Lake Watch: 1996 Volunteer Lake Monitoring Program

by:

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What is a Volunteer Citizens' Lake Monitoring Program?

Lakewatch is a water quality monitoring program designed to have volunteer citizens from local communities and summer villages to take water samples and record water quality data. Local volunteers are trained by water quality professionals in lake sampling techniques and data compilation. Lakewatch is an opportunity for citizen's to learn more about their lake and increase their own environmental awareness.

Why a Lake Monitoring Program?

Much concern has been raised recently over the 'pollution' of Alberta lakes. It is a common belief that human activities, including industry, urbanization, forestry, agriculture, and residential dwellings, can contribute pollutants to lakes causing excessive algal growth, weeds and murky water. This 'pollution' has caused many citizens to become more aware of their lakes' water quality. As a result, many citizens are actively involved in monitoring their lake for water quality indicators.

For the past seven years, 17 lakes and reservoirs have been monitored by local volunteer citizens in conjunction with Alberta Environmental Protection. The objectives of the Lakewatch Program are threefold:

1. to provide an opportunity for lakeshore property owners to learn first hand about water sampling procedures related to lake management;
2. to improve the existing water quality database for a particular lake; and
3. to encourage environmental responsibility among lake users.

In 1996, six lakes were monitored by local volunteer citizens with the assistance of volunteers from the Alberta Lake Management Society (ALMS). The 1996 monitoring program included Buffalo, Chickenhill, Jackfish, Hardisty, Wizard and Matchayaw lakes.

Water Quality Monitoring: Indicators

The focus of a lake monitoring program is to determine the fertility of the lake or the lakes' trophic status. The fertility of a body of water depends on the amount of nutrients, particularly phosphorus and nitrogen, that are available to growing aquatic plants (macrophytes) and algae (phytoplankton). Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Phosphorus is the plant nutrient that is in shortest supply in most fresh waters. Therefore, even a slight increase of phosphorus in a lake can, given the right conditions, set off a whole chain of undesirable events. Furthermore, prolific algae and aquatic plant growth may impair recreational uses. However, it is important to remember that algae and aquatic plants are important components of the food web and therefore, the total elimination of these plants may have catastrophic implications on the lake ecosystem.

Total Phosphorus

Total phosphorus is the measure of the amount of inorganic and organic phosphorus (P) in a water sample. Total phosphorus is one indicator of lake trophic status. High phosphorus levels promote algal blooms causing the water to turn green in the summer and increase aquatic plant growth along the shoreline.

Secchi Disk Transparency

The measure of the transparency or clarity of the water is used with a Secchi disk. Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the plate disappears is the Secchi depth. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. Low secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low secchi depths despite low algal growth and nutrient concentrations.

The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter.

Chlorophyll *a*

Chlorophyll *a* is a photosynthetic pigment that green plants, including algae, have to convert the suns' energy to living material. Chlorophyll *a* can be easily extracted from algae in the laboratory. Consequently, chlorophyll *a* is a good estimate of the amount of algae in the water. Chlorophyll *a* is also a way to estimate a lakes' fertility or trophic status. Lakes with high levels of chlorophyll *a* (26 to 75 µg/L) are usually termed eutrophic. Eutrophic lakes are fertile lakes. Highly productive or fertile lakes are termed hyper-eutrophic, while moderate to low productive lakes are termed mesotrophic and oligotrophic, respectively. Chlorophyll *a* is never used alone as a measure of trophic state because many highly productive lakes are dominated by larger aquatic plants rather than algae. In these lakes, chlorophyll *a* values taken from water samples do not include aquatic plant productivity and can thus give a lower trophic state than actual conditions. Consequently, chlorophyll *a* and total phosphorus tend to be the main indicators of trophic status.

General Water Chemistry

Water in lakes is never 'pure'. It always contains various chemical substances that have been transported by rain and snow or have entered the lake in ground water and inflow streams. These substances may be dissolved in the water or suspended as particles. Some of these substances are familiar, such as sodium and chloride, which when combined are table salt, but when dissolved in water separate into the two electrically charged components. Chemicals that separate like this into electrically charged elements are called ions. All the ions in particular water sample make up its salinity, or saltiness, and this is measured as total dissolved solids (TDS), specific conductance or total ions. Within individual lakes, ion concentrations vary from year to year depending on the amount and mineral content of the water entering the lake and climate. This year to year variation is very small compared to the variation from lake to lake across Alberta.

When a lake is very saline, game fish and other organisms may not be present, and the amount of algae in the water maybe less. A lake that is low in total dissolved solids is said to have fresh water, whereas a lake that has between 500 - 1000 mg/L TDS is said to be slightly saline. Water that has over 1000 mg/L but less that 5000 mg/L is considered moderately saline. Very few Alberta lakes have TDS concentrations higher than 5000 mg/L. Ocean water has a TDS concentration of about 33 000 mg/L.

Methods

Six lakes were routinely sampled every 3 to 4 weeks over the months of open water for physio-chemical water quality parameters during the 1996 Alberta Lake Watch Program. These lakes included Jackfish Lake, Hardisty Lake, Wizard, Matchayaw Lake, Chickenhill Lake, and Buffalo Lake. Several lakes were also sampled on a one-time basis to answer the specific concerns of the local residents or as a teaching exercise. These lakes included Big Lake sampled on June 21, 1996 and Twin Lake sampled September 13, 1996.

Two sampling protocols were used during the course of the program year: 1) composite lake sampling of euphotic zone and 2) site-specific depth profiles and discrete water-column analysis. The first sampling protocol was taught to the volunteers at the initial training session held at each of the lakes in the spring to early summer of 1996. The volunteers were organized ahead of time by the lake association coordinator who made the arrangements for the training session at the lake. At this meeting the coordinator was provided with a recent morphological map of the lake, a copy of the “Lake sampling Procedures Manual” (Alberta Environmental Protection, 1995) and the equipment necessary to collect and prepare water samples for analysis. The equipment included a Secchi disk, integrating water sampling tube, filtering pump and apparatus, water collection carboy, pre-labeled and coded sample bottles, standard record sheets, cold pack and cooler chest.

Training of the volunteers was conducted between “ice-off” and mid-summer at each of the six lakes in the 1996 program. The number of volunteers at these training sessions ranged from 2 to 12 individuals. Training included an informal lecture style presentation of the theory and practical aspects of water quality and monitoring, boating and water safety issues, and an “on-the-lake” demonstration of equipment and sampling procedures. Training sessions concluded on land with a demonstration of sample preparation. The volunteers all had an opportunity to master the procedures at each stage of the sampling process before the session ended.

The main sampling site and 9 additional locations representative of the different water qualities exhibited around the lake were selected. These sites were selected on the basis of morphometric data and information on land use and water quality provided by the volunteers. The deepest location in the lake was chosen as the main sampling site because current theory suggests that such locations best represent the dominant open-water environment of the lake. The ten sites were marked on the morphometric map for future reference and a laminated copy was later provided to the lake coordinator.

On the training day and on each sampling day the volunteers - in their own boat(s) - anchored at the main sampling site of the lake. All pertinent meteorlogical, lake activity data, and the Secchi depth were measured according to the method outlined in the procedures manual (Alberta Environmental Protection, 1995). The euphotic depth was estimated by multiplying the Secchi depth by a factor of 2.0.

An integrated water sample from the surface to the bottom of the euphotic zone was collected with the sampling tube into a clean, rinsed carboy. In relatively clear water lakes more than one sample was often collected to ensure a sufficient amount of water for the analyses to be carried out. If multiple samples were necessary the same number of samples were taken at each site to maintain an equal and consistent representation from all ten sites.

The integrated water sample(s) of the euphotic zone were collected at each of the remaining nine sites and combined with the sample from the main site. Determination of the sampling depth was based on the estimate of the euphotic depth from the main site. Where water column depth was less than the euphotic depth the water sample was collected from approximately 0.5m above the bottom, without disturbing the bottom sediment. Effort and care was required to eliminate contamination of the water samples.

The samples were brought back to a suitable location on land and the samples were prepared for analysis. The sample carboy was shaken vigorously and whole water samples were poured off into several water chemistry bottles used to estimate, among other parameters, phosphorous and selected chemical ions. Triplicate whole water samples were individually filtered for chlorophyll analysis through a 0.4 um glass-fiber filter. Sample volume was determined subjectively from information on algal density noted during sampling. A final volume was reached when the filter had obtained an established level of green color. The filters were sprinkled with $MgCO_2$ to reduce chlorophyll *a* degradation, folded so as to retain its contents inside a pouch and wrapped in aluminum foil. All samples were prepared under subdued light conditions to prevent photo-oxidative breakdown. The samples were placed in a thermally insulated cooler with freezer packs to keep the temperature of the samples as close to 4^oC as possible. Arrangements were made to transport the samples for analysis within 24 hours of being collected.

At the lab the samples were stored in a dark refrigerator at 4^oC. The filters used for chlorophyll analysis were placed in a freezer at -20^oC. Samples for routine chemical analyses, including major anions and cations, alkalinity, hardness and ionic balance, were contracted out to Chemex Labs Alberta Ltd., Edmonton. Analyses for total phosphorus and chlorophyll a were carried out at the AEP Water Quality Laboratory.

The Water Quality Branch of AEP, administered the data collected in 1996. A copy of the results as they became available was sent to the Alberta Lake Management Society for inclusion in the annual Alberta Lake Watch Report for 1996.

A second sampling regime was carried out on several occasions to provide more extensive information on water quality conditions in the summer and to include information on the often over-looked winter stratification period. In the winter months, usually prior to the start of the summer sampling program, a profile of the physical and chemical characteristics of the entire water column was established using a combination of data collected with a Hydrolab H2O data transmitter and discrete water samples collected at three representative depths. Specific parameters were measured at 1m-depth intervals from the surface to the bottom. These included specific conductance (mSiemens.cm^{-1}), pH, temperature (^{o}C), % O_2 saturation, dissolved oxygen (mg.L^{-1}) and redox potential (mV). Additionally, discrete water samples were collected at the surface (i.e. 0.1m), at the thermocline and near the bottom stratum for dissolved oxygen by the Winkler Titration Method, total and dissolved phosphorus, and routine chemistry as described earlier. Samples were collected near the deepest location with a 1-liter volume Kemmer water sampler. This site corresponded to the main sampling site of the summer sampling program.

Discrete water column profiles were carried out whenever an ALMS representative was at the lake (i.e. during training sessions and “follow-up” visits). On these occasions depth profiles of specific conductance, pH, % O_2 saturation, dissolved oxygen, and redox potential provided additional information on water quality conditions at the main lake sites. Unlike the winter sampling, however, no water samples were collected from discrete depths.

Table 1. Physical Characteristics of Chickenhill, Jackfish, Matchayaw, Wizard, and Buffalo Lakes

Lake Characteristics:	Chickenhill Lake	Jackfish Lake	Matchayaw Lake	Wizard Lake	Buffa
Lake area, km^2	3.68	2.39	2.11	2.48	
Volume, m^3 X 10^6	9.3	8.18	9.18	14.8	
Maximum Depth, m	10.0	9.0	10	11	
Average Depth, m	2.5	3.4	4.35	6.2	
Drainage Basin area, km^2	9.79	12.6	1018	29.8	
Elevation (m) above sea level	n/a	approximately 730	678.9	784.01	
Water residence time, years	4.3*	>100	unknown	13.5	
Drainage area / lake area ratio	2.7	5.3	482	12.0	
Ecoregion	Boreal Mixedwood	Moist mixedwood subregion of Boreal Mixedwood		West half: Moist Mixedwood subregion of Boreal Mixedwood; East half: Aspen Subregion of Aspen Parkland	A

*estimated

NOTE: Physical characteristics for Hardisty Lake were not available. Alberta Environmental Protection does not have these data.

Table 2. Concentration of major ions and other physical variables for Buffalo, Chickenhill, Hardisty, Jackfish, Wizard and Matchayaw Lakes. Units are mg/L unless indicated otherwise. If more than one sample taken, average is reported.

	Buffalo	Chickenhill	Hardisty	Jackfish	Wizard	Matchayaw
number of samples taken	1	2	1	2	3	1
pH, pH units	7.4	8.5-8.78	9.2	7.97-8.01	7.99-8.01	8.4
Specific Conductance, (μS cm^{-1})	541	689	1170	652	327.5	503
Total Dissolved Solids	301	404	724	412	184	301
Calcium	45.5	21.7	8.82	63.4	30.3	42.9
Magnesium	26.5	71.7	112	35.6	9.2	16.1
Sodium	35.3	26.8	87.0	19.9	30.4	53.3
Potasium	8.3	25.5	32.9	18.8	5.8	7.9
Sulphate	16.4	5.35	22.7	193.3	3.9	38.2
Chloride	3.1	4.2	29.7	2.6	4.3	6.7
Bicarbonate	331	433	561	172	200	268
Carbonate	<0.05	32.2	140	<0.5	<0.5	2.1
Total Hardness, (as $CaCO_3$)	223	349	524	540	113.7	174
Total Alkalinity, (as $CaCO_3$)	271.7	408.5	694	141	164.3	223
Silica	13.7	4.92	7.9	<0.05	0.69	5.7
True Colour, TCU	---	10	10	10	10	---
Total Suspended Solids	3.3	nd	9.0	nd	nd	---
Total Phosphorus, mg/m^3	147.3	30.1	27.2	29.2	62.0	98.7
Chlorophyl *a*, mg/m^3	53.2	6.9	6.52	10.7	31.9	24.3
Secchi Depth, m	2.1	2.7	2.6	3.0	2.0	2.5

nd-not detected; --- no value

Results and Discussion

Table 2 presents the results for Secchi depth and average concentrations of chlorophyll a, total phosphorus and water chemistry variables for the six lakes that were sampled during 1996 for the Lakewatch program.

To obtain data that are representative for the lake, it is important to sample at regular intervals throughout the open water season. Since the data in Table 2 represent only one or few sampling dates, it is difficult to characterize the water chemistry of an entire lake from one sampling period. Consequently, sparse data makes the interpretation of water quality for each lake difficult. Water quality is described for each lake according to the data available and therefore may not be representative for the entire year.

Average total phosphorus and chlorophyll *a* concentrations indicate the trophic status of a lake. High phosphorus and chlorophyll *a* concentrations, greater 8 mg/m^3 suggest that a lake is eutrophic or productive and experiences algal blooms in the summer months. Lakes are hypereutrophic when total phosphorus or chlorophyll *a* concentrations are greater than 25 mg/m^3. These lakes are highly productive and experience a considerable amount of algal and macrophyte (or aquatic weed) growth. Based on average chlorophyll *a* concentrations alone, Buffalo, Wizard and Matchayaw would be hypereutrophic, highly productive lakes while Jackfish Lake would be eutrophic. Although the total phosphorus concentrations in Chickenhill and Hardisty Lakes was high, the average chlorophyll *a* concentrations that were measured during the sampling season indicate that they would be mesotrophic or moderately fertile lakes.

Matchayaw, Buffalo and Jackfish Lakes experienced mid-summer algal blooms that caused decreased Secchi depths and correspondingly high chlorophyll concentrations, however the low transparency in Jackfish Lake during the spring sampling period may have been from runoff carrying a high suspended sediment load. Wizard Lake, however, had shallow secchi depths (low transparency) with corresponding high chlorophyll concentrations throughout summer months.

Hardisty and Chickenhill Lakes did not experienced any large changes in transparency and maintained relatively consistent chlorophyll and phosphorus concentrations throughout the year.

All of the lakes that were monitored in Lakewatch in 1996 are hardwater lakes that are well buffered with total alkalinities greater than 100 mg/L $CaCO_3$. Most of the lakes in Alberta have both hardwater and are alkaline. The amount of total dissolved solids (TDS) is the measure of the amount of ions present in the water. The lakes in the Lakewatch Program are freshwater lakes however, high TDS (> 500 mg/L) indicated that the lakewater may be saline. Hardisty Lake falls in the range of being slightly saline with an average TDS concentration of 724 mg/L while Chickenhill and Jackfish lakes are approaching the slightly saline range (500 - 1000 mg/L TDS).

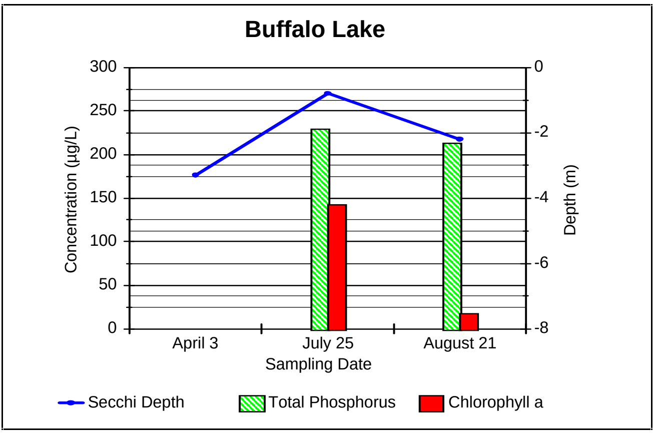

Figure 1. Secchi depth and concentrations of chlorophyll a and total phosphorus in Buffalo Lake, summer 1996

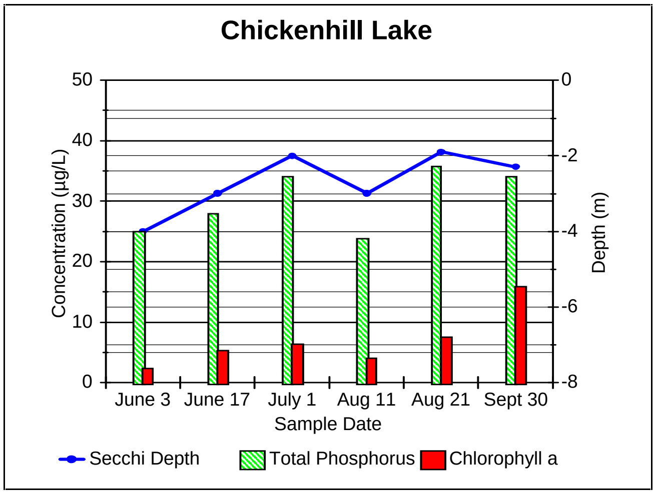

Figure 2. Secchi depth and concentrations of chlorophyll a and total phosphrous in Chickenhill Lake, summer 1996.

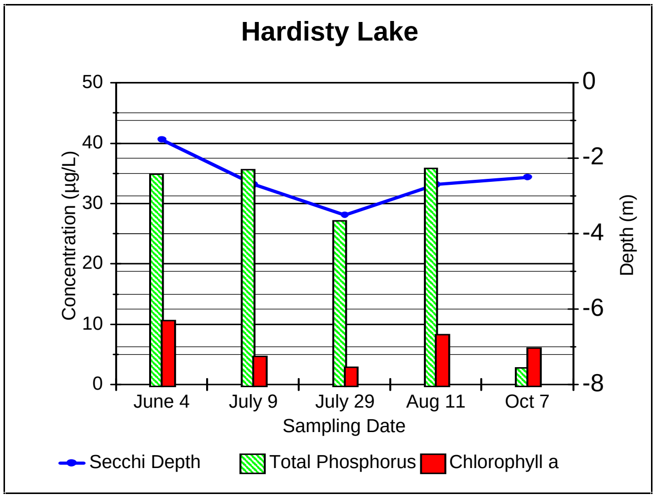

Figure 3. Secchi depth and concentrations of chlorophyll a and total phosphorus in Hardisty Lake, summer 1996.

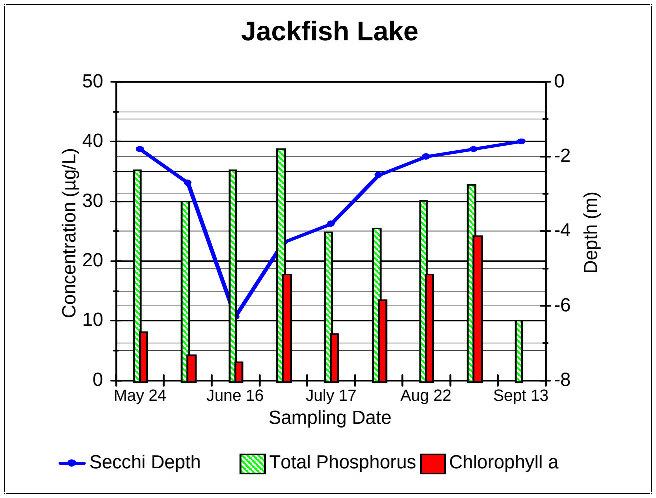

Figure 4. Secchi depth and concentrations of chlorophyll a and total phosphorus in Jackfish Lake, summer 1996.

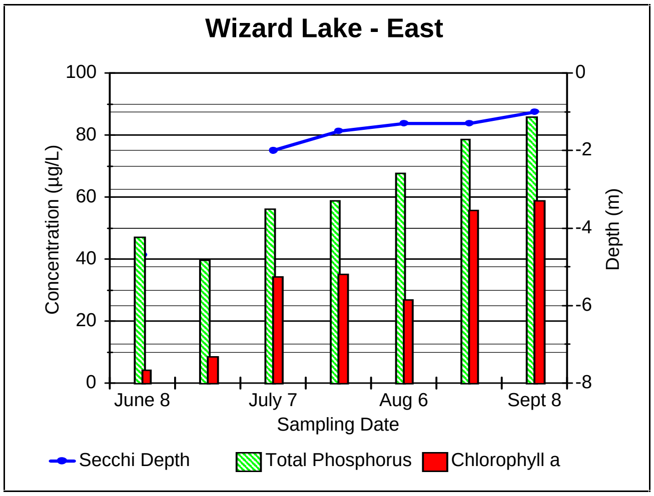

Figure 5. Secchi depth and concentrations of chlorophyll a and total phosphorus in Wizard Lake, east basin, summer 1996.

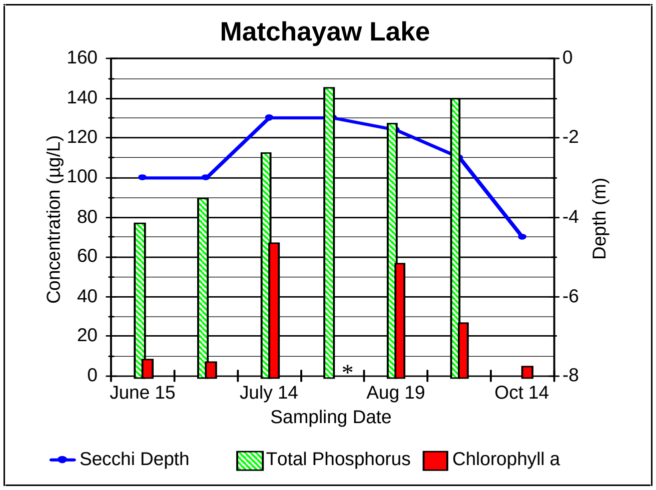

Figure 6. Secchi depth and concentrations of chlorophyll a and total phosphorus in Matchayaw Lake, summer 1996.

Conclusions

The Volunteer Citizens' Lake Monitoring Program was conducted on Buffalo, Chickenhill, Hardisty, Jackfish, Wizard and Matchayaw Lakes in 1996. Based on the results from the Lakewatch program, all of the lakes are productive, eutrophic lakes with the exception of Chickenhill and Hardisty Lakes. However, high total phosphorus concentrations would also indicate that they would be productive lakes. Nuisance algal growth and abundant shoreline vegetation may be expected in all of the lakes studied in the Lakewatch program.

Alberta is blessed with many productive lakes that experience summer blooms of algae and significant aquatic macrophyte (weed) growth. The sources of the nutrients that support algae and macrophyte growth in the summer can come from either the bottom sediments in the lake or from the watershed surrounding the lake. Nutrients (e.g. phosphorus and nitrogen) can be carried in runoff from the watershed with spring snowmelt and summer rainfall from various land uses within the watershed such as forestry, agriculture, or lawn or crop fertilizers. Faulty or poorly maintained septic systems in residential dwellings surrounding the lakes can also contribute nutrients to the lake through seepage or direct flow. An increased nutrient supply to a lake can increase its' probability of experiencing more algal blooms and increased aquatic macrophyte growth which decreases the recreational water quality of the lake. Citizens' can help protect water quality by being aware of possible sources of nutrients to the lake and then work towards reducing the phosphorus supply from those sources.

Valuable data were collected by all of the volunteer citizens' who monitored the lakes that were studied in 1996. These data will be baseline data from which future comparisons can be made. Through the participation of each volunteer citizen, there has been greater interest in the water quality and stewardship of Alberta lakes. With increased awareness, more citizens can work towards conserving and protecting Alberta lakes.

References

Alberta Environmental Protection, 1995. Provincial Parks and Volunteer Citizen water Quality Monitoring Program – Lake Sampling Procedures Manual. pp8.