

ENGR 351

Memo

To:	Margarita Otero-Diaz
From:	Daniel Aceves
Date:	10/07/2018
Re:	Nutrient Concentration at different stages in the Arcata WWTP

Introduction:

During wastewater treatment, incoming effluent is treated for the removal of BOD, solids, nutrients, and pathogens. However, most wastewater treatment centers do not have the means to properly remove all the nutrients present in the wastewater at the end of the process. The nutrients that are of most interest and concern at the end of the treatment process are phosphorus, nitrate, and ammonia. These three nutrients, when in excess amounts can lead to various environmental problems like algal blooms and dead zones. Measuring the different levels of these nutrients throughout the various stages of the treatment process is of great importance in order to make the proper adjustments to mitigate the nutrients being discharged from the WWTP.

Method:

Water samples were collected from the different stages at the Arcata WWTP on September 18, 2018. These samples were tested for concentration levels of phosphorus, nitrate, and ammonia using standard methods 4500-P, 4500-NO₃⁻, 4500-NH₃ respectively. Dilutions were made in order to create the calibration curves for each nutrient.

Results:

Calibration curves for the nutrients (ammonia, nitrate, and phosphorus) were created using known concentrations of each nutrient and recording the electrode potential of each in mV. Using a linear regression model equations were derived to determine nutrient concentration in wastewater samples.

Table 1: Calibration curve linear regression equations for Phosphorus, Nitrate, & Ammonia

	NO ₃ ⁻	NH ₃	P
Cal. Linear regression equation	$Y = -51.36x + 66.28$	$Y = -40.604x + 171.44$	$Y = 0.395x + 0.2309$

Table 2: Average nutrient concentration found in P.E.W.

Nutrients	Average nutrient concentration (mg/L)
NO ₃ ⁻ (mg/L-N)	0.475
NH ₃ (mg/L-N)	0.634
P (mg/L-P)	3.155

Discussion:

Using the dilution concentration from table 3 in the appendix, calibration curves and linear regression equations were derived for each nutrient relating electrode potential (mV) to concentration. The linear regression equation that was derived from the data collected for ammonia was $y = -39.72x + 60.65$. The desired slope value for the ammonia equation needed to be close to -56 in order to get accurate concentration values from the wastewater samples. Another group created a calibration curve/equation for ammonia based data collected from their dilution values. Their regression equation was more accurate ($y = -51.36x + 66.28$). This linear regression equation was used in determining the ammonia concentration for the P.E.W. sample resulting in an average value of 0.634 mg/L. This concentration value was in line with the average weekly allowance for the discharge of ammonia set by the NPDES of 2.9 mg/L (Davis et. al, 2014). Using the Linear regression equations for phosphorus and nitrate from table 1 the average concentrations for the P.E.W. samples were 3.155 mg/L & 0.475 mg/L respectively. The MCL for nitrate established by the NPDWR is 1.0 mg/L (EPA, 2018). The nitrate concentration in the P.E.W. sample is in compliance. The average weekly allowance for phosphorus based on the NPDES limits is 10.4 kg/day. The average discharged released by the Arcata WWTP is 2.3 million gallons per day (MGD) (Humboldt County). This means that the average allowance for phosphorus leaving the Arcata WWTP would be 1.19 mg/L. The average phosphorus concentration measured was 3.155 mg/L. this value is not in compliance with the NPDES limits. These results however are not conclusive. The general trend for an WWTP should be that the amount of nutrients decreases as the wastewater passes through the various stages of the plant. The values that were measured did not follow this trend. For the P.O. stage the average value for phosphorus, nitrate, and ammonia were 3.298, 1.76, and 0.455 mg/L respectively. The nutrient concentration values measured for the P.T.W. were 3.8846, 0.4362, and 0.2775 mg/L respectively. Some possible errors that could have led to this discrepancy in values could have been due to mechanical error, improper use of measurement devices, or not allowing for the proper duration of time needed for each test. Another error could have been that improper dilutions were made. This would have led to discrepancy's in the calibration curve and the linear regression equations which would have led to inaccurate nutrient concentration values.

Conclusion:

Testing samples for nutrient concentration levels from the different stages within the Arcata WWTP is essential in order to ensure that the plant is meeting the standards set by the NPDES. The results from the P.E.W. (PO₄-P 3.155 mg/L, NH₃-N 0.634 mg/L, NO₃-N 0.475 mg/L) indicate the Arcata plant is in compliance with all regulation except for phosphorus levels.

Appendix:

“National Primary Drinking Water Regulations.” *EPA*, Environmental Protection Agency, 22 Mar. 2018, www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#one.

“Humboldt County Homepage.” *GIS Data Download | Humboldt County, CA – Official Website*, humboldt.gov.org/.

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.

Davis, Mackenzie Leo, and Susan J. Masten. *Principles of Environmental Engineering and Science*. 3rd ed., McGraw-Hill Higher Education, 2014.

Table 3: Dilutions of Phosphorus, Nitrate, & Ammonia

Nutrient	Initial concentration of solution (mg/L)	Volume of stock solution used (mL)	Volume of DI water (mL)	Desired concentration (mg/L)
Phosphorus (PO₄-P)	50	2.0	23.0	4.0
	4	6.25	18.75	1.0
	1	2.5	22.5	0.1
	0.1	2.5	22.5	0.01
Nitrate (NO₃-N)	100	25.0	225.0	10.0
	100	1.0	99.0	1.0
	10	5.0	95.0	0.5
	10	1.0	99.0	0.1
Ammonia (NH₃-N)	100	100.0	0	100.0
	100	25.0	225.0	10.0
	100	1.0	99.0	1.0
	10	1.0	99.0	0.1

Table 4: Ammonia Calibration Data

Concentration (mg/L)	0.1	1.0	10.0	100.0
Potential (mv)	90.1	76.3	19.9	-23.5

Table 5: Nutrient concentration values from P.O. sample

Nutrients	Average nutrient concentration (mg/L)
NO ₃ ⁻ (mg/L-N)	1.76

NH ₃ (mg/L-N)	0.455
P (mg/L-P)	3.298

Table 6: Nutrient concentration values from P.T.W sample

Nutrients	Average nutrient concentration (mg/L)
NO ₃ ⁻ (mg/L-N)	0.4362
NH ₃ (mg/L-N)	0.2775
P (mg/L-P)	3.8846

Table 7: Nutrient concentration values from P.E.W sample

Nutrients	Concentration (mg/L)	Concentration (mg/L)
NO ₃ ⁻ (mg/L-N)	0.559	0.391
NH ₃ (mg/L-N)	0.695	0.573
P (mg/L-P)	2.87	3.44

Figure 1: Graph relating known concentrations (mg/L) of Ammonia solution to electrode potential (mV)

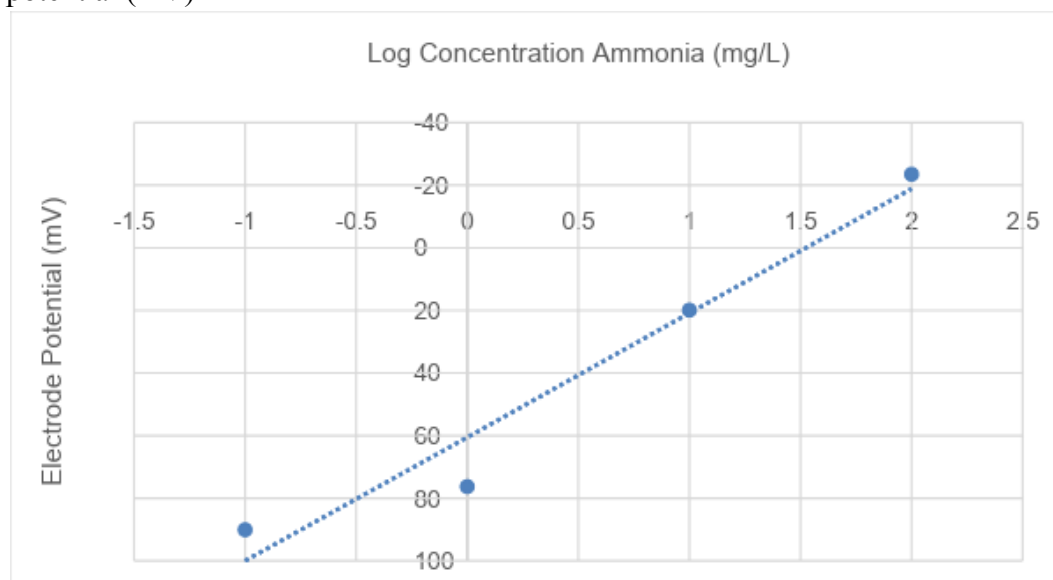


Figure 2: Dilution calculations of Nitrate solution

Dilution values

Nitrogen $C_1 V_1 = C_2 V_2$
 $V_1 = \frac{C_2 V_2}{C_1}$

100 mg/L $\text{NO}_3^- \text{-N}$
 $V_1 = \frac{10 \text{ mg/L } 250 \text{ mL}}{100 \text{ mg/L}} = 25 \text{ mL}$

1 mg/L $\text{NO}_3^- \text{-N} = 1 \text{ mL}$
 $0.5 \text{ mg/L } \text{NO}_3^- \text{-N} = V = \frac{0.5 \text{ mg/L } 100 \text{ mL}}{10 \text{ mg/L}} = 5 \text{ mL}$
 $0.1 \text{ mg/L } \text{NO}_3^- \text{-N} = V = \frac{0.1 \text{ mg/L } 100 \text{ mL}}{10 \text{ mg/L}} = 1 \text{ mL}$

Figure 3: Dilution concentration of Phosphate and Ammonia solutions

Phosphorus:
 stock solution 50 mg/L $\text{PO}_4 \text{-P}$

4 mg/L $\text{PO}_4 \text{-P} = V = \frac{4 \text{ mg/L } 25 \text{ mL}}{50 \text{ mg/L}} = 2 \text{ mL}$
 $1 \text{ mg/L } \text{PO}_4 \text{-P} = V = \frac{1 \text{ mg/L } 25 \text{ mL}}{4 \text{ mg/L}} = 6.25 \text{ mL}$
 $0.1 \text{ mg/L } \text{PO}_4 \text{-P} = V = \frac{0.1 \text{ mg/L } 25 \text{ mL}}{1 \text{ mg/L}} = 2.5 \text{ mL}$
 $0.01 \text{ mg/L } \text{PO}_4 \text{-P} = V = \frac{0.01 \text{ mg/L } 25 \text{ mL}}{0.1 \text{ mg/L}} = 2.5 \text{ mL}$

Ammonia:
 stock solution 100 mg/L $\text{NH}_3 \text{-N}$

100 mg/L $\text{NH}_3 \text{-N} = 100 \text{ mL}$
 $10 \text{ mg/L } \text{NH}_3 \text{-N} = V_1 = \frac{10 \text{ mg/L } 250 \text{ mL}}{100 \text{ mg/L}} = 25 \text{ mL}$
 $1 \text{ mg/L } \text{NH}_3 \text{-N} = 1 \text{ mL}$
 $0.1 \text{ mg/L } \text{NH}_3 \text{-N} = V_1 = \frac{0.1 \text{ mg/L } 100 \text{ mL}}{10 \text{ mg/L}} = 1 \text{ mL}$