UNIVERSITY OF WATERLOO
Faculty of Environment

LAKE ASSOCIATIONS WATER QUALITY REPORT: JULY 2014

ERS 341: Conservation and Restoration Practice
Waterloo, Ontario

Prepared by
Elizabeth Stec and Sarah Allemang
2B Environment and Resource Studies
ID 20475599, 20458413
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1.0 Overview

Water quality sampling was completed for the nine lakes outlined in the contract. Communication between lake associations and the field supervisor began May 6th and continued throughout July until all sampling was completed. Previous to sampling, background research was conducted to determine where sampling on each lake was done in the past. Each lake was then sampled twice, in six different locations, between July 1st and July 31st 2014. Water samples were tested for the following parameters; DO, conductivity, pH, NO2, NO3, PO4, TP, and secchi. All samples, where possible were take from bellow the thermocline. An electronic spreadsheet of all lab and field data was created along side this report. This report outlines the methods, data, and analysis used in this study.

2.0 Introduction

The Water Quality Initiative is important for the protection of the Muskoka lakes as it establishes locations where nutrient levels have fluctuated from previous years. The data is used to determine the safety level for recreational use, and preferred levels for aquatic wildlife (Nairn & Aitken, 2013). The goal of the project is to collect data on an annual basis so that the results can be compared and analyzed. Each year a different consultant company is hired by MLA to write the final Water Quality Report.

2.0 Methodology

The contract for this project stated that the following nine lakes were to be sampled twice in July 2014; Mary Lake, Skeleton Lake, Lake Vernon, Fairy Lake, Peninsula Lake, Muldrew Lake, Clear Lake, Fox Lake, and Three Mile Lake. These lakes were determined based on availability of past data, lack of data, or through community request. Some lakes were tested last year, and these coordinates were to be used this year to ensure accuracy and consistency with the data. However, once sampling began on these lakes, it was clear that last years coordinates were incorrect and therefore unusable. Maps were used to estimate as close as possible to the six sampling locations on each lake from last year. New, correct coordinates were taken at these sites, then recorded and revisited on the second sampling day. The lakes new to the program had six sites that were randomly and strategically chosen to best represent the lake. Sample sites were primarily chosen at the community partner's request.

Sampling Schedule:

The original schedule in the methodological protocol that was created before July had field and lab days alternating in order to ensure all samples were tested within 24 hours of being collected. The strategy for water quality testing was to sample two lakes that were relatively close in one day, then for lakes that were further away to be sampled in one day. There were many adjustments and changes made to the original field and lab schedule throughout July. Changes were made to accommodate the needs of the community partners and to work around the other water quality groups, to ensure there were no conflicts. The schedule found in Appendix A outlines all field and lab testing done in July 2014.

Field Sampling Procedure:

All water quality sampling was completed in the month of July. In July, thermal stratification occurs and warm water, which is less dense then cold water, rises to the surface (Jones, Clark, Bond, & Powers, 2012). Warmer water has a higher productivity than colder water; therefore a greater amount of nutrients will be available for sampling during thermal stratification. Water bellow the thermocline is stagnant and this water was tested when possible as it gives a more accurate indication of the overall lake health.

A GPS was used for navigation to the correct sample sites. Once arrived to the appropriate location, the boat was anchored if there were strong waves or a current that would cause the boat to drift. A site description, weather, and lake conditions were recorded at each site. The thermocline reader was then used to locate the thermocline and samples were taken half a meter below that to ensure stagnant water was being tested. Shallower sites often did not have a thermocline and in this case, samples collected were taken one meter above the bottom. The horizontal vandoran was used to collect the water sample and water was poured slowly to fill a sample bottle, which was then directly placed into the cooler. Sample bottles and lids were rinsed three times with lake water before filling, and gloves were worn to prevent any possible contamination of the bottle and sample. Secchi depth was found using a secchi disk and recorded at each site.

The field data template sheet was redone after sampling began and it was clearer to what information needed to be recorded at each site. Appendix B contains the field data template that was used for each lake when sampling. All field procedures to collect water samples followed the protocols set in place by the Canadian Council of Ministers of the Environment, Protocols Manual for Water Quality Sampling in Canada (Canadian Council of Ministers of the Environment, 2011). A list of field equipment used for sampling can be found in Appendix C.

Lab Procedures:

All lab procedures used in the study followed the protocol set in place by the Hach manual (Hach Company, 2014). Nutrient testing was done using the powder pillow reagent method. The following parameters were analyzed using the Hach Spectrophotometer and detailed procedures can be found in Appendix D; Nitrate Cadium Reduction Method LR (0.01 to 0.05mg/L NO3-_N), Phosphorus, Reactive USEP1 PhosVer 3 (Ascorbic Acid) Method 0.02 to 2.50mg/L PO_4^{3-}, Nitrite USEPA[1] Diazotization LR (0.002 to 0.300mg/L NO_2-_N), and Phosphorus Total and Reactive Method 10209 Reactive; Method 10210 Total (TNT 843).

Dissolved oxygen and pH were tested using the Hach multimeter because it is more accurate then using the orion meter. Dissolved Oxygen was the first parameter tested when samples returned to the lab to avoid exposure to oxygen, which may affect the sample readings. All parameter tests were completed within 24 hours of sample collection. The following equipment was used to test for the nine different parameters:

Hach Multimeter:

- Dissolved Oxygen (DO), (mg/L)
- pH

Hach Orion Meter:

- Conductivity (μS/cm)

Hach Spectrophotometer:

- Nitrate (mg/L)
- Nitrite (mg/L)
- Orthophosphates (mg/L)
- Total Phosphate (TP) (μg/L)

Statistical Analysis:
The program "Past" was used for all calculations. A T-test was the only statistical analysis used to compare data from the two sample days. For many lakes this was the first year data had been collected, therefore it is too early to start analyzing trends in the data. Once there are five to ten years of data and the same parameters are tested each year, then greater forms of statistical analysis can be done.

3.1 Project Parameters

Dissolved Oxygen:

Dissolved oxygen (DO) is the amount of oxygen that is carried within an ecosystem (CCME, 1999). The atmosphere and photosynthesis are two major sources that contribute to DO levels (CCME, 1999). Oxygenation also occurs from currents, winds, and inflows (CCME, 1999). DO is essential for aerobic aquatic organisms as they rely on it for respiration and metabolism (CCME, 1999). In shallow water most of the DO is lost due to high concentrations of organic matter and bacterial activity (CCME, 1999). As opposed to deep water where the dissolved oxygen is consumed through species respiration (CCME, 1999). Dissolved DO as deforestation, wastewater deposits, and agriculture (CCME, 1999). Increases in nutrients like Nitrogen and Phosphorus decrease DO levels as well through algae growth, then decomposition (Anderson, Burkholder, & Gilbert, 2002).

A deficiency in DO is more harmful to an ecosystem than an excess of it (CCME, 1999). Species must adjust their energy levels to cope with a low level of DO, creating damaging effects on their long-term survival (CCME, 1999). Fish are the most sensitive species to reduced DO levels causing lethal circumstances in most cases (CCME, 1999). The CCME guideline for the lowest acceptable DO concentrations in the early life stage is 9.5 mg/L, and for the other stages it is 6.5mg/L (CCME, 1999). The MOE states that the early stage of life should have a DO level of 9mg/L while the other stages have a level of 5mg/L (MOE, 1997). The PWQO include an acceptable range for warm water bodies of 4-7mg/L and 5-8mg/L for cold-water bodies (MOE, 1994).

pH:

The acidity or alkalinity of water is determined by the pH value. The pH scale ranges from 0-14, with 7 being neutral. pH values that are lower then 6.5 are considered to be highly acidic, while pH values higher then 9 are highly basic(Credit Valley Conservation, 2014). Health Canada (2012) Guidelines for Canadian Recreational Water Quality state that the pH of water for recreational purposes should be in between the ranges of 5-9. Water that is too acidic or too alkaline may cause swimmers to have skin or eye irritations (Health Canada, 2012). Standards for aquatic life, set in place by CCME (1987) reveal that pH measurements should be between 6.5-9. pH measurements that are higher or lower then this range may be unable to sustain certain plant and aquatic life (Credit Valley Conservation, 2014). Changes in pH in an aquatic ecosystem are often indicators of chemical changes, or availability of nutrients and therefore, pH values should be closely monitored to ensure long-term water quality health (Credit Valley Conservation, 2012).

Conductivity:

Conductivity is the ability of water to pass through an electrical current. Conductivity measures the amount of dissolved substances, however does not indicate what these substances are. Water temperature affects the conductivity of water as warmer water has higher conductivity (Brunskill, Povoledo, & Stainton, 2011). Rain dilutes concentrations of minerals, causing the conductivity of water to decrease (Brunskill et al., 2011). Geology of an area can also cause an area to have naturally higher or lower conductivity (Brunskill et al., 2011). Environment Canada (2011), targets for conductivity in fresh water lakes is under 500 $\mu S\ cm^{-1}$ Conductivity should be monitored to determine the lakes normal ranges, as an increase in conductivity over time could be a sign of discharge or other source of pollution (Brunskill et al., 2011).

Temperature:

Temperatures of each sample were taken directly after they were bottled in this study. Temperatures varied as samples were taken accordingly based on the water depths in each location. The samples taken closer to the surface of the water had the warmest temperatures because of the sunlight penetrating on the surface of the water.
In some shallow locations there was no thermocline, therefore the water sample taken would be warmer then a sample taken from a location with a thermocline. Factors that influence temperatures include different seasons, weather, and time of day samples were taken at. There are no temperature guidelines for lakes, however many aquatic species are sensitive to temperature change. Temperature in a lake ecosystem should not be altered to such a degree where the environment and abundance of aquatic life significantly changes. Temperature changes in a lake ecosystem should be monitored in order to determine the lakes normal temperature range.

Secchi Depth:

A secchi disk is a round, flat disk that was used to measure the clarity and turbidity of water in our study. Turbidity is important as it measures the amount of total suspended solids (TSS) in a body of water. Sources of suspended soils are not limited too, but may include; agriculture, dams and reservoirs, flooding, erosion, and urban development (Kerr, 1995). Some sources of suspended solids occur naturally, while others are intensified by anthropogenic disturbances (Kerr, 1995). Turbid waters have higher levels of TSS and are aesthetically displeasing as they are generally murkier in colour, and may give off an odor (CCME, 2011). It is desirable to have lakes with clear water as sunlight is able to penetrate deeper into the water compared to murky waters, encouraging the photosynthesis of aquatic plants and higher ecosystem productivity (Effler, 1988). Reduced light penetration has indirect and direct affects on aquatic plants, invertebrates, and fish populations (Kerr, 1995). Higher secchi depth readings are desirable because this means the water is clearer, and less turbid.

The upper most surface of the secchi disk is divided into four segments. Two quadrants opposite each other are black, while the other two opposite quadrants are white. Attached to the disk is a rope with measurements marked along it. The rope allows the disk to be lowered into the water and the depth between where the disk is visible, then where it is no longer visible is recorded as the secchi depth. The optimal time for secchi depth readings is in mid-day (Health Canada, 2012). Factors such as the observer, light, and weather conditions will all affect the measurements. Health Canada (2012) suggests that secchi depth should be visible at a minimum of 1.2-meter depth for healthy aquatic life and recreational purposes . In learn to swim areas; the secchi disk should be visible at bottom so swimmers are able estimate water depth, steer clear of any hazards including rocks, and so submerged or distressed swimmers can be easily detected (Health Canada, 2012).

Nitrate and Nitrite:

Nitrogen is a naturally occurring chemical in the environment that can be converted into nitrate and nitrite through oxidation (CCME, 2009). Anthropogenic influences such as fertilizer runoff from farms and residential lawns, waste water systems, industries, and acid rain from pollution add to the increase of nitrogen levels in lakes (CCME, 2009). In small concentrations nitrogen is essential for the growth of aquatic plants (Anderson, et al., 2002). Increased nitrogen levels, coupled with elevated phosphorus levels can accelerate algal and plant growth leading to eutrophication (Anderson, et al., 2002). Resulting in an accumulation of decomposing plant material and species decline (Anderson, et al., 2002). Nitrate is not as toxic as nitrite for aquatic organisms, however it can have lethal impacts on organisms during their first stage of life (Anderson, et al., 2002). An excess of nitrate and nitrite in lakes can be harmful to human health, if ingested it can cause shortness of breath or blueness of the skin (CCME, 2009). There are no set standards for acceptable levels of nitrate and nitrite in lakes, however the MOE has proposed maximum levels (MOE, 2001). For nitrate it is suggested that levels do not exceed 200mg/L for aquatic life, while nitrite has a recommended limit of 0.06mg/L (MOE, 2001).

Total Phosphorus and Orthophosphate:

Phosphorus is an essential nutrient for an aquatic ecosystem as it contributes to the biological metabolism of species (CCME, 2004). However, phosphorus is the most common nutrient to limit the biological productivity of an aquatic ecosystem (Correll, 1998). A low concentration of phosphorus within a water body will contribute to a diverse, abundant, and self-sustaining aquatic life (CCME, 2004). Elevated levels of phosphorus will have a direct inverse affect on the ecosystem and can cause eutrophication within the water body (Correll, 1998). An increased level of phosphorus can be detrimental as it decreases biodiversity, changes the dominant biota, and decreases sensitive species while creating a habitat for tolerant species (CCME, 2004). As phosphorus levels increase so do the biomass, organic matter, and turbidity levels within the water body (CCME, 2004). Elevated phosphorus levels can affect anthropogenic preferences by creating an unsafe environment for human health in places like swimming areas, increasing the cost of treating potable water, and causing the species imported for recreational use to disappear (CCME, 2004).

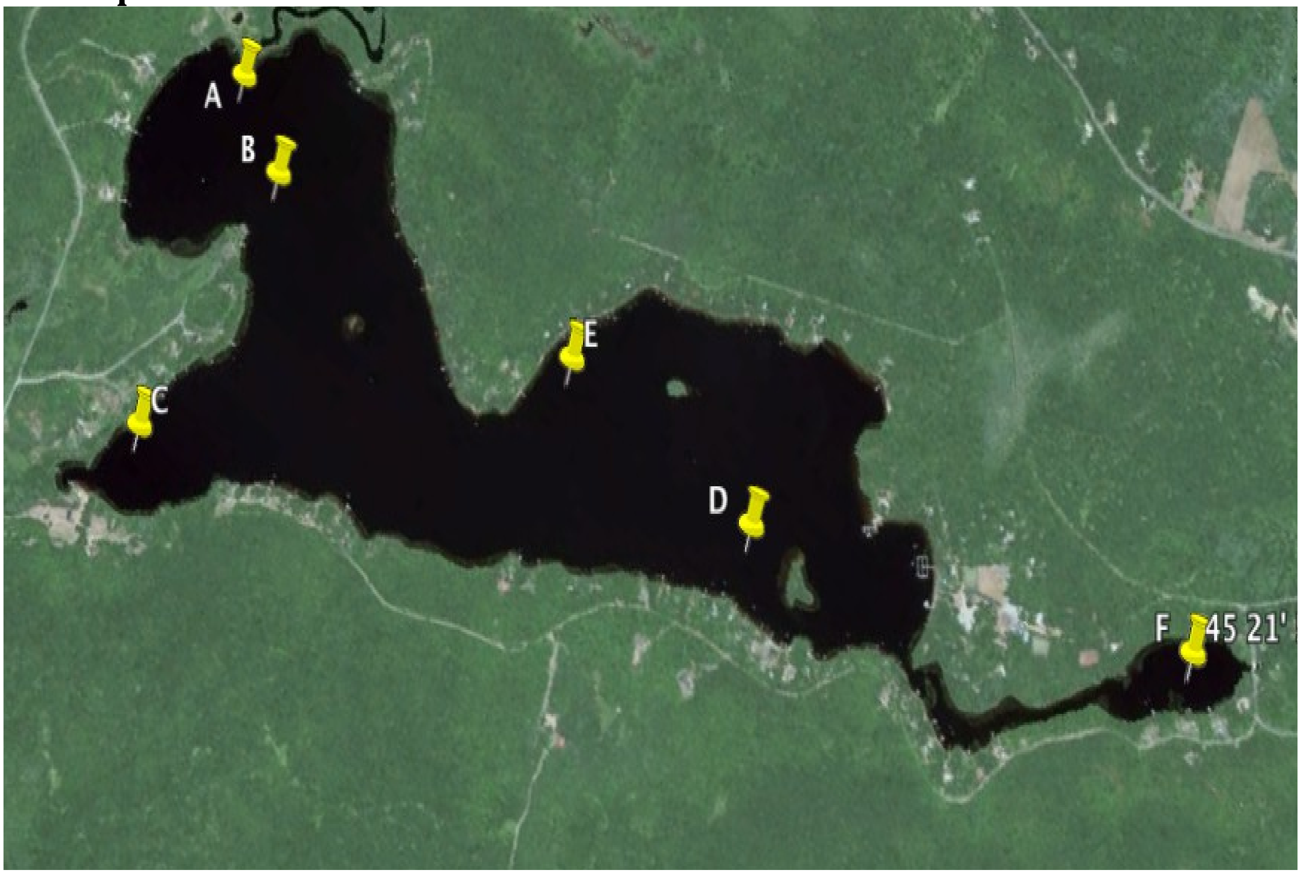
There are many ways in which the excess amounts of phosphorus are being deposited into lakes, through fertilizer runoff, septic systems, residential lawns, and storm water inputs (Litke, 1999). Phosphorus is also a naturally occurring nutrient in the environment and is dependent on the soil and rock influences throughout the surrounding area (Litke, 1999). Total Phosphorus is the measurement of condensed phosphate, orthophosphate, and organic phosphate (Kurtz, et al., 2012). Orthophosphate is the soluble and inorganic form of phosphorus that influential for algae growth (Kurtz, et al., 2012).

There are no National standards for total phosphorus or orthophosphate levels in fresh water lakes (CCME, 2004). However, there is a trigger range that outlines the desired levels of total phosphorus in different trophic lakes (CCME, 2004). The Ministry of Environment has created guidelines for total phosphorus levels. To prevent excess algae growth total phosphorus should not surpass 20ųg/L, and for aesthetic or recreational concerns total phosphorus should not surpass 10ųg/L (MOEE, 1994).

4.0 Fox Lake

Fox Lake is a small and relatively shallow lake located northeast of Huntsville on highway 2. Buck River is the inflow for Fox Lake and is surrounded by a small marshy area, the effluent of the lake flows through a small river and into a dam. Fox Lake has a forested shoreline with some cottages and two camps along the lake. There are two big islands within the lake, they have not been developed and remain natural.

4.1 Map of Fox Lake



4.2 Fox Lake Field Data				
Day 1: July 18, 2014			Day 2: July 28, 2014	
Weather Conditions			Weather Conditions	
Beginning: Wind: 0.5m/s, Humidity: 79.9%, Temperature: 18.4°C, sunny with no clouds			Beginning: Wind: 3.1m/s, Humidity: 87.5%, Temperature: 16.1°C, partially sunny	
End: Wind: 1.5m/s, Humidity: 63.5%, Temperature: 18.5°C, sunny with no clouds			End: Wind: 3.5m/s, Humidity: 67.3%, Temperature: 16.5°C, sunny	
Lake Conditions			Lake Conditions	
The lake was calm, glare made it difficult to see the secchi disk.			The lake was very wavy making it difficult to keep the boat in the correct location.	
Sample Site	**Sample Depth (m)**	**Thermocline (Y/N)**	**Secchi Depth (m)**	**Sample Temp (°C)**
A1	6.5	Y	2	10.9
A2	8	Y	1.75	10.1
B1	7.5	Y	1.75	10.7

B2	8.5	Y	1.75	16.1
C1	3	N	1.75	19.8
C2	4	N	1.5	18.4
D1	7	Y	1.75	10.9
D2	8	Y	1.75	14.1
E1	4.5	N	2.25	19.8
E2	4	N	1.75	22.2
F1	1.25	N	2	21.1
F2	1.25	N	2	21

Sampling Site	GPS Coordinates	Site Description
A	N 45° 23' 33.2" W-079° 21' 12.8"	At mouth of Buck River that flows into the lake, surrounded by a marshy area and cottages
B	N 45° 23' 26.3" W-079° 21' 18.1"	Deepest part of the lake
C	N 45° 23' 26.5" W-079° 21' 48.1"	In bay near a summer camp with a beach
D	N 45° 22' 36.1" W-079° 21' 10.6"	Near an island and shoreline with many cottages
E	N 45° 22' 50.0" W-079° 21' 04.8"	Close to an island, shoreline very developed
F	N 45° 22' 50.0" W-079° 21' 04.8"	End small river outflow into a dam, very forested shoreline

4.3 Fox Lake Lab Data and Results

Site	DO (mg/L)	pH	Conductivity (µS/cm)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	TP (µg/L)
A1	7.7	6.3	20.56	0.01	<0.001	0.08	14
A2	6.5	6.2	23.55	0.04	<0.001	0.11	15
B1	7.0	6.0	20.82	0.01	0.001	0.07	13
B2	7.4	6.0	23.34	0.01	0.001	0.10	9
C1	8.6	6.1	21.03	<0.01	<0.001	0.09	12
C2	6.8	5.9	24.02	<0.01	<0.001	0.20	13
D1	6.9	5.9	20.79	0.01	<0.001	0.08	15

D2	6.4	6.0	23.21	0.02	<0.001	0.15	13
E1	7.7	6.0	21.31	<0.01	<0.001	0.07	5
E2	8.4	6.0	23.2	<0.01	<0.001	0.13	8
F1	8.4	6.1	21.43	<0.01	0.001	0.12	9
F2	8.7	6.0	23.27	<0.01	<0.001	0.11	9
Mean	7.53	6.05	22.21	0.01	0.00	0.11	11.25
Standard Deviation	0.84	0.11	1.31	0.01	0.00	0.04	3.17
Minimum	6.36	5.92	20.56	0.01	0.00	0.07	5.00
Maximum	8.69	6.30	24.02	0.04	0.00	0.20	15.00
T-test: P (same mean)	0.69	0.18	0.00	0.24	1.00	0.03	0.88

*pH values for all sites were slightly lower than the normal range of 6.5-9.

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