MEMORANDUM

To: Dr. Valerie Budig-Markin
From: Patricia Angeles
Subject: Dissolved Oxygen and Biochemical Oxygen Demand
Date: 2/22/19

INTRODUCTION

In order to sustain aquatic life, dissolved oxygen and biochemical oxygen demands are parameters used to measure the concentrations in a water body. Dissolved oxygen (DO) is oxygen carried onto a water surface through atmospheric aeration, mixing, and photosynthesis. The DO depends on temperature, pressure and the DO % saturation, which measures the amount of oxygen water can hold. Microorganism use the dissolved oxygen to degrade organic matter or waste. Biochemical oxygen demand (BOD) is the measurement of how much oxygen was used to break down the organic matter. The objective of this lab was to analyze the BOD in different samples in order to 1.) measure the initial and final DO for each sample 2.) determine how much actual BOD was exerted over five days in each sample, and 3.) assess the effectiveness of the treatment train .

METHODOLOGY

Four samples from Arcata Marsh Wastewater Treatment Plant, were directly taken from the Post-Treatment Wetlands (PTW) on February 5th. The samples measured, on February 6th from 4:41 p.m. to 4:52 p.m., were of the initial DO, DO % saturation, and temperature. After five days, the samples were analyzed on February 11th from 12:26 p.m. to 12:34 p.m. for the final parameters. Both days were following the *Standard Methods* procedure 5210B (APHA, 2005).

RESULTS

Results of the measured DO, BOD, undiluted volume, average and standard deviation are presented in Table 1. The BOD bottles are reads from the control as the lowest concentration rate to bottle 32 being the highest concentration. In addition, there was no expected BOD5 for the control measured.

Table 1. Results for samples tested reading the average and standard deviation of the BOD exerted over 5 days.

BOD Bottle #	**Control (C)**	**22**	**67**	**32**	**Avg BOD**	**Std Dev**
Expected BOD5 (mg/L)	N/A	50	37.5	25	41.3 (mg/L)	8.69
Initial DOi (mg/L)	8.72	8.46	8.27	7.92		
Final DOf (mg/L)	8.68	6.09	3.02	0.46		
DOi – Dof (mg/L)	0.04	2.37	5.25	7.46		
BOD5 (mg/L)	0	29.1	48.5	46.4		
Undiluted Vol (mL)	0	24	32	48		

DISCUSSION

Lower concentrations demonstrate good water quality because when organic matter is consumed, BOD levels will decline. As opposed to higher concentrations, where DO is required to consume all the organic matter. When DO increases, the BOD decreases, vice versa (Otero-Diaz, lecture slides, 2019). The results of the BOD5 compared to the expected BOD5, is lower for bottle #22 and higher for bottle #67 and #32. The expected BOD5 for the PTW fall into a range of 25- 50 mg/L. All three samples calculated fell within that scope. The only results that correspond with each other is bottle #67 which displayed a critical level of DO as 5.25 mg/L and BOD5 of 48.5 mg/L. However, if the DOf is not greater than or equal to 1.0 mg/L, bottle #32 results display that it was over depleted (Budig-Markin et al., lab handout ,2019) The measured DO for bottle #32 also showed its results as 7.46 mg/L which means higher levels of DO is healthy. Nonetheless, the data is not coherent due to having a low DOf. In addition to incoherent data, bottle #22 demonstrates a low DO of 2.37 mg/L expressing death of aquatic organisms who need high levels of DO, when the calculated BOD also displayed low levels. Generally, BOD will decline when the DO is high. Despite the results exhibiting discrepancy bottle #67 and the average BOD5 of 41.3 mg/L confirms that the wastewater treatment in the PTW is effective.

By analyzing a different group, who sampled from the same site, they had no depletion in there results. However, the same parameters for the expected BOD of 50 mg/L had a low DO around 2 mg/L out of all the other sites. Also, PTW2 had a low BOD level as well displaying the same dilemma of contradicting values. Considering that the PTW had removed the suspended solids, and harmful nutrients, the possibility that the two contradicting values for DO and BOD means; there is still an awful lot of organic matter and the rate of how much oxygen was used is slower.

The other sites from other groups, Post Oxidation Ponds (POx), PTW, and Post Treatment Enhancement (PEW), illustrated corresponding results that were within their expected ranges. For example, PEW1 and PEW2 in table 3 (in appendix), were slightly under and over the expected BOD5 of 5 mg/L. POx were approximately equivalent to their expected BOD5 as well. Those results correspond to what the waste water treatment is treating or removing at each site. For POx, the BOD is high because there are nutrients are added, traces of metal and so on, whereas PEW has a low BOD because most of the organic matter has been decomposed. Overall, these results clarify the effectiveness of the waste water treatment components.

CONCLUSION

In this lab, BOD was analyzed through measuring the DO and calculating the BOD exerted in order to determine the effectiveness of the treatment train. The results of each site illustrated a coherent relationship between the BOD exerted and the DO that was measured by comparing what the expected BOD5 would be respectively. In doing so, each site confirms that the BOD calculated falls into a range of what the expected BOD5 is determined as proving that the Arcata Wastewater Treatment plant is successfully doing the job right.

REFERENCES

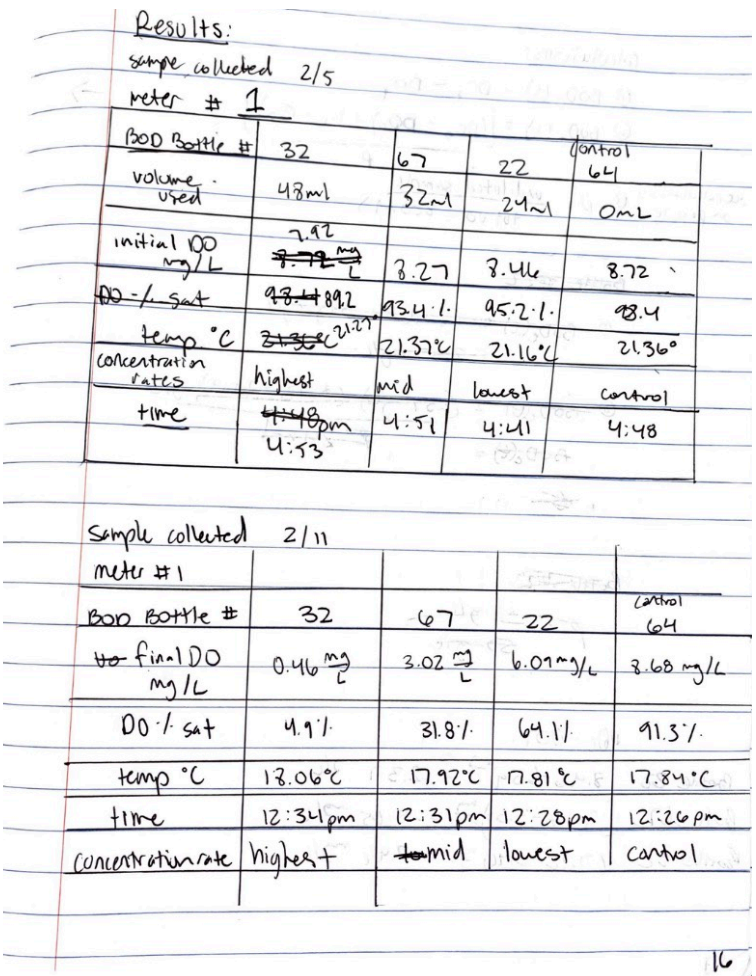
American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF). (2005). *Standard methods for the examination of water and wastewater,* 21st Ed., American Public Health Association, Washington DC, USA.

Sawyer et al. (2003). *Chemistry for Environmental Engineering and Science.* McGraw Hill, New York, NY.

APPENDIX

A. Table 2 (pic of table on lab notebook)

Table 2. Raw data for four samples that were used to measure the initial and final DO, % saturation, temperature, volume of undiluted sample, time and range of concentrations for both days of when it was measured.



Results:

sample collected 2/5

meter # 1

BOD Bottle #	32	67	22	control 64
volume used	48ml	32ml	24ml	0mL
initial DO mg/L	~~8.72~~ 7.92 mg/L	8.27	8.46	8.72
~~DO~~-% sat	~~98.4~~ 89.2	93.4%	95.2%	98.4
temp °C	~~21.36~~ 21.27°C	21.37°C	21.16°C	21.36°
concentration rates	highest	mid	lowest	control
time	~~4:48~~pm 4:53	4:51	4:41	4:48

Sample collected 2/11

meter #1

BOD Bottle #	32	67	22	control 64
~~Vo~~ final DO mg/L	0.46 mg/L	3.02 mg/L	6.07 mg/L	8.68 mg/L
DO % sat	4.9%	31.8%	64.1%	91.3%
temp °C	18.06°C	17.92°C	17.81°C	17.84°C
time	12:34pm	12:31pm	12:28pm	12:26pm
concentration rate	highest	~~to~~ mid	lowest	control

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B. Table 3 (info from other sites)

Table 3. Raw data for each site including the initial, final and change of DO, expected BOD5, volume of undiluted sample, average and standard deviation.

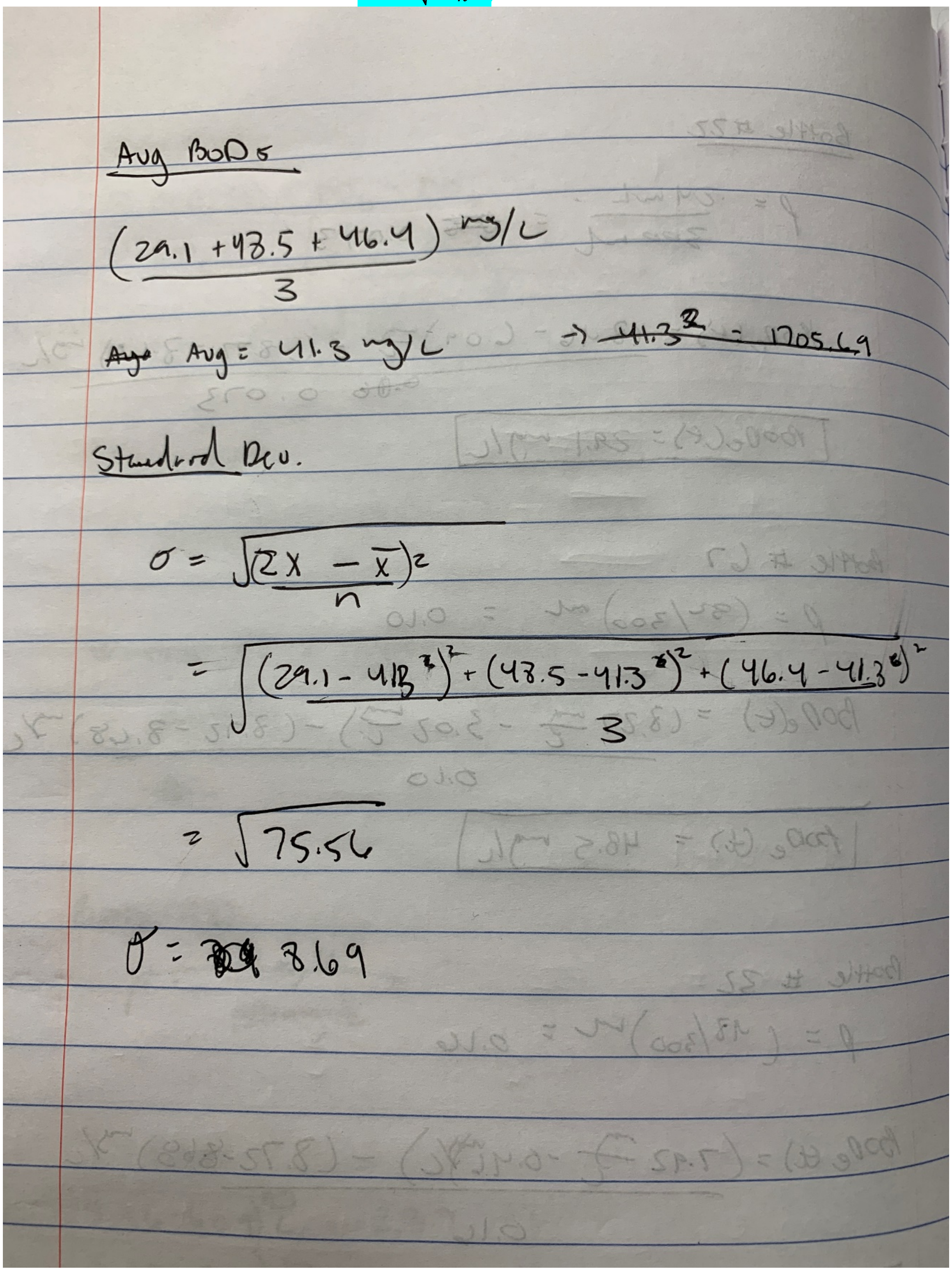
	POX2		PTW1		PTW2			PEW1	PEW2
Expected BOD (mg/L)	45	60	50	37.5	50	37.5	25	5	5
Volume (mL)	26.7	20	24	32	24	32	48	240	240
DOi – DOf (mg/L)	4.87	4.21	2.37	5.25	2.21	6.25	5.15	4.07	4.16
Ci-Cf (mg/L)	0.02		0.04		0.04			0.17	0.09
BOD5 (mg/L)	54.49	62.85	29.1	48.5	29.7	62.1	31.9	4.85	5.08
Avg BOD	45.05		38.8		22.6			4.85	5.08

C. Sample Calculations

a. Equations

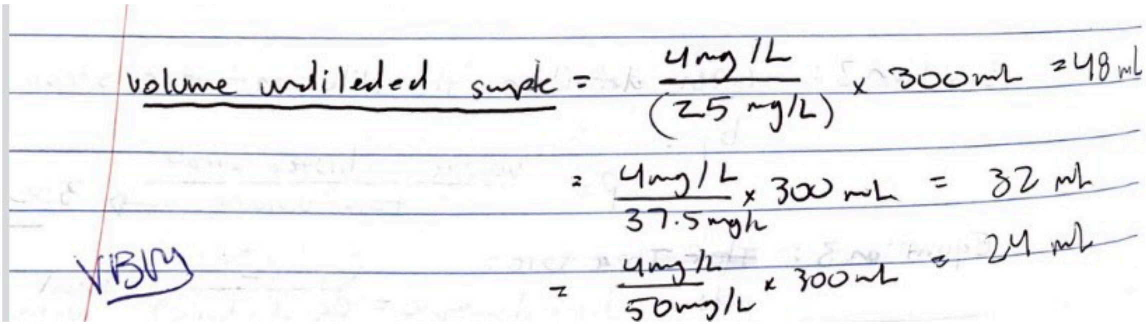
i. standard deviation

1. $\sigma = \sqrt{\frac{(x-\bar{x})^2}{n}}$



ii. Volume of Undiluted sample

1. P = [(4 mg/L)/(expected BOD5)] * total vol



volume undiluted sample = $\frac{4\ mg/L}{(25\ mg/L)} \times 300\ mL = 48\ mL$

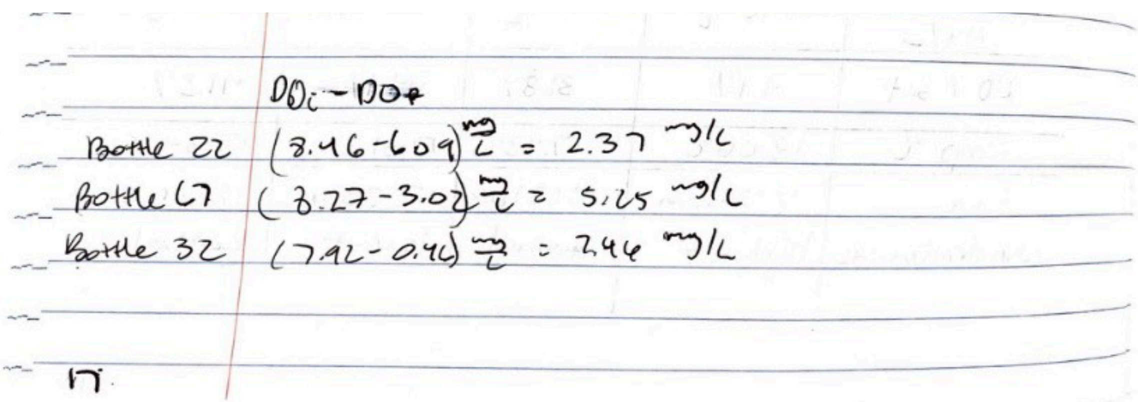
$= \frac{4\ mg/L}{37.5\ mg/L} \times 300\ mL = 32\ mL$

VBVY

$= \frac{4\ mg/L}{50\ mg/L} \times 300\ mL = 24\ mL$

iii. BOD estimation

1. DOi- DOf



$DO_i - DO_f$

Bottle 22 (8.46−6.09) mg/L = 2.37 mg/L

Bottle 67 (8.27−3.02) mg/L = 5.25 mg/L

Bottle 32 (7.92−0.46) mg/L = 7.46 mg/L

17.

iv. BOD estimation

1. BOD5= [(DOi – DOf) – (Ci-Cf)]/P
   a. Where C is control

Bottle #22

$P = \frac{24\ mL}{300\ mL} = ~~0.06~~\ 0.073$

$BOD_e(t) = \frac{(8.46 - 6.09)\frac{mg}{L} - (8.72 - 8.68)\frac{mg}{L}}{~~0.06~~\ 0.073}$

$BOD_e(t) = 29.1\ mg/L$

Bottle # 67

$P = (32/300)\ mL = 0.10$

$BOD_e(t) = \frac{(8.27\frac{mg}{L} - 3.02\frac{mg}{L}) - (8.72 - 8.68)\frac{mg}{L}}{0.10}$

$BOD_e(t) = 48.5\ mg/L$

Bottle # 32

$P = (48/300)\ mL = 0.16$

$BOD_e(t) = \frac{(7.92\frac{mg}{L} - 0.46\frac{mg}{L}) - (8.72 - 8.68)\frac{mg}{L}}{0.16}$

$BOD_e(t) = 46.4\ mg/L$