

Memorandum

To: Dr. Valerie Budig-Markin

From: Sophia Pasinski

Subject: Biochemical Oxygen Demand Analysis

Date: 27 September 2019

Introduction

This lab focused on analyzing water samples from the Arcata Waste Water Treatment Plant (AWWTP) for the Biochemical Oxygen Demand (BOD) after five days. The researchers used Post Treatment Water (PTW) from the AWWTP for their samples. The analysis of a five-day BOD test is important for the researchers to determine the effectiveness of the water treatment train at the AWWTP. After the BOD at five days were determined, the researchers were able to know the amount of dissolved oxygen (DO) that was consumed by microorganism in the water; and ultimately understand the effectiveness of the treatment train at the AWWTP that will discharge water into the Humboldt Bay.

Methodology

For this lab, the researchers used the PTW from the AWWTP for their analysis. The samples used were collected on September 3rd, 2019 in the late morning. The samples were analyzed for initial DO (mg/L) on September 10th between 2 and 5 p.m. and for DO (mg/L) after five days on September 15th at 3 p.m. For the procedure of BOD testing, all samples were diluted with BOD water to fill the 300mL BOD bottles. The procedure that was used for this lab was Standard Methods 5210 B. and the proper in-test citation for this is (APHA 2005). In the researcher's analysis, they measured for the parameters as follows: initial DO (mg/L), DO percent saturation (mg/L), and temperature (°C) and DO (mg/L), DO percent saturation (mg/L), and temperature (°C) after a five-day period.

Results

The BOD 5 (mg/L) values that were calculated from the lab and the expected BOD 5 (mg/L) values that the researchers looked for can be found in table 1. These results were for the samples from the post treatment water at the AWWTP.

Table 1: Expected and Calculated BOD 5 and the undiluted sample volumes for post treatment water at the AWWTP

Sample	Expected BOD 5 (mg/L)	Undiluted Sample (mL)	Calculated BOD 5 (mg/L)
Control	Control	0	
1	50	24	40.75
2	37.5	32	41.9
3	25	48	38.13

Discussion

After the lab was completed and the researchers did their calculations, it was found that for an undiluted sample of 24 mL the calculated BOD 5 was 40.75 mg/L when it was expected to be 50 mg/L. For an undiluted sample of 32 mL, the calculated BOD 5 was 41.9 mg/L when it was expected to be 37.5 mg/L and for the undiluted sample of 48 mL, the calculated BOD 5 was 38.13 mg/L when it was expected to be 25 mg/L. The researchers had expected the BOD 5 value

for the post treatment water from the AWWTP to be between 25 and 50 mg/L and the average of the calculated BOD 5 from the lab was 40.26 mg/L, which should be expected. The class data for these values for the post oxidation water (POX) and the post enhancement water (PEW) can be found in tables 6 and 8 in the appendix.

When looking at the other BOD 5 values from the class data, table 6 states that the average BOD 5 for the post oxidation water is 40 mg/L. The expected BOD 5 for POX was between 30 and 60 mg/L. The value that the class calculated makes sense for the lab. In the class data for the post enhancement water, the BOD 5 value, as shown in table 8, was 4.63 mg/L. The expected BOD 5 for PEW was between 5 and 15 mg/L. The class calculated average was close but it was still below the expected BOD 5 values. The class determined that the PEW values had too low of an initial dissolved oxygen reading, making the calculated BOD 5 value to not be as significant. Since the BOD 5 values lower, as expected, as water goes through the stages of the treatment train, the researchers can conclude that the AWWTP is effective in treating the water that will be discharged into the Humboldt Bay.

As presented in the *Principles of Environmental Engineering and Science* textbook table 11-7, The average monthly limit for BOD 5 is 30 mg/L and the weekly average BOD 5 limit is 45 mg/L (David and Mastersen 2014). The researcher's data shows that it is below this weekly limit for the POX and PTW but not under the monthly limit for these parameters. However, the PEW value is lower for both weekly and monthly average.

There were potentially some errors in the lab. Since the BOD 5 value for the PEW was below the expected, it was possible that the sample of the PEW from the AWWTP was under depleted so that there are not enough microbes in the water to consume dissolved oxygen. There may have also been an error with the probes that were used to measure DO. The researchers had gotten relatively the same DO initial value for all four samples, including the control. This could have caused a problem in the calculated data.

Conclusion

With the average BOD 5 values from the POX (40 mg/L), PTW (40.26 mg/L), and PEW (4.63 mg/L) samples lowering, and being in the range of their expected BOD 5 values, the researchers can conclude that the water being treated at the AWWTP is effective in removing dissolved oxygen before the water is discharged into the Humboldt Bay. To get these results, the researchers placed undiluted water samples into BOD bottles and filled the rest of the bottles with BOD water and measured for DO. The bottles then sat in a controlled temperature for five days before being measured a second time for the dissolved oxygen value. After this was measured, the researchers were able to calculate the BOD 5 value in mg/L.

References

American Public Health Association (APHA).
American Water Works Association (AWWA).
Water Environment Federation (WEF). (2005).
Standard methods for the examination of water and wastewater, 21st Ed.
American Public Health Association, Washington, DC.
David and Mastersen, Principles of Environmental Engineering and Science (2014).

Appendices

Included in the appendix are the (A) raw data of the measurements from the researchers analyzing post treatment water, (B) class data of the change in DO and BOD 5 for the three water parameters of the treatment train, and (C) equations and sample calculations for data presented in the tables.

- A. Tables 3 through 5 contain all the raw data that the researchers had measured for the post treatment water from the AWWTP.

Table 3: Initial readings for DO (mg/L), DO percent saturation, and temperature (°C) for the post treatment water from the AWWTP.

Sample	DO (mg/L)	DO % Saturation	Temperature (°C)
Control	8.59	96.8	21.26
1	8.55	96.6	21.39
2	8.5	96	21.34
3	8.5	96.2	21.44

Table 4: Readings after a five-day period for DO (mg/L), DO percent saturation, and temperature (°C) for the post treatment water from the AWWTP.

Sample	DO (mg/L)	DO % Saturation	Temperature (°C)
Control	8.49	94.1	20.41
1	5.19	57.4	20.33
2	3.93	43.5	20.34
3	2.3	25.5	20.38

Table 5: The volumes of the undiluted sample and the BOD water that were included in each BOD testing bottle and the calculated dilution factor, P, used to determine BOD 5.

Sample	Undiluted Sample (mL)	BOD Water (mL)	Dilution Factor P
Control	0	300	
1	24	276	0.08
2	32	268	0.107
3	48	252	0.16

- B. Tables 6 through 8 present the class data for the change in DO, the BOD 5, and the averages and standard deviation for each process of the treatment train at the AWWTP, post oxidation water, post treatment water, and post enhancement water.

Table 6: Class data of the post oxidation water of the treatment train at the AWWTP including change in DO (mg/L), BOD 5 (mg/L), and their respective average and standard deviation.

Sample	Change in DO (mg/L)	BOD 5 (mg/L)
Control	-0.22	
1	4.83	37.97
2	3.13	37.81
3	2.73	44.23
Average	3.56	40.00
Standard Deviation	0.91	2.99

Table 7: Class data of the post treatment water of the treatment train at the AWWTP including change in DO (mg/L), BOD 5 (mg/L), and their respective average and standard deviation.

Sample	Change in DO (mg/L)	BOD 5 (mg/L)
Control	0.1	
1	3.36	40.75
2	4.57	41.9
3	6.2	38.13
Average	4.71	40.26
Standard Deviation	1.16	1.58

Table 8: Class data of the post enhancement water of the treatment train at the AWWTP including change in DO (mg/L), BOD 5 (mg/L), and their respective average and standard deviation.

Sample	Change in DO (mg/L)	BOD 5 (mg/L)
Control	-0.08	
1	1.04	4.725
2	1.97	5.475
3	3.47	3.69
Average	2.16	4.63
Standard Deviation	1.00	0.73

C. Equations and sample calculations for dilution factor P, volume undiluted sample, and BOD 5 are included below.

Dilution Factor P:

$$P = \frac{4\left(\frac{mg}{L}\right)}{\text{Expected BOD 5}}$$

$$P = \frac{4\left(\frac{mg}{L}\right)}{50} = .08$$

Volume Undiluted Sample:

$$V(mL) = \frac{4\left(\frac{mg}{L}\right)}{\text{expected BOD}} * \text{total volume}$$

$$V(mL) = \frac{4\left(\frac{mg}{L}\right)}{50} * 300 = 24$$

BOD 5:

D1 = Initial DO (mg/L)

D2 = DO after 5 days (mg/L)

B1 = Initial DO of control (mg/L)

B2 = DO of control after 5 days (mg/L)

$$BOD\ 5\ \left(\frac{mg}{L}\right) = \frac{(D1 - D2) - (B1 - B2)}{P}$$

$$BOD\ 5\ \left(\frac{mg}{L}\right) = \frac{(8.55 - 5.19) - (8.59 - 8.49)}{.08} = 40.75$$