WATER QUALITY MEMORANDUM

TO: DR. EILEEN CASHMAN

FROM: KELSEY BURRELL

SUBJECT: NUTRIENTS IN THE ARCATA WASTEWATER TREATMENT TRAIN

DATE: MARCH 10, 2017

INTRODUCTION

Part of the goal of domestic wastewater treatment in Arcata is to remove ammonia, nitrate, and phosphorus. Phosphorous is a critical nutrient for organisms involved in the biological processes of wastewater treatment. In excess it can lead to algal blooms, which deplete the dissolved oxygen in the system as a byproduct of their decomposition. Nitrate results from the bacterial oxidation of ammonia, which itself is a product of decomposition. Our lab tested water samples for the aforementioned nutrients collected from the Arcata Wastewater Treatment Plant (AWWTP). Several groups analyzed the effluent of three locations: the primary clarifier (Point 2), the first oxidation pond (Point 3), and the treatment wetlands (Point 9). Our group's objective for this lab was to examine the sample from Point 9, which feeds into the chlorination chamber. Ammonia is of specific concern at this juncture since it will react with chlorine and can disrupt the disinfection process, rendering the water unsafe for release into Humboldt Bay.

MATERIALS AND METHODS

The water samples analyzed were collected by our lab instructor. Our group prepared and measured nutrient concentrations in samples from Point 9 on February 14th. Ammonia was measured using Standard Methods procedure 4500-NH_3 D, nitrate by procedure 4500-NO_3^- D, and phosphate by procedure 4500-P E. Triplicates were not produced due to a lack of available time during the lab.

RESULTS

Table 1 contains the nutrient concentrations at Point 9 found by our group. The results produced by the class as a whole for each point are located in Table 2, which presents an overall decrease in nitrate and phosphate, and no considerable change in ammonia.

Table 1. Nutrient concentrations found by our group at Point 9.

Nutrient	Concentration (mg/L)
Nitrate	0.347
Ammonia	14.12
Phosphate	0.807

*Table 2. Nutrient values found by the class. * Denotes approximate or estimated values.*

Location	Nutrient	Concentration (mg/L)
Point 2	Nitrate	0.3
	Ammonia	15*
	Phosphate	2.3, 3
Point 3	Nitrate	0.1
	Ammonia	15*
	Phosphate	N/A
Point 9	Nitrate	0.5
	Ammonia	10-20*
	Phosphate	N/A

DISCUSSION

Although no finite standards exist for nutrient concentrations in effluent municipal wastewater, the AWWTP monitors for levels of ammonia, nitrate and phosphorus. Ammonia reacts with chlorine during disinfection and form chloramines, which retain disinfectant properties but are slower-acting than chlorine and could diminish the effects of the disinfection process. Our group found the concentration of ammonia exiting secondary treatment to be 14.12 mg/L, which shows a decrease in ammonia by less than 1 mg/L compared with the primary treatment effluent. This data can be trusted since the calibration curve has a very high R^2-vaue, although it is only a point-sample representative of conditions the day it was collected. The internal load of ammonia at the AWWTP explains the lack of its decline. The secondary treatment systems rely heavily on biological processes, and when involved organisms die and decompose they contribute ammonia to their environment. Although nitrate is virtually nonexistent in raw sewage, ammonia oxidizes to nitrite, which oxidizes to nitrate, and depletes the dissolved oxygen of the system in the process. Our group found the concentration of nitrate at Point 9 to be around 0.35 mg/L. This presents an increase in the species through the treatment wetlands, while nitrate levels decreased through the oxidation ponds. The nitrate calibration has a reasonably high R^2-value, and small errors could have occurred when we measured our sample volumes. The decrease could be contributed to uptake by pants in the oxidation ponds, while the increase downstream could be contributed to nitrification (bacterial oxidation) of ammonia. Finally, the class data shows an average phosphate concentration in the primary effluent of 2.7 mg/L, with a 13% error. Phosphates are removed by gravity through secondary treatment, and our group found 0.807 mg/L at Point 9. The calibration curve for phosphorus is the least trustworthy of the three produced for this nutrient analysis, although it's R^2 exceeds 0.92. This uncertainty could be due to inaccurate measurements of the calibration solutions.

CONCLUSION

In general, we found the ammonia concentration remained relatively constant through secondary treatment, likely due to decomposing organic matter which creates an internal load in the treatment wetlands. The nitrate concentration fluctuated in both directions as the wastewater traveled though secondary treatment, probably because of a combination of plant uptake and the nitrification of ammonia. The phosphate concentration was less than 1 mg/L after it had a chance to settle during primary and secondary treatment.

In order to quantify the proper amounts of chlorine to add during disinfection and the proper retention time in the chlorination chamber, engineers must know the average ammonia concentration of the wastewater (Sawyer et. al 2003). Ammonia and nitrate concentrations can tell engineers whether the wastewater has enough nitrogen for the required biological processes to occur, or if it is in great excess.

REFERENCES

APHA et. al (2005). Standard Methods for the Examination of Water and Wastewater – 21st Edition. Port City Press, Baltimore, MD.

Davis, Mackenzie and Masten, Susan (2010). Principles of Environmental Engineering and Science – 2nd Edition. McGraw-Hill, New York, NY.

Sawyer, C. N., McCarty, P. L., and Parkin, G. F. (2003). Chemistry for Environmental Engineering and Science – 5th Edition. McGraw-Hill, Boston, Mass.

APPENDIX

* Our group's raw data is located in the Results section.

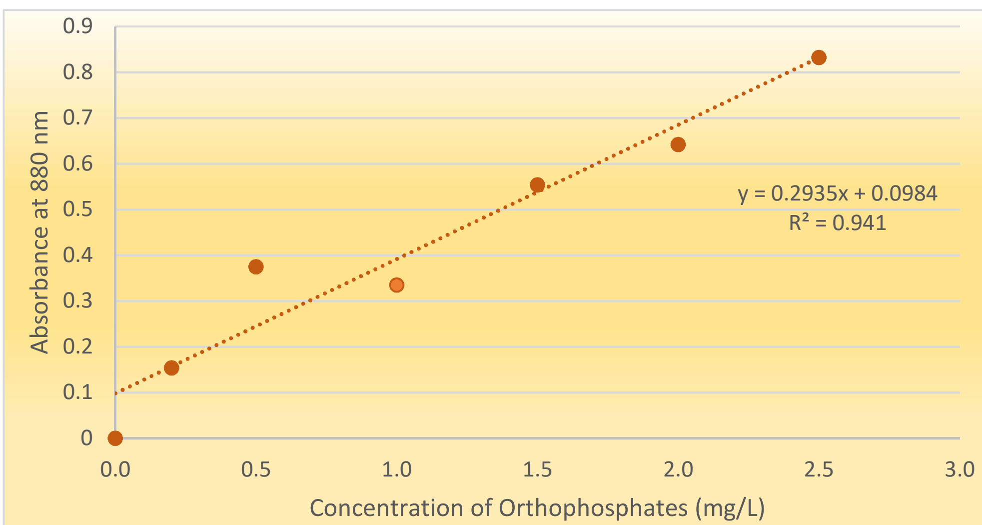

Figure 1. Calibration curve for orthophosphates.

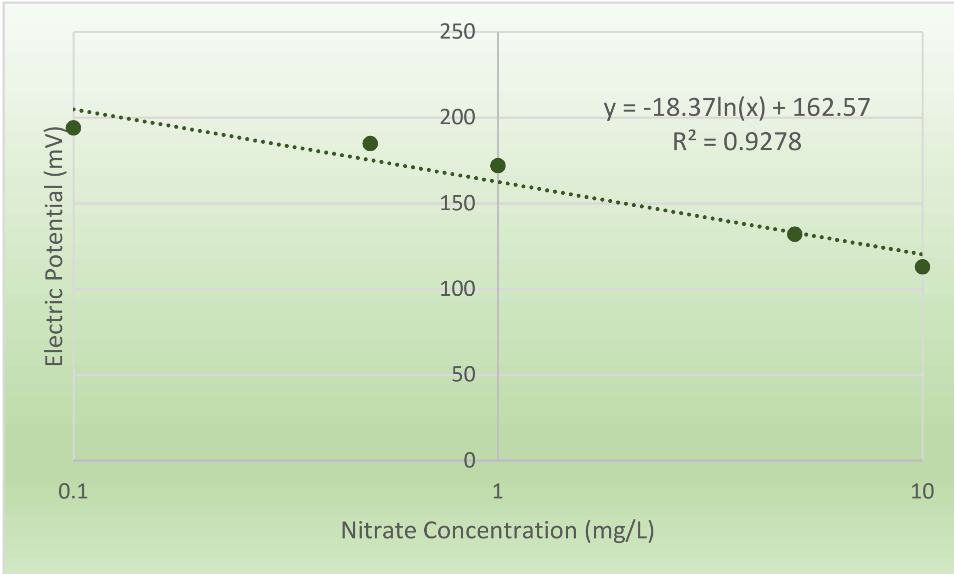

Figure 2. Calibration curve for nitrates.

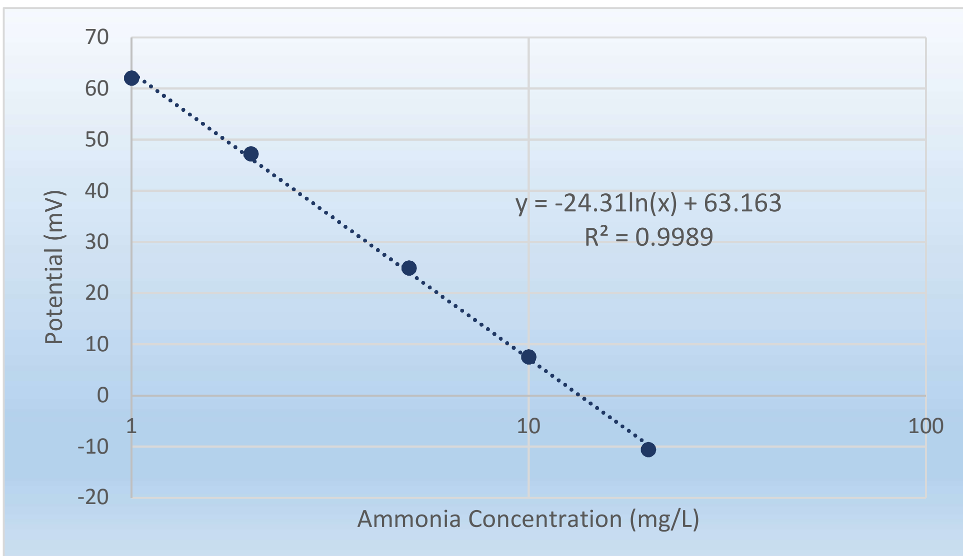

Figure 3. Calibration curve for Ammonia.

Sample calculation:

$$\text{Phosphate Concentration} = \frac{(\text{absorbance at 880 nm})(\text{dilution ratio}) - 0.0984}{0.2935}\ {}^{\text{mg}}/_{\text{L}}$$

$$[PO_4] = \frac{(0.637)\left(\frac{10}{19}\right)}{0.2935}\ {}^{\text{mg}}/_{\text{L}}$$

$$[PO_4] = 0.807\ {}^{\text{mg}}/_{\text{L}}$$

$$\text{Phosphate deviation, Point 2} = \left(\frac{(\frac{2.3+3}{2} - 2.3)\ {}^{mg}/_{L}}{2.65\ {}^{mg}/_{L}}\right)100\%$$

$$\text{Phosphate deviation, Point 2} = \left(\frac{(2.65 - 2.3)\ {}^{mg}/_{L}}{2.65\ {}^{mg}/_{L}}\right)100\%$$

$$\text{Phosphate deviation, Point 2} = 13.2\%$$
