St. Olaf College

Local Ecology Research Papers

Comparing the Composition of Four St. Olaf Natural Land Ponds

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Abstract:

The St. Olaf Natural Lands contain 15 restored wetlands. The majority of them are surrounded by other natural areas such as prairies or forests to buffer them from agriculture and developmental runoff. The purpose of this study was to compare the composition of four ponds and how they differ from one another in respect to their location. Two of the four ponds, Big and Regents are susceptible to higher levels of developmental runoff due to their close proximity to parking lots and academic buildings, whereas East Coyote and Baseball are surrounded by either prairie or forest. Data collection commenced mid October and ended late November with a series of measurements taken *in-situ.* Water samples extracted were taken to the lab for further analysis to determine NO_3- and NH_3 levels. It was hypothesized that ponds with greater buffers such as East Coyote, would have better water quality and composition than those who didn't such as Regents. The data collected supported this hypothesis revealing that Regents pond had the lowest averages for pH and dissolved oxygen, and highest averages for conductivity and nitrates. This proves how exposure to drainage from academic buildings and a lack of natural surroundings ultimately results in poorer water quality.

Introduction:

There are many types of wetlands in Minnesota, each with widely varying characteristics because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance (EPA 2018). Some wetlands are dry for much of the year; others are almost always covered by several feet of water. Some wetlands have grasses and sedges, shrubs, or trees. They may be small confined basins or extend for hundreds of miles (Minnesota DNR 2018). Wetlands are important to ecosystems because they support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils (EPA 2018). Their vegetation helps with erosion control by reducing the wave damage along lakes and stream banks. They help with flood control by decreasing and retaining runoff water, as well as reducing the frequency of flooding along streams and rivers. Wetlands recharge groundwater by holding surface water, allowing it to slowly filter into the groundwater reserves. Some wetlands are discharge areas meaning they receive groundwater even during dry periods and help maintain flows in nearby rivers and streams. They also improve water quality by removing pollutants from downstream lakes, streams and rivers. On top of that they provide rare species habitat; 43 percent of threatened or endangered species in the U.S. live in or depend on wetlands. They also have recreational and economic value since they are great places to canoe, hunt, fish or watch wildlife, as well as provide commodities such as wild rice and bait fish (Minnesota DNR 2018).

It is estimated that Minnesota has lost about 50 percent of its original wetland acreage which becomes problematic when considering the benefits wetlands provide for the environment. It's important to maintain the overall quality of these areas and keep them healthy, not only for our own benefit but for the various organisms that rely on their existence. The St. Olaf Natural Lands have 15 wetlands, and in this study four were chosen because of their location to buffers, and their levels of human interaction and disturbance. It was hypothesized that ponds with greater buffers such as East Coyote, would have better water quality and composition than those who didn't such as Regents. The purpose of this study was to see how these factors influence the overall water quality of the ponds.

The specific objectives of this study were to:

1. Compare the water quality of two ponds surrounded by natural buffers to two ponds that experience point-source pollution.
2. Determine if location of ponds and presence of natural buffers influence water quality.

Methods:

This study consisted of three trips spaced two weeks apart out to the St. Olaf Natural Lands located in Northfield, MN. Big pond and East coyote are located on the eastern part of campus, whereas Baseball is located on the northern side and Regents is located on the southernmost tip of campus. When visiting Big, Baseball, Regents and East Coyote pond I tested levels of: conductivity, pH (converted into H+ ions before finding average), dissolved oxygen, percent dissolved oxygen, and temperature. I also measured turbidity of the water using a secchi tube which was 60cm deep. All measurements were taken *in-situ* and one meter from the edge of the pond. When collecting ammonia (NH_3) and nitrate (NO_3-) data, 25 ml of water from each pond was filtered and transferred into another vial, which was then stored in the laboratory freezer for two weeks until it was ready for analysis.

Once all the data were compiled, I created a table in excel comparing the composition of the four ponds from all three visits. This data was then exported it into R-Commander (version 2.3) to create an ANOVA table that would give me the standard deviation, mean and p-values for each characteristic (Table 1). The p-values displayed in the table helped me determine the significance of my results and whether or not I should accept or reject my hypothesis.

Results:

The averages for conductivity were highest in both ponds that experienced point-source pollution and the most surface runoff from a lack of natural buffers. Regents had an average of 436.8µS/cm and Big pond had an average of 299.6µS/cm (Table 1). Whereas East Coyote had an average of 89.73µS/cm and Baseball's average was 185.2µS/cm (Table 1). The location of these two ponds in relation to campus buildings put them at an advantage since they weren't exposed to any unnatural runoff that contained chemicals or inorganic materials such as alkalis, chlorides and sulfides. Conductivity had a significant p-value of 0.000000402 (Table 1) which explains how greatly each ponds average differed from one another (Figure 1).

Regents also had the highest average for nitrates (0.115mg/L) and water clarity which was 23.0cm (Table 1). Aside from having some of the highest averages in these three categories they had the lowest for dissolved oxygen (D.O) which was 4.66mg/L (Table 1). Baseball inversely had the lowest average for nitrates (0.024mg/L), and East Coyote had the highest averages for D.O (8.22mg/L) and %D.O which was 70.3% (Table 1). Although East coyote had the highest averages for dissolved oxygen, they had the lowest average for water clarity which was 5.3cm (Table 1) because the turbidity of the water was so high. Big pond had the highest average for ammonia, (0.310ppm) which is pH dependent therefore supports why it also had the highest average pH which was 7.31 (Table 1).

Discussion:

Conductivity

Out of all four ponds Regents had the highest levels for conductivity with an average of 436.8µS/cm (Table 1). Ponds with high levels of conductivity may indicate that a discharge or some other source of disturbance has decreased the relative condition or health of the water body and its associated biota. Generally, human disturbances tend to increase the amount of dissolved solids entering waters which result in increased conductivity (EPA 2018). Big Pond which had the second largest average for conductivity, 299.6µS/cm (Table 1), experiences the same level of human disturbances as Regents, which supports why both had the highest averages of all four ponds (Figure 1). There are drain pipes at both locations that deposit liquids directly from campus buildings into these bodies of water, which result in the increase of dissolved ions and discharge. East Coyote in turn had the lowest average for conductivity (89.73µS/cm) and this further shows how a ponds location and exposure to natural buffers help reduce the impact of developmental runoff.

Nitrates (NO_3^-), Turbidity, Dissolved oxygen and % Dissolved Oxygen

Regents also had the highest average for NO_3^- (0.115mg/L) and the lowest average for dissolved oxygen which was 4.66mg/L (Table 1), This data made sense considering increased water nutrient levels cause decreased aquatic oxygen levels, less biodiversity, and fish kills (Carpenter 1998). Nitrates are an essential source of nitrogen for plants which would also explain why this pond had such a dense layer of duckweed on the surface. Though this didn't seem to affect the clarity of the water since Regents had the best average water clarity (23.0cm) of all four ponds (Table 1). The purpose of using the secchi tube was to test turbidity which is an optical characteristic of water. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid include clay, silt, finely divided inorganic and organic matter, algae, soluble colored organic compounds, and plankton and other microscopic organisms (USGS 2018).

High levels of organic matter and silt were found in East coyote pond which is why it had the poorest water clarity which was 5.3cm (Table 1). Though this doesn't reflect on the overall quality of the pond since East Coyote had the highest averages for D.O (8.22 mg/L) and %D.O (70.3%) which puts it in good standing. If D.O levels were to drop below 5.0 mg/L, then aquatic life is put under stress (USGS 2016). The lower the concentration, the greater the stress. This information is useful when analyzing Regents water quality since its average D.O level was 4.66 mg/L (Table 1) which means its aquatic life, if existent, is considered a "stressed" environment. It's also important to note that oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. As for total dissolved gas concentrations in water, it should not exceed 110% because concentrations above this level can be harmful to aquatic life (USGS 2016).

Ammonia (NH_3) and pH

Ammonia is one of several forms of nitrogen that exist in aquatic environments. Unlike other forms of nitrogen, which can cause nutrient over-enrichment of a water body at elevated concentrations and indirect effects on aquatic life, ammonia causes direct toxic effects (EPA, 2018). Big pond had the highest NH_3 average (0.310ppm) and pH (7.31) which comes to no surprise since the two are dependent of one another. The higher the pH, the more NH_3 present. NH_3 safe levels are known to fluctuate anywhere between <0.5ppm to >2.0ppm depending on the season (Hargreaves 2004). It's hard to measure ammonia toxicity in freshwater ponds since toxicity tests are typically conducted in systems maintaining a constant ammonia concentration. Therefore, these conditions can not reflect the fluctuating concentrations of NH_3 in ponds. Some fish and various invertebrate species have the ability to acclimate to repeated exposure of high concentrations of ammonia, which also complicates the toxicity spectrum.

Ammonia can enter the aquatic environment via direct means such as municipal effluent discharges and the excretion of nitrogenous wastes from animals, and indirect means such as nitrogen fixation, air deposition, and runoff from agricultural lands (EPA 2018). In this case NH_3 leaching into Big pond is likely due to the drain pipe that leaches these chemicals into the water. This leads me to question if the natural buffers surrounding Big pond will be able to keep NH_3 levels within "safe" parameters for the many years to come.

Conclusion

After reviewing all the data and understanding why certain ponds had increased or decreased levels for whichever characteristic being analyzed, it all made sense in the end. Ponds that experienced point source pollution with little to no buffers (Big and Regents) tended to have increased conductivity, NO_3- and NH_3 levels and low D.O and %D.O levels compared to those that didn't (East Coyote and Baseball). As mentioned earlier some of these characteristics are dependent on one other which is why they increased or decreased together, and in some cases--an increase in one category caused a decrease in the other. Figures 1 and 2 give a visual representation of ponds with similar composition following the same trends in response to either conductivity or %D.O. This study supported my hypothesis and further exemplifies the importance of natural buffers and how they help improve water quality and support aquatic life.

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Table 1: Presents the averages and standard deviations (in parenthesis) of each characteristic tested at all four ponds. Conductivity and % dissolved oxygen had the only two significant p-values.

	Big	East Coyote	Baseball	Regents	p-value	S/NS
Conductivity (µS/cm)	299.6(13.1)	89.73(9.05)	185.2(42.5)	436.8(4.12)	4.02E-07	Significant
D.O (mg/L)	7.57(4.72)	8.22(1.86)	8.16(0.628)	4.66(0.9657)	0.35	ns
NH_3 (ppm)	0.310(NA)	0.150(0.133)	0.015(0.00778)	0.068(0.041)	0.175	ns
NO_3- (mg/L)	0(0.0030)	0.106(0.144)	0.024(0.020)	0.115(0.104)	0.478	ns
pH	7.31(7.95)	7.07(7.18)	7.17(7.01)	6.04(5.85)	0.426	ns
Secchi tube (cm)	18.0(3.6)	5.3(2.5)	16.6(9.0)	23.0(15.5)	0.199	ns

Temperature (°C)	4.86(3.61)	5.93(3.55)	6.93(2.30)	6.66(2.57)	0.843	ns
%D.O	17.7(10.04)	70.3(7.76)	69(2.10)	43.8(11.8)	0.000228	Significant

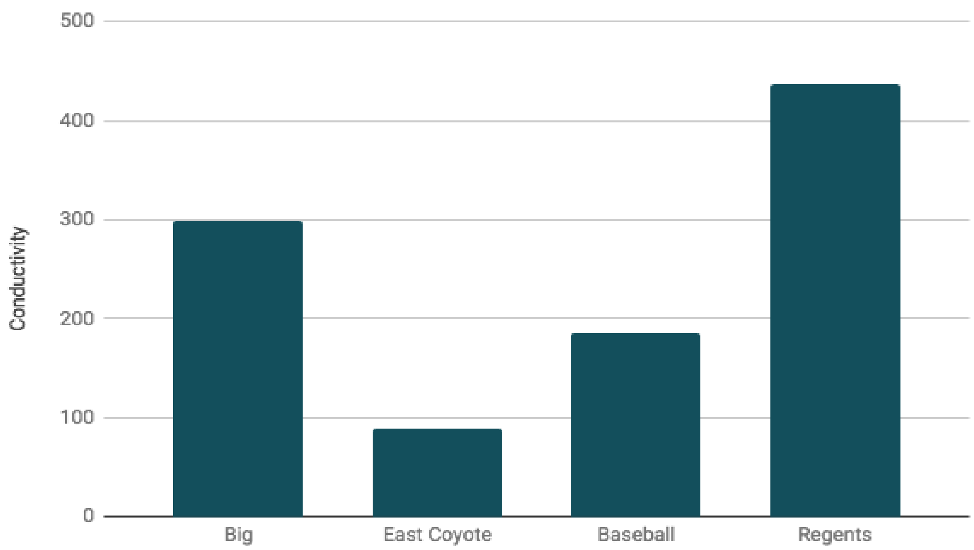

Figure 1: The average conductivity levels of all four ponds. Big pond and Regents having the highest averages of 299.6µS/cm and 436.8µS/cm.

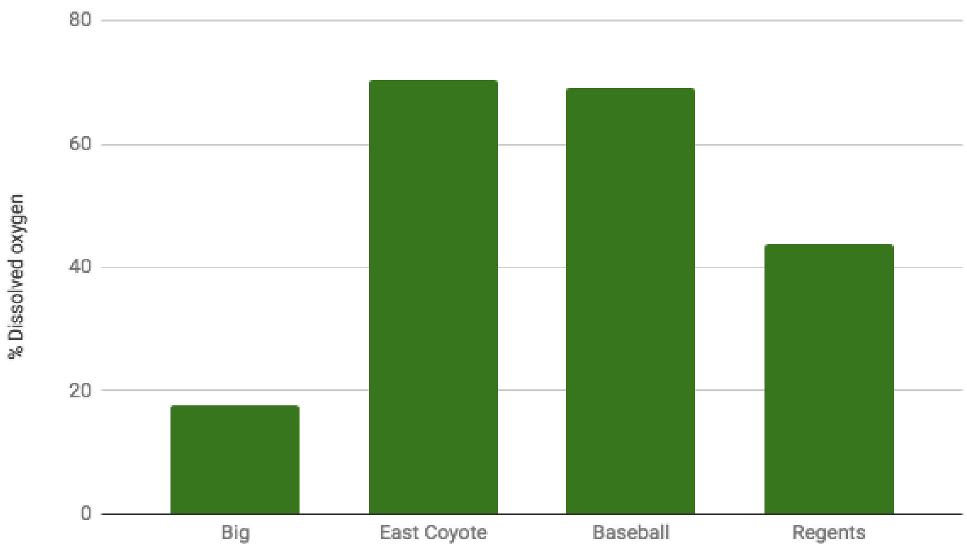

Figure 2: The average levels of percent dissolved oxygen at all four ponds. East Coyote and Baseball having the highest averages of 70.3% and 69%.

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