Determining the Optimal Concentration of Polyelectrolyte as a Flocculant in Combined Sewage Overflow Treatment

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INTRODUCTION

- Municipal wastewater carries a plethora of pollutants that have the potential to disturb the environment, such as phosphates, heavy metals and man-made chemicals. To protect the environment from these pollutants, wastewater is treated prior to being released. For example, in Europe, there are over 1 000 000 synthetic chemicals that are registered and may potentially wind up in municipal wastewater. [3]
- Coagulation-flocculation (CF) is a crucial step in wastewater treatment. Its simplicity and effectiveness allows it to be one of the oldest and most widely used wastewater treatment processes. For example, evidence suggests that coagulants such as alum were used as far back as 1 500 BC, in ancient Egypt.[1]

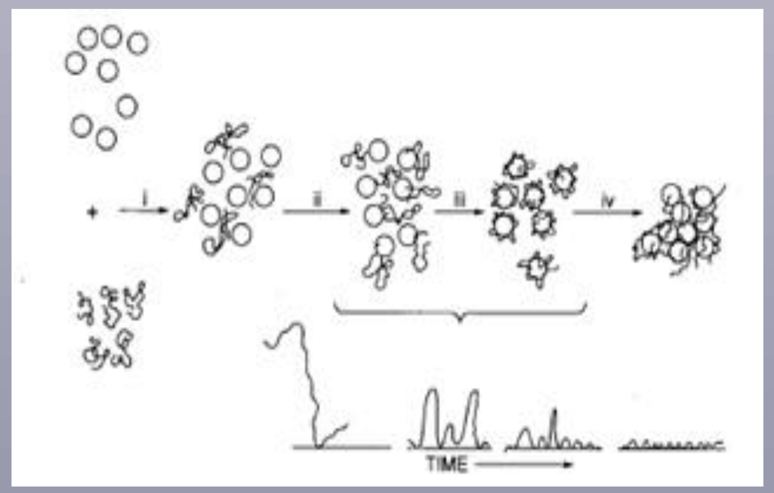

Figure 1.1 Diagram of polyelectrolyte creating floc[5]

Figure 1.2 Aerial view of the Goldbar Water Treatment plant, Edmonton, Alberta[6]

- The CF process is comprised of two primary components. Coagulation refers to the charge neutralization of suspended particles, while flocculation is the process during which these stabilized particles make contact and join to form larger suspended particles. These particles then settle to the bottom of the effluent as a sludge and allow the water to be separated from the sludge of pollutants at the bottom.[1]
- The aim of this process is to remove as many of the suspended pollutant particles from the water as possible. Measuring turbidity and Total Suspended Solids (TSS) allow us to test the effectiveness of the coagulants and flocculants.[2]
- Polyelectrolytes are a type of flocculant. Generally, they are composed of long, cationic chains that neutralize the surface charge of particulates and cause them to bind together to form flocs. These flocs then settle to the bottom of the effluent and can be easily separated from the water. [4]
- Polyelectrolytes are inexpensive, non-toxic and generally accessible, making them excellent candidates for municipal wastewater treatment.

[1] Teh, C. Y., Budiman, P. M., Shak, K. P., & Wu, T. Y. (2016). Recent Advancement of Coagulation–Flocculation and Its Application in Wastewater Treatment. *Industrial & Engineering Chemistry Research,55*(16), 4363-4389. doi:10.1021/acs.iecr.5b04703
[2] Choumane, F. Z., Benguella, B., Maachou, B., & Saadi, N. (2017). Valorisation of a bioflocculant and hydroxyapatites as coagulation-flocculation adjuvants in wastewater treatment of the steppe in the wilaya of Saida (Algeria). *Ecological Engineering,107*, 152-159. doi:10.1016/j.ecoleng.2017.07.013
[3] Kolk, J. V. (2011). United Nations Environment Programme and UNEP Chemicals. *Chemicals, Environment, Health,*427-434. doi:10.1201/b11064-36
[4] Haver, L. V., & Nayar, S. (2017). Polyelectrolyte flocculants in harvesting microalgal biomass for food and feed applications. *Algal Research,24*, 167-180. doi:10.1016/j.algal.2017.03.022
[5] Stages in the bridging mechanism [Digital image]. (2013, September). Retrieved August 1, 2017
[6] Maple.ca, Project Gallery. (n.d.). Goldbar Water Treatment Plant [Maple.ca, Project Gallery]. Retrieved August 1, 2017, from http://www.maple.ca/projectgallery/123/

OBJECTIVE

- In this experiment, the ideal concentration of the polymer, polyelectrolyte, as a flocculant was determined. This information can be used for the treatment of the secondary effluent of sewage overflow.

METHODS

- To replicate secondary effluent in sewage overflow treatment, 15 L of tap water was mixed with various chemicals that mimic those that may be found in the actual secondary effluent. The quantities added can be seen in Figure 2.1.
- Roughly 0.5 L of this artificial secondary effluent is taken out and tested for turbidity, TSS and pH. Then, 2.0 L of water was added to each of the seven containers to be used in the jar test.
- One sample was kept as a control, with no additional chemicals.
- The rest of the samples were used to create different flocculant concentrations and their replicates.1 mg/L, 0.8 mg/L and 1.5 mg/L of polyelectrolyte 6.6. Additionally, 35 mg/L of alum was added to each of the samples as a coagulant.
- These samples were mixed at a high speed for 1 minute (roughly 300 rpm), then at a lower speed for 20 minutes (roughly 30 rpm)
- Afterwards, the mixing was stopped and the samples were left to settle for 60 minutes.
- After resting, 0.25 L was taken from each of the jars. These 0.25 L samples were then tested for turbidity, TSS and pH.

	Concentration (g/L)	Amount added (g per 15.0L)
Glutamic acid	0.020	0.300
Humic acid	0.036	0.536
Sodium bicarbonate	0.012	0.180
Sodium chloride	0.029	0.441

Table of the amount of each substance added to the solution to form artificial secondary effluent.

Figure 2.1 Dry test units in which the solutions underwent mixing

RESULTS

- The turbidity, TSS and pH of each sample was taken both before and after the jar tests. Three readings of pH and turbidity were taken on each sample, to eliminate as much random error as possible. The values on the given table are averages of those three readings, round to four significant digits.
- The values given by TSS fluctuated greatly. As a result, more data must be collected before any definitive pattern can be found amongst the change of TSS.

	Control	0.1 mg/L Trial A	0.1 mg/L Trial B	0.8 mg/L Trial A	0.8 mg/L Trial B	1.5 mg/L Trial A	1.5 mg/L Trial B
pH (average of 3 readings)	7.637	7.370	7.356	7.346	7.363	7.34	7.303
Turbidity (average of three readings-NTU)	13.46	11.53	13.10	7.453	7.097	3.637	2.280
TSS (mg/50mL)	0.6000	0.1000	0.4000	0.3000	0.9000	0.3000	0.3000

RESULTS

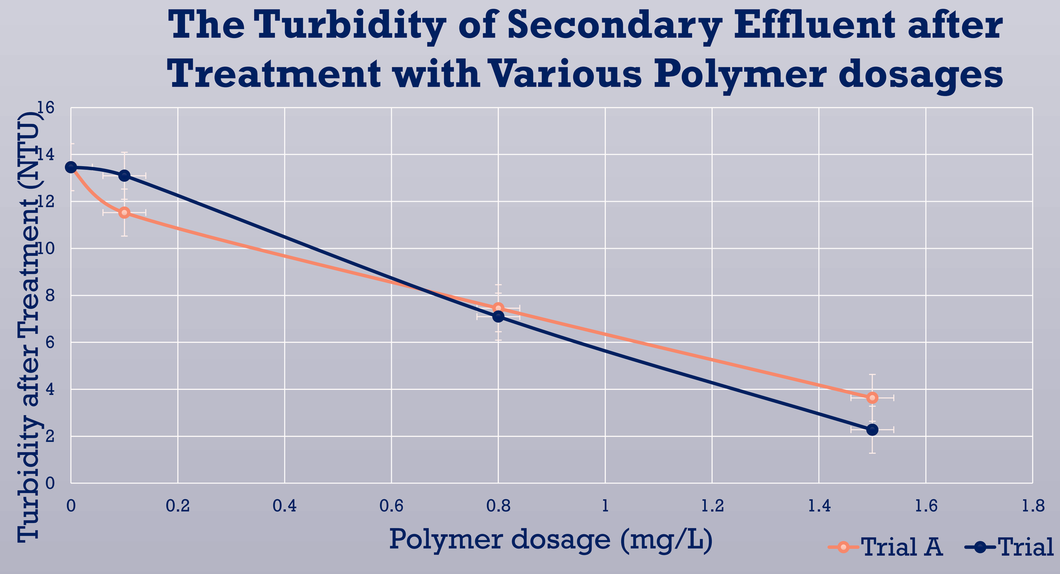

Figure 3.1 A graph of the relationship between the concentration of polymer in the effluent and the turbidity after treatment

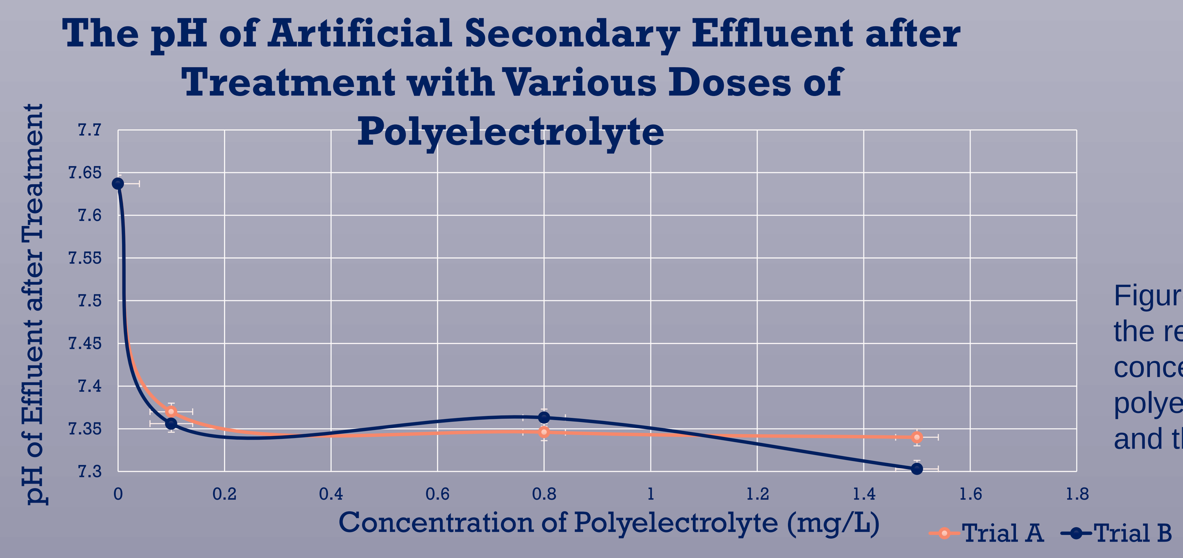

Figure 3.2 A graph showing the relationship between the concentration of polyelectrolyte in the effluent and the pH after treatment

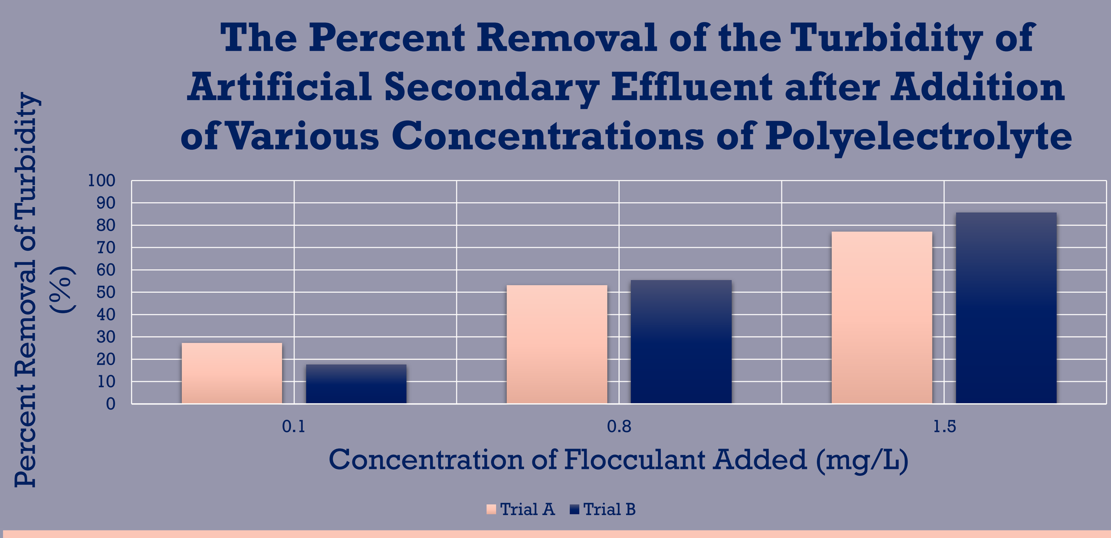

Figure 3.3 A graph showing the percent removal of turbidity from the artificial secondary effluent. These values are based on the measurements taken of the original effluent, before the jar tests.

CONCLUSION

- The most effective dosage tested was 1.5mg/L . Both trials had the highest percent removal of turbidity out of the three trials tested by a considerable margin, as indicated by Figure 3.3.
- In Calgary, a city of similar size and demographics as Edmonton, over 950 000 000L is processed on a daily basis. [1] Since Edmonton likely consumes a similar, if not greater, amount of water and is based around a river, it is important to consider the environment when deciding the dosage. The 1.5mg/L dosage removes the most pollutants from the effluent and therefore would be best suited to the needs of the city.

[1] Services, W. (2015, January 16). Water treatment online tour. Retrieved August 01, 2017

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