Ammonia and Phosphate in Algonquin Park

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This paper describes the ammonia and phosphate concentrations in the water systems of Algonquin Park by outlining the main associations, and irregularities in the data collected from Algonquin's diverse waters throughout the last two decades. The results of this paper support correlations between ammonia and phosphate gradually increasing and decreasing, respectively, as well as the associations that are a product of human activity within Algonquin Park. Through analyzing unique patterns within the ammonia and phosphate concentrations, the effects of an external event such as the algal bloom in 2018 were recorded to have drastically increased ammonia and phosphate concentrations.

I. Introduction

For 20 years, an annual expedition to Algonquin Park (each expedition is marked as AP, followed by the expedition number) has been lead to gather environmental data and statistics assessing the health of the park and the organisms that inhabit it. Data on the levels of ammonia and phosphate present within water locations throughout the park have been recorded to better understand associations between ammonia and phosphate, and other correlations between ammonia, phosphate and other data in the park.

II. Observations

To understand general trends in the ammonia and phosphate concentrations collected throughout the expedition, the mean concentrations for each expedition are displayed in **Figures 1 and 2**.

The mean ammonia concentrations have a mean of 1.766 ppm and an SD (standard deviation) of 0.50 ppm. The mean phosphate concentrations has a mean of 2.451 ppm, an SD of 0.77 ppm, and has one outlier at 0.63 ppm, recorded during AP15.

To study the potential effects of human activity, six sample stations were chosen and divided into two groups depending on their relative distance from Highway 60 - the location in Algonquin Park with the highest concentration of human activity. Group 1 consisted of 3 sample stations that are over 2 kilometers away from the highway, while Group 2 consisted of 3 sample stations that are less than 2 kilometers away from the highway. The sample stations in Group 1 were at Coon Lake, Madawaska River, and Smoke

Lake, which are 3.77 km, 9.39 km, and 2.20 km away from the highway, respectively. The sample stations in Group 2 were at Starling Lake, Pog Lake, and Costello Lake, which are 1.41 km, 0.475 km, 0.391 km away from the highway, respectively. To understand general trends within the sample stations far from the highway, the mean ammonia and phosphate concentrations for each sample station per year are described in Figures 3 - 6. The ammonia concentrations for Group 1 have a mean of 1.51 ppm and an SD of 0.59, while ammonia concentrations for Group 2 have a greater mean of 1.68 ppm and greater spread, with an SD of 0.91 ppm. The phosphate concentrations for Group 1 have a mean of 2.52 ppm and an SD of 1.97 ppm, while the phosphate concentrations for Group 2 have a greater mean of 3.02 ppm, and greater spread, with an SD of 2.18 ppm. The ammonia concentrations of Coon Lake, Madawaska River, and Smoke Lake in Group 1, have a mean of 1.13 ppm, 2.03 ppm, and 1.65 ppm and an SD of 0.76 ppm, 1.07 ppm, and 1.14 ppm, respectively. The phosphate concentrations of Coon Lake, Madawaska River, and Smoke Lake in Group 1, have a mean of 2.78 ppm, 2.29 ppm, and 2.54 ppm and an SD of 3.12 ppm, 2.27 ppm, and 2.85 ppm, respectively. The ammonia concentrations of Starling Lake, Pog Lake, and Costello Lake in Group 2, have a mean of 1.41 ppm, 1.79 ppm, and 1.77 ppm and an SD of 1.35 ppm, 0.89 ppm, and 1.48 ppm, respectively.The phosphate concentrations of Starling Lake, Pog Lake, and Costello Lake in Group 2, have a mean of 2.46 ppm, 2.77 ppm, and 3.90 ppm and an SD of 2.02 ppm, 3.11 ppm, and 3.48 ppm, respectively.

To study the potential effects that locations may have on the ammonia and phosphate concentrations, 4 different sample stations were chosen among the sample stations in the 4 cardinal directions. These four sample stations were at Polly Lake, Little McCauley Lake, South Madawaska River and Little Hardy Lake, represented a cardinal direction. The mean of the ammonia concentrations is 1.48 ppm, 1.48 ppm, 2.01 ppm, and 2.10 ppm with SD of 1.27 ppm, 1.82 ppm, 1.07 ppm, and 1.35 ppm respectively. The mean of the phosphate concentrations is 3.97 ppm, 2.42 ppm, 2.15 ppm, and 0.89 ppm, with SD of 3.28 ppm, 2.67 ppm, 2.27 ppm, and 0.51 ppm, respectively.

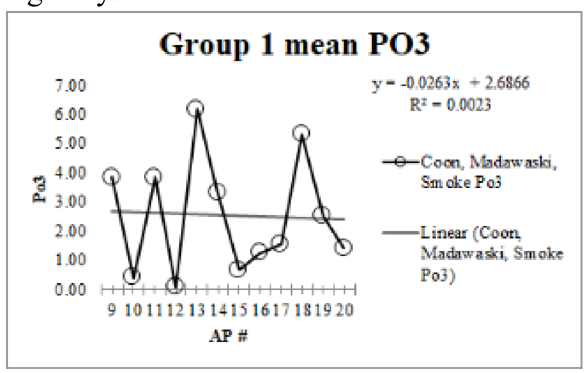
III. Analysis

As shown in Figure 1, there was a very weak positive correlation between ammonia concentrations and time, as the regression line had a very low coefficient of correlation,r=0.06, and predicted that the mean ammonia concentration will rise by 9.51*10-3ppm on average per year. Moreover, the coefficient of determination, r2= 0.4%, showed that only a marginal 0.4% of the variation in the mean ammonia concentrations could be explained by the variation in the regression line. The low coefficient of determination was primarily due to the dramatic decrease and subsequent increase from AP 14 to AP 16 and then AP 16 and 18, which suggested that external factors outside of the natural nitrogen cycles in Algonquin Park affected the ammonia concentrations in the park.

As shown in Figure 2, there was a very weak positive correlation between the mean phosphate concentrations per year, as it had a very low coefficient of correlation,r=0.05. The regression line predicted that, for every year in the future, the mean phosphate concentration will increase by 9.78*10-3ppm on average. Moreover, the coefficient of determination, r2=0.2%, showed that only a marginal 0.2% of the variation in the mean phosphate concentrations can be accounted for by the variation in the regression line. Since the regression line is vulnerable to be affected by outliers, a model that better fits the data can be made if the mean phosphate concentration collected during AP 15 is not considered. As expected, not considering AP 15 increases the coefficient of determination marginally to r2=1.1%, an increase of 0.7% for the original coefficient of determination. The model now predicts that, on average, the mean phosphate concentration across the park will increase by 0.0174 ppm.

Figure 3 depicts the mean ammonia concentrations of the sample stations chosen that were more than 2 km away from the highway. As shown in Figure 3, there is a moderate positive association between time and mean ammonia concentration, as shown by the coefficient of correlation,r=0.44, and the coefficient of determination,r2=19%, shows that 19% of the variation in the mean ammonia concentrations of Group 1 can be explained by the variation in the regression line. Moreover, the regression line predicts that the mean ammonia concentration will increase by an average of 0.09 ppm per year. As shown in Figure 5, there is a moderate positive association between AP year and the mean ammonia concentration, given by the coefficient of correlation,r=0.24, as well as the coefficient of determination,r2=5.9%, which explains that 5.9% of the variation in the mean ammonia concentrations can be accounted for by the variation in the regression line. Moreover, the regression line predicts that the mean ammonia concentration will increase, on average, by 0.07 ppm per year. Comparing the two Groups will yield further analysis into the possible correlation between human activity and ammonia concentrations. Group 2 has a greater mean ammonia concentration than Group 1, with 1.68 ppm and1.51 ppm respectively, suggesting that a lower distance from human activity is associated with higher ammonia concentrations and a greater distance from human activity is associated with lower ammonia concentrations. Moreover, the rate at which the ammonia concentration is predicted to grow is higher in Group 1 than in Group 2, with 0.09 ppm in Group 1, and only 0.07 ppm in Group 2, suggesting that a greater distance from human activity is associated with a higher rate of mean ammonia concentration increases. The strength of the correlation, given by the coefficients of correlation and determination also support the association between a greater distance from human activity and a higher rate of mean ammonia concentration increases.

Figure 4 depicts the mean phosphate concentrations of the sample stations chosen that are more than 2 km away from the highway.



As shown in Figure 4, there was a slight negative association between the AP year and mean phosphate concentration, as shown by the coefficient of correlation,r=-0.04, and the coefficient of determination,r2=0.2%, shows that a marginal 0.2% of the variation in the mean phosphate concentrations of Group 1 can be explained by the variation in the regression line. Moreover, the regression line predicts that the mean phosphate concentration will decrease by an average of 0.03 ppm per year. Figure 6 depicts the mean phosphate concentrations of the chosen sample stations that were less than 2 kilometers away from highway 60. As shown in Figure 6, there is a slight negative association between AP year and the mean phosphate concentration, given by the coefficient of correlation,r=-0.06, as well as the coefficient of determination,r2=0.4%, which explains that a marginal 0.4% of the variation in the mean phosphate concentrations can be accounted for by the variation in the regression line. Moreover, the regression line predicts that each subsequent year, the mean phosphate concentration will decrease, on average, by 0.04 ppm. Group 2 had a greater mean phosphate concentration than Group 1, Group 2 had a mean phosphate concentration of 3.02 ppm while Group 1 had a mean ammonia concentration of 2.52 ppm, suggesting that a lower distance from human activity is associated with higher phosphate concentrations and a greater distance from human activity is associated with lower phosphate concentrations. Moreover, the rate at which the phosphate concentration is predicted to decrease is higher in Group 2 than in Group 1, as it was predicted that mean phosphate concentration would increase, each year, by 0.04 ppm in Group 2, but by only 0.03 ppm in Group 1, suggesting that a lower distance from human activity is associated with a higher rate of mean phosphate concentration decreases. The strength of the correlation, given by the coefficients of correlation and determination also supported the association between a lower distance from human activity and a higher rate of mean phosphate concentration decreases.

IV. Discussion

From observing the mean of phosphate and ammonia levels from AP10 to AP20, it is evident that there is an abundant amount of algae (Kreamer, n.d.) within the bodies of water that are contained in Algonquin Park. The high levels of algae are correlated to the level of nutrients and oxygen received by the various aquatic organisms. Due to this major depletion in the amount of dissolved oxygen in the water, the habitability for aquatic wildlife has decreased as dissolved oxygen levels rise by over 0.55 ppm. General yearly levels of phosphate have increased incrementally from around 1 ppm to 3 ppm. Levels that rise above 0.1 ppm indicate the existence of organic pollutants. From these levels, it can be inferred that there is extreme algae growth in Algonquin Park.

There are multiple factors contributing to the results of phosphate and ammonia levels in Algonquin Park. Human interference, nutrient and bacterial pollution are all major variables. Consumer byproducts such as soap residue, grey water and septic tank runoff contribute to increased growth of algae and biomass (Euler et al, 2009). Nutrient and bacteria pollutants are generally caused by runoff and the decomposition and waste products of dead animals, which will accumulate over the years. High dissolved oxygen levels are essential for the livelihood of the Lake Trout, Brook Trout and Lake Whitefish, which are at the top of the fish food web in Algonquin Park (Euler et al, 2009). This is a great threat as these fish, in particular, are thermally sensitive, restricting the area that is habitable. Nutrient pollution is produced from the presence of excessive algae and eutrophication. As the algae die off, organisms that decompose the algae consume the oxygen in the water and lead to a low-oxygen environment causing hypoxia. Anoxic hypolimnia, phenomena caused by reduced levels of dissolved oxygen in low lit areas by the decomposition of the algae, is when sediments from the lower layer of water release additional phosphorus and nitrogen, further increasing the oxygen deficiency (Euler et al, 2009). Algae blooms disrupt normal ecosystem operations and functions, causing severe problems and creating uninhabitable environment. The algae may use up all of the available oxygen in the water, leaving none for other aquatic organisms that require oxygen to survive. Other than killing marine life, algae blooms will also block sunlight from reaching photosynthesizing aquatic plants below the water surface, and some algae even produce toxins that are harmful to primary or secondary consumers. This will result in a disruption in the functions of the interdependent food webs within the aquatic ecosystem (Oram, B. n.d.).

An excess in ammonia levels also affect aquatic animals. Although ammonia is a necessary nutrient for aquatic life, an overabundance may accumulate in the organism and cause alteration in metabolism or an increase in body pH. Although different species of fish can take in different amounts, overexposure may be extremely harmful (Ammonia in Water, n.d.). At ammonia levels higher than 0.1ppm, even short exposure can lead to skin, eye, and gill damage. This fish may also experience a deterioration in hatching success, and a decrease in their rate of growth. A decline in the fish population will severely impact the food web. Trout especially are the most sensitive to the change of ammonia concentration which is a major problem as trout are, as previously stated, at the top of the fish food web in Algonquin (Oram, B., n.d.). The presence of ammonia in the water at high enough levels also make it difficult for organisms to effectively excrete the toxicant, creating in toxic buildup in tissues and blood, potentially resulting in death (Ammonia Life Criteria, n.d.). As a result, both the health of the fish species and the population of general aquatic wildlife in Algonquin Park may start to deteriorate as the years go by (Oram, B., n.d.).

The data gathered from AP8 to AP20 has shown significant issues with the ecosystems in Algonquin Park due to the high levels of phosphate and ammonia. There is excessive eutrophication and major oxygen depletion. The biomass has hit a critical level and the damage done by phosphate and ammonia have deemed the water bodies throughout Algonquin nearly uninhabitable by a majority of the species that were once native in Algonquin Park.

V. Conclusions

Since AP9, the ammonia and phosphate levels have been fluctuating drastically, but have been continuously increasing. Further study within each group lead to observation about the lack of specificity of the correlation between ammonia and phosphate concentrations and the distance of a sample station from concentrated human activity. If trends persist, both the wildlife in aquatic ecosystems as well as the water quality will continue to deteriorate quickly. These issues are primarily caused by human interference and natural pollutants, as indicated by the patterns in the results of data. Low water quality has also proven to cause rapid algae growth, as algae blooms have been prevalent in the water. This has had a detrimental impact on multiple trophic levels in the various aquatic ecosystems present at Algonquin Park. This year, both ammonia and phosphate levels decreased significantly from previous years, meaning that it is possible for thermal and oxygen sensitive organisms to reappear in the ecosystem and restore the vast amount of biodiversity that was once plentiful in Algonquin Park.

V. Sources

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