AMMONIA AND PHOSPHATE IN ALGONQUIN PARK

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(Received 31 May 2019)

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 concentrations of ammonia and phosphate present within water locations throughout the park were used to better understand associations between their concentrations and other factors 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 **Figure 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 sample stations are chosen among the sample stations in the 4 cardinal directions. These four sample stations, at Polly Lake, Little McCauley Lake, South Madawaska River and Little Hardy Lake, representing North, West, South, East, respectively. The mean of ammonia, respectively, is 1.48, 1.48, 2.01, and 2.10, and the SD is 1.27, 1.82, 1.07, 1.35. The mean phosphate, respectively, is 3.97, 2.42, 2.15, and 0.89. The SD for phosphate, is 3.28, 2.67, 2.27, and 0.51.

III. Analysis

As shown in **Figure 1**, there was a very weak positive correlation between ammonia concentrations and the expedition year, as the regression line had a very low coefficient of correlation, $r = 0.06$, and predicted that the mean ammonia concentration will rise by $9.51 * 10^{-3}$ppm on average per year. Moreover, the coefficient of determination, $r^2 = 0.4\%$, 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. Although the linear model does not describe the mean ammonia concentrations very well, analyzing the residual plot, shows no discernible pattern and the data points are relatively spread out from the regression line, suggesting that the linear model is sufficient to describe this data. 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 $9.78 * 10^{-3}$ppm on average. Moreover, the coefficient of determination, $r^2 = 0.2\%$, 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. Although the linear model did not describe the mean ammonia concentrations very well, analyzing the residual plot, shows no discernible pattern and the data points are relatively spread out from the regression line, suggesting that the linear model is sufficient to describe this data. Since the regression line was suspected of being 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 $r^2 = 1.1\%$, 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.

Splitting the 6 chosen sample stations into two groups based on their relative distance from the highway revealed key insight into the possible correlations concentrated human activity may have with ammonia and phosphate concentrations.

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 the AP year and mean ammonia concentration, as shown by the coefficient of correlation,$r = 0.44$, and the coefficient of determination,$r^2 = 19\%$,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. Figure 5 depicts the mean ammonia concentrations of the chosen sample stations that are less than 2 kilometers away from highway 60. 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, $r^2 = 5.9\%$, 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 each subsequent year, the mean ammonia concentration for Group 2 will increase, on average, by 0.07 ppm. 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, Group 2 has a mean ammonia concentration of 1.68 ppm while Group 1 has a mean ammonia concentration of 1.51 ppm, 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, as it was predicted that each new year would increase the mean ammonia concentration by 0.09 ppm in Group 1, but by 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, $r^2 = 0.2\%$, 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, $r^2 = 0.4\%$, 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 for Group 2 will decrease, on average, by 0.04 ppm. Comparing the two Groups will yield further analysis into the possible correlation between human activity and phosphate concentrations. Group 2 had a greater mean phosphate concentration than Group 1, Group 2 has a mean phosphate concentration of 3.02 ppm while Group 1 has 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 each new year would increase the mean phosphate concentration 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, which are correlated to the level of nutrients and oxygen received by 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. Annual 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 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 Salvelinus Namaycush (Lake trout), Salvelinus Fontinalis (Brook trout) and Coregonus Clupeaformis (Lake Whitefish), which are at the top of the fish food chain 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 producing additional algae and 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 the ammonia molecule 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. Specifically, the gill filaments become clumped together and swollen, restricting the rate of respiration in fish. This is called hyperplasia, which is an enlargement of tissue as the reproduction rate of cells quickens (Oram, B. n.d.). This fish may also experience a deterioration in hatching success, a decrease in their rate of growth and 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 chain in Algonquin (Oram, B., n.d.). With a decline in the population of trout, a rise in the population of zooplankton is inevitable. The abundance of zooplankton, which are a primary source of nutrition for planktivorous fish in Algonquin Park such as the Lake Trout and Brook Trout, have been shown to be a clear indicator of water quality and amount of water pollutants. 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 uninhabitable by a majority of the species that used to be native with Algonquin Park.

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 collected close to the highway compared to the data that has been collected further away from said highway. Low water quality has also proven to be cause rapid algae growth, as multiple 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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Topics:

- Intro
- Observations
- Analysis
- Discussion
- Sources

Requirements:

- Introduce experiment as if investigators
- Observations and implications of observations
- Techniques used, estimation of measurement precision
- Address errors (calibration, etc.)
- 6pg limit
- Times font
- Title is 20pt, small caps
- Names are 12pt small caps
- Credentials of each person
- Citations according to APA - labeled SOURCES, over cite
- 9pt italic sources in alphabetical by surname
- 3rd person past tense
- Only 5 -6 sections

Stuff for Discussion:

Data on the ammonia and phosphate levels at water locations was collected through
Data would be collected by . Data has been collected yearly at over 70 sample stations since AP 8 in 2007. With ammonia and phosphate levels as crucial parts obtained from experimental observations at various bodies of water at each separate sample station. The ammonia levels collected throughout the years have indicated how polluted or clean the water is, with 1ppm indicating clean water, and 30 ppm indicating polluted water. Nitrate levels of above 3ppm are indicative of fertilizer and septic waste pollution running off the land and into aquatic habitats. As for phosphate, high phosphate levels are correlated with large volumes or sewage or animal wastes entering the body of water

Archive:

BACKGROUND

Background: Ammonia

Ammonia (NH_3) is a chemical compound composed of nitrogen and hydrogen. It is one of the most widely. It is one of the most important sources of nitrogen in the biosphere. Nitrogen is imperative in the making of DNA and proteins in living organisms. Although the atmosphere is made up of roughly 78% nitrogen, this nitrogen is useless to many of the organisms since it's most commonly found as NO_3^- or NH_3. When found as ammonia, decomposers, such as mushrooms or fungi, are able to convert the NH_3 to ammonium (NH_4^+) via a process known as ammonification.

Background: Phosphate

Phosphate (PO_4) is naturally found everywhere and it is an essential part in aquatic habitats. It plays a major role in stabilizing nutrient levels and preventing eutrophication. Although most of the phosphorus exposed to environments originate from the environment itself, consumer products make up a third of the phosphorus that is present. The molecular structure and pH of the phosphate ultimately determine its uses whether it be buffering strength, dispersion and absorptive capabilities, sequestering or chelating power and solubility.

II.III Relationship Between Ammonia and Phosphate

Are they independent?

I. Methods

Ammonia and phosphate level testing is included in the Photo Comparison Experiments (PCE). Ammonia is tested for by taking 5mL of water from a given sample station in a singular test tube. First, 8 drops of Ammonia 1 are dropped into the test tube and shaken for 5 seconds. 8 drops of Ammonia 2 are then dropped into the test tube and shaken for another 5 seconds. Results are received after 5 minutes.

For phosphate, 5 mL of water is taken from a given sample station and 6 drops of Phosphate 1 are added and shaken into the test tube for 5 seconds. After, drop 6 drops of Phosphate 2 into the test tube and shake for another 5 seconds. This solution is set aside for 3 minutes to achieve the desired results.

Procedure

Data was collected using water samples from various bodies of water in Algonquin Park. At each location where data was collected (referred to as sample stations), 2 test tubes each filled with 5mL of sample water were taken from the given body of water. 6 drops of ammonia 1 and 8 drops of phosphate 1 were dripped into their respective water samples, then the process was repeated with ammonia 2 and phosphate 2. After allowing the ammonia 1 and 2, and phosphate 1 and 2 to mix with the water sample for 5 and 3 minutes respectively, the colour of the water samples would be compared to a colour scale that would determine the ammonia and phosphate levels of each solution. The comparison of colour between the solutions and the colour scales would represent the parts per million for each water sample. The correlations between ammonia and phosphate has the ability to reveal potential causes for plant growth and changes in Algonquin Park and the surrounding area's water systems. It is imperative to note that conclusions about causality between ammonia and phosphate concentrations and other variables such as the distance from human activity cannot be made because of the observational study nature of this expedition. As such, only conclusions about associations are reached in this paper.

II. Analysis

III. Conclusions

IV. Sources

- NH levels show that algonquin's water is relatively clean as it's under 10 ppm

- Excessive algae levels in algonquin park looking at the PO levels

        - Scale of (0.1 to 2) - 0.1 clean water, >2 very polluted water
        - Gradually incremented from AP 9-20 from ~1 to ~3
- PO levels have risen in recent years indicating the presence of meaning the water has become more polluted
    - Levels above 0.1 - generally caused by human related pollution sources
    - Toxic, nutrient and bacterial pollution?
        - Runoff into waterways
        - Decomposition and waste products of dead animals
    - Depletes oxygen levels (can maybe relate to DO)
- Data before around AP 16 seems like PO and NH levels generally stayed below 1 but now it's generally between 1-10 indicating an increase in pollutants and hazardous environments for aquatic animals
- General steadiness from

- Data before around AP 16 seems like PO and NH levels generally stayed below 1 but now it's generally between 1-10 indicating an increase in pollutants and hazardous environments for aquatic animals

Ammonia
- No trends

Phosphate
- Greatly fluctuates

- Mostly caused by humans - human interference with aquatic ecosystems is not regular
- Weak positive association
    - Gradually incementing