve including dilution factor.

5.2.0 Chemical Oxygen Demand

5.2.1 COD of samples A,B,C and D

Sample A COD= 8.29-6.03 = 2.26 mg/l	Sample B COD= 8.19-4.93 = 3.26 mg/l
Sample C COD= 7.93-5.11 = 2.82 mg/l	Sample D COD= 7.92-3.37 = 4.55 mg/l

Figure 4: Calculation of COD sample A,B,C and D

Formula: COD (**mg L**) = DO initial sample – Do final sample

5.2.2. Representation of the COD measurements of samples A,B,C and D with standards and blanks

Sample	COD dilution factor	COD value (abs.)	DO initial of blank (mg/L)	DO final of blank (mg/L)	DO initial of sample (mg/L)	DO final of sample (mg/L)	COD Concentration (mg/L)
A	-----	-0.1248	8.4	8.08	8.29	6.03	2.26
B	1:5	-0.3051	8.13	7.95	8.19	4.93	3.26
C	1:5	-0.2678	8.38	7.84	7.93	5.11	2.82
D	1:500	-0.1736	8.43	7.83	7.92	3.37	4.55

Figure 5: COD measurements as well as standards and blanks of the sample provided.

5.3.0 Biological Oxygen Demand

5.3.1 BOD5 of samples A,B,C and D

<p>Sample A $BOD_5 = ((8.29-6.03) - (8.4-8.08)) (1-0.1)/0.1$ $= 17.46 \text{ mg/l}$</p>	<p>Sample B $BOD_5 = ((8.19-4.93) - (8.13-7.95)) (1-0.01)/0.01$ $= 304.92 \text{ mg/l}$</p>
<p>Sample C $BOD_5 = ((7.93-5.11) - (8.38-7.84)) (1-0.01)/0.01$ $= 225.72 \text{ mg/l}$</p>	<p>Sample D $BOD_5 = ((7.92-3.37) - (8.43-7.83)) (1-0.0001) / 0.0001$ $= 39,496.05 \text{ mg/l}$</p>

Figure 6: Calculation of BOD5 in sample A,B,C and D.

Formula: **BOD5 (mg L) = [(Do i,s – Do t,s) – (Do i,b – Do t,b)] (1-P) / P**

5.3.2 Representation of the BOD5 measurements of samples A,B,C and D with standards and blanks

Sample	BOD dilution factor	DO initial of blank (mg/L)	DO final of blank (mg/L)	DO initial of sample (mg/L)	DO final of sample (mg/L)	BOD5 (mg/L)
A	30:300	8.4	8.08	8.29	6.03	17.46
B	3:300	8.13	7.95	8.19	4.93	304.92
C	3:300	8.38	7.84	7.93	5.11	225.72
D	0.03:300	8.43	7.83	7.92	3.37	39,496.05

Figure 7: BOD5 measurements as well as standards and blanks of the sample provided.

6.0 Discussion

Discussion #1

Topic: How can COD and BOD be used to assess quality?

Answer: BOD is the traditional, most widely used test to establish organic matter concentration in wastewater samples. BOD is based on the principle that aerobic biological decomposition by microorganisms will continue until all waste is consumed if sufficient oxygen is available. The change in DO concentration over five days represents the oxygen demand for respiration by the sample's aerobic biological microorganisms. COD is the most popular alternative test to BOD for establishing organic matter concentration in wastewater samples. COD can test wastewater that is too toxic for the BOD test. The COD test should be considered an independent measure of the organic matter in a wastewater sample rather than a substitute for the BOD test. The COD test uses a chemical that oxidizes organic and inorganic substances in a wastewater sample, resulting in a higher COD concentration than BOD concentration for the same wastewater sample since only organic compounds are consumed during BOD testing.

Discussion #2

Topic: Discuss whether each of the samples represents a high, medium or low influent municipal wastewater in North America (include references). Also, discuss the implications of the blank and control measurements on your sample BOD calculations.

Answer: sample A is low, sample B and C are medium and sample D is high. Sample A is low due to low BOD, sample B & C are medium due to approximately similar BOD values. Sample D is high due to high BOD value. As the BOD value increases, the concentration of influent municipal WW will increase. The difference between initial and final blank measurements influence the BOD value as follow:

sample A has a small change in blank measurements due to the source collected from which indicate stormwater has less organic materials indicated by small BOD value. Sample B & C have similar change due to both samples' source, which indicates the existence of organic matter that has been consumed by bacteria which resulted in BOD value. [3]

Discussion #3

Topic: What kind of treatment systems can effectively reduce COD and BOD values of wastewaters? Provide general numbers related to treatment efficiency for each treatment and discuss each method's positive and negative aspects (include references).

Answer:

COD Reduction

1) Precipitation Process (Coagulation)

The principle is to bind the sludge to one another so that a more massive clump of sludge can be deposited in a sedimentation tank. Some chemicals are commonly used as a coagulant: PAC, FeCl₃ (Ferric Chloride), and Al. COD reduction process to become more effective perfect, it is advisable to give more concern to mixing and sedimentation. Due to the proper mixing process, the precipitation reaction that occurs will be less than perfect.

2)Oxidator

Chlorine, Hydrogen peroxide, and Ozone will mengoksdiasikan chemicals in the water so that the automatic COD value will go down. Limit dose usage of Oxidator, because the Oxidator possess sufficient risk, especially for living organisms. COD reduction technique is suitable for waste to have COD values derived from non-biodegradable waste such as Phenol, surfactants.[4]

BOD Reduction

1) extended aeration: to more thoroughly digest the sewage solids.

2)Attached culture systems: are designed so that wastewater flows over microbial films attached to surfaces in the treatment unit.

3)suspended culture of microorganisms to treat the sewage aerobically. This type of treatment assumes that a resident population of bacteria are present in the solids and sludge in the treatment unit; vigorous mixing of the sewage in the treatment compartment causes these bacteria to stay in suspension where they can aerobically digest the sewage.[4]

Discussion #4

Topic 4: Discuss anthropogenic factors which could have effects on the COD and BOD of the given water samples? How do these processes affect the overall COD and BOD readings?

Answer: Human activities have always played a crucial role in environmental issues. Many anthropogenic factors can influence the COD and BOD values. The nature of these factors determines which value will be affected. Biological factors, including fertilizers, garbage disposal, and city runoff, will influence BOD value due to bacteria's existence in the WW. Nonbiological factors, including disposal chemicals and pharmaceutical wastes in the WW, influence the COD due to the presence of inhibitors that inhibit the oxidizing agents, resulting in high COD. [5]

7.0 Conclusion

To conclude, wastewater is the main component that returns to the water stream to take its role in the ecosystem. Testing methods developed over the years in which the main two are COD and BOD. BOD method used biological microorganisms to measure wastewater degree of contamination. BOD measures the consumption of oxygen to be used as fuel by bacteria degrading organic matter. On the other hand, COD is a chemically performed process used to measure oxygen used by oxidizing agents to consume organic matter. Both methods are time-restricted, where BOD takes five days to be completed, and COD is faster one needs two hours to be completed. These methods ensure that our aqua life is filtered and safe.

8.0 References

- [1] Kinsley, C., Dr. (2020). *CVG 21332 Laboratory Manual 2020*. Ottawa, Ontario: UOttawa.
- [2] “Water Treatment Solutions,” *Lenntech Water treatment & purification*. [Online]. Available: <https://www.lenntech.com/aquatic/organic-pollution.htm>. [Accessed: 25-Nov-2020].
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CVG 2132 LABORATORY REPORT EVALUATION CRITERIA

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