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Some Physical, Chemical and Morphometric Parameters of Ed's Bog And Kickapoo Lake, Gogebic County, Michigan, June, 1979: Comparison and Contrast.

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6/29/79
Biology 569
Drs. Duman and Greene

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Introduction

Ed's Bog and Kickapoo Lake are both located slightly east of the center of the University of Notre Dame Environmental Research Center (UNDERC) outside Land o' Lakes, Wisconsin. Although they they are separated by less than one-half mile, the lakes differ in morphometry, chemistry, flora and fauna. The purpose of this report was to compare and contrast the two lakes with respect to the above categories and explain any differences which were found.

Geology and Climate

When the Wisconsin ice sheet of the Pleistocene glaciation receded six to seven thousand years ago, it left behind many kettle lakes in the area now considered to be the Notre Dame properties. Depressions were formed by the melting away of glacier fragments and the sloughing off of glacial drift in the sandstone base and sandy soil of this area. Mounds of debris were left around kettleholes, which were usually of the soft-water, acid-bog type (Prescott, 1973).

Kickapoo Lake was a soft-water drainage lake, having inflows from Plum and Emeline Lakes and being drained via Brown Creek (Figure 1.A). Ed's Bog was a soft-water seepage bog without outlet (Figure 1.B).

UNDERC falls at a latitude of 46°North and its climate has been described as humid microthermal (Greene, 1976). There is no dry season; winters are cold (January average temperature = -20° to -10°C); summers are long and cool (July average temperature = 16° to 21°C). The annual precipitation is 50 to 100 cm. of snow and rain. Lakes freeze within the first two weeks of November and remain frozen until May.

Lake Surroundings and Morphometry

Kickapoo Lake had a surface area of over 5 hectares. It was very shallow, being three meters deep at its deepest points. Submerged macrophytes were found growing at all depths throughout the lake. It was a relatively circular lake with only three or four very small and shallow coves, one near the inflow from Plum Lake and one near the outflow of water to Brown Creek where a beaver dam was located (Figure 1.A). Some water lillies were found floating on the water and emergent macrophytes completely encircled the lake. Beyond the marshy area (70 m. wide) were many old, dead trees and beyond them was a forest comprised of both conifers and hardwood trees (Table 1.A).

Ed's Bog had a surface area of less than one hectare and was oval in shape, being no more than 7 meters wide and 15 meters long (Figure 1.B). There was no littoral zone and the bog was uniformly deep (~6 m.). There were no inlets or shallow bays in the bog. It was surrounded by the typical shrub-like bog flora of bog rosemary, leatherleaf and Sphagnum moss, which was in turn surrounded by a coniferous forest (Table 1.B).

Stratification, Color and Transparency

Solar radiation is absorbed quickly by the upper layers of water. Light, warm water remains within the first few meters of the surface and is easily mixed by wind (epilimnetic waters). Denser, cold water is found below the surface water (hypolimnetic waters). In between the two layers is a zone of rapidly dropping temperature (thermocline). A cutoff of mixing ability of the water is caused by an increase in the density differences imparted by temperature between water in the epilimnion and hypolimnion. Thermal stratification exists in many lakes throughout the summer.

Due to its extreme shallowness and openness to wind activity, Kickapoo Lake was not thermally stratified, but remained uniform in temperature throughout its depth. Ed's Bog was stratified, exhibiting a thermocline between 0.5 and 1.5 m. Bottom waters remained uniformly cool at 5°C (Figure 2.B).

The minimum intensity of subsurface light permitting photosynthesis equals one per cent of the surface light incident on a body of water

(Cole, 1979). The euphotic or photic zone is the region from the surface to the depth at which 99 % of the surface light has disappeared. Doubling of the secchi disc reading gives an indication of the amount of light penetrance in a body of water. To standardize disc readings and to make comparisons between bodies of water possible, disc readings should be made between 10 A.M. and 2 P.M., off the shady side of the boat. Unfortunately, disc readings cannot help but be qualitative since they depend on the eyesight of the observer and the amount of contrast between the disc and the surrounding water.

Secchi disc readings on Kickapoo Lake were not taken since the bottom of the lake was visible at all times. The secchi disc reading on Ed's Bog was 0.85 m., indicating that photosynthesis could occur only within the upper 1.7 m. of this bog whereas it could occur throughout all depths in Kickapoo Lake.

Apparent color is the result of materials in solution and particulate matter (Cole, 1979). By centrifugation or filtration, particulate matter is removed and the remaining color attributed to the water is known as its true color. Color of water samples was measured using a Hach kit (PR-EL/2 Model) spectrophotometer. Water samples were centrifuged at 250 rpm for ten minutes and then decanted before being measured for true color.

For the three water samples taken from Kickapoo Lake, apparent color ranged from 30 to 50 units (Table 2.A). True color measurements ranged from zero to 40 units, the higher readings being due to small particulate matter remaining in suspension even after centrifugation.

The apparent color reading was high in the epilimnion of Ed's Bog (240 units) and even higher in the hypolimnion (300 units) (Table 2.B). True color was not much lower than the above figures. Darkness of the water was attributed to dissolved humic material leached from the soil, peat and lake sediments around Ed's Bog. No such leaching occurs in the vicinity of Kickapoo Lake.

Acidity, pH, Alkalinity, Hardness and Specific Conductivity

Acidity is the measure of the ability of a solution to donate protons to solution. In natural waters, salts, acids and bases contribute to the amount of hydronium and hydroxide ions dissociated in water. The pH of a solution is defined as:

$$pH = \log \frac{1}{[H+]},$$

so that solutions with high pH have low hydrogen ion concentrations and solutions with low pH have a high hydrogen ion concentrations. Low pH readings are usually correlated with high acidity readings. pH in most fresh waters is controlled and buffered by the following reaction:

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H+ + HCO_3^- \rightleftharpoons H+ + CO_3^{-2},$$

hydrogen ions being released from dissociating carbonic acid. pH values range from 6 to 9 in open lakes which contain varying amounts of carbonate and are regulated by the CO_2-HCO_3^--CO_3^{-2} buffering system (Wetzel, 1975). Alkalinity is a measure of the quantity and kinds of compounds which buffer or maintain the pH of a body of water and is usually due to the presence of bicarbonates, carbonates and hydroxides. The hardness of a body of water is controlled by its content of calcium and magnesium salts, largely combined with bicarbonate and carbonate (temporary hardness) and with sulfates, chlorides and other anions of mineral acids (permanent hardness)(Wetzel, 1975). Magnesium carbonates are much more soluble than calcium carbonates, and in ordinary hardwater lakes in which precipitation of carbonates occurs as a result of the photosynthetic activity of plants, the precipitate consists mainly of calcium carbonate (Hutchinson, 1957).

Specific conductivity is a measure of the resistance of a solution to electrical flow and increases with an increasing content of ionized salts, as would be found in a hardwater lake. The major ions contributing to conductivity are CO_3^{-2}, HCO_3^-, SO_4^{-2}, Cl^-, Mg^{+2}, Na^+, Ca^{+2}, and K^+ (Wetzel, 1975).

Acidity was measured by titrating the water sample with standard 0.020 N. sodium hydroxide to an endpoint indicating the equivalence points of HCO_3^- (pH 8.3) and H_2CO_3 (pH 4.5). No "free" acidity (titration to pH 4.5) was found in Kickapoo Lake. Total acidity ranged from 100 to 130 mg/l. $CaCO_3$ at the three sample sites tested on Kickapoo Lake (Table 2.A). A pH of 7.2 was found in all three samples which correlates well with the obtained acidities. Ed's Bog had total acidities of greater than 100 mg/l. in the epi- and hypolimnetic samples and had a free acidity of 10 mg/l. in its epilimnion (Table 2.B). pHs for both samples were close to 4.5 which made it difficult to determine the amount of free acidity.

Total alkalinity was measured by titrating the water samples with standard 0.020 N. sulfuric acid to an endpoint of pH = 5.1 (Hach Chemical Co., 1975). Alkalinity ranged between 20 and 30 mg/l $CaCO_3$ in surface samples from Kickapoo Lake. Alkalinities of 2.5 mg/l. were obtained from the epilimnion and hypolimnion of Ed's Bog.

Hardnesses (Calcium, Magnesium, Total) were determined by observing color change in a dye (calmagite) which reacts with free calcium and magnesium ions to form a red complex. As the water samples were titrated with the chelator ethylenediaminetetraacetic acid (EDTA), EDTA reacted with all free calcium and magnesium ions causing a color change from red to blue. Total hardness was 30 mg/l. $CaCO_3$ in all three surface samples from Kickapoo Lake with calcium hardness being higher as expected (Table 2.A). Total hardness in the epilimnion of Ed's Bog was 5 mg/l. and in the hypolimnion was 10 mg/l. (Table 2.B).

Specific conductances were measured using the Hach kit conductivity meter. Specific conductance in Kickapoo Lake ranged between 61 and 65 micromhos/cm., and in Ed's Bog ranged between 15.5 (epi-) and 20 (hypo-) micromhos/ cm.

Kickapoo Lake like other lakes in this geographic region was a softwater lake and did not have a high content of calcium and magnesium salts. It was a productive lake as evidenced by the macrophytes growing throughout its depths and maintained a pH slightly in the alkaline range due to the CO_2-HCO_3^--CO_3^{-2} buffering system. The lake is becoming more acidic than it previously was (Table 3.A).

This may be due to permanent loss of ions to the bottom sediments or to a lessening of the photosynthetic activity in the lake. Kickapoo Lake will gradually fill up to become a marsh and will then undergo terrestrial succession.

Humic acids from the surrounding forest have found their way into the water seeping into Ed's Bog, partly accounting for its low pH. Sphagnum moss secreted other organic acids and acted as an active cation exchange column, releasing H+ as it took up Ca^{+2} (Wetzel, 1975). This accounted for the low pH and the low hardness of the bog water. The bog waters were very unproductive in comparison to Kickapoo Lake due to their acidity, little transparency to light and very shallow epilimnion. There was only a very small CO_2-HCO_3^--CO_3^{-2} buffering system. Alkalinity, specific conductance and hardness were slightly higher in the deeper waters due to sedimentation of particles falling from the epilimnion, but these particles were soon lost permanently in the bottom sediments. Ed's Bog had a lower pH in 1979 than it did in 1975 (Table 3.B). It is continuing its succession in dystrophy until the point where the bog will be completely filled with sediment.

Nitrates and Phosphorus

Nitrogen and phosphorus, along with carbon and hydrogen, are the major constituents of cellular protoplasm. Nitrogen occurs in many forms, including dissolved molecular nitrogen, amino acids, amines, humic compounds, ammonia, nitrite and nitrate. Nitrogen enters the water via precipitation, nitrogen fixation in water and sediments and inputs from runoff from the watershed. Nitrogen exits the water through outflow from the basin, reduction of nitrate to nitrogen by bacterial denitrification and loss to the air and permanent loss to the sediments. Phosphorus is a major cellular constituent found in the ribonucleic and deoxyribonucleic acids (RNA, DNA) and the nucleotide phosphates (AMP, ADP, ATP). The only significant source of inorganic phosphorus is orthophosphate (PO_4^{-3}). A phosphorus deficiency is more likely to limit production in any region of the earth's surface than a deficiency of any other material aside from water (Hutchinson, 1957). Phosphorus enters the water primarily via precipitation, runoff and sewage contamination. Phosphorus is regenerated from organisms after their decomposition in deep waters. Release of phosphorus from leaves and roots of emergent, submerged and floating macrophytes after death is an important phosphorus source (Wetzel, 1975).

A measure of color intensity using the Hach kit spectrophotometer was used to indicate the concentration of nitrate in water samples. Nitrate was first reduced to nitrite by cadmium metal. Nitrite ions were reacted with sulfanilic acid to form an intermediate salt which in the presence of gentisic acid formed an amber-colored compound directly in proportion to the nitrate concentration of the sample.

Nitrate concentrations ranged between 0.25 and 0.60 mg/l. NO_3^- in samples from Kickapoo Lake and Ed's Bog, with hypolimnetic samples from Ed's Bog showing the highest concentrations (Tables 2.A; 2.B).

Total phosphorus was determined by first pretreating the water samples to convert all phosphorus to the orthophosphate form. Acidic ammonium molybdate was then reacted with orthophosphate to form a yellow complex which was then reduced with ascorbic acid to give a blue complex whose intensity was measured with a spectrophotometer.

Phosphorus contents ranged between 0.25 and 0.46 mg/l. in samples collected from Ed's Bog and Kickapoo Lake (Tables 2.A; 2.B).

Nitrate and phosphorus were quickly cycled through the lakes. Higher nitrate content in the bottom sample from Ed's Bog was due to percolation of nitrogenous substances into the groundwater feeding the bog. High nitrate content at surface sample #3 for Kickapoo Lake may be due to introduction of nitrogenous substances into the water from the nearby beaver dam. An increase in phosphorus and nitrate are expected in the bottom waters of both lakes later in the summer due to decomposition of sedimenting plankton. The nutrients may be recycled in Kickapoo Lake, but are permanently lost to the bottom sediments in Ed's Bog.

Hydrogen Sulfide and Oxygen

Oxygen measurements were not directly made on either lake. Oxic or anoxic conditions were indicated by the presence or absence of hydrogen sulfide. Under oxic conditions, hydrogen sulfide (H_2S) is oxidized rapidly to sulfate therefore H_2S is present only in water depleted of oxygen and is a byproduct of the anaerobic decomposition of organic matter.

No H_2S was detected in Kickapoo Lake water samples, but H_2S was detected in the hypolimnion samples from Ed's Bog. Due to stratification and inability of oxygen to reach the deeper waters, the hypolimnion of Ed's Bog was anaerobic. Anaerobic sulfur-reducing bacteria such as Desulfovibrio and Desulfotomaculum play a part in forming H_2S in the hypolimnion of Ed's Bog (Wetzel, 1975).

Plankton Analyses

Plankton is the name given to the small organisms whose primary movement is a function of the water movement itself and not of the plankton. Planktonic organisms may have locomotory parts (i.e. cilia, flagella, gas bladders), but their movements due to these are unimportant when compared to water.

A. Phytoplankton

Phytoplankters are the plant life of open waters. They must remain within the photic zone and require certain organic and inorganic nutrients in order to perform photosynthesis, grow and reproduce.

A diversity of algae were found in the morning (A.M.) and evening (P.M.) samples taken from Kickapoo Lake (Tables 4.A; 4.B). Cocoid blue-green algae, filamentous blue-green algae, coccoid green algae, desmids, green flagellates and three types of diatoms were found in the A.M. sample. The P.M. sample contained almost all of the above, plus an additional filamentous green and blue-green, a dinoflagellate and two additional genera of diatoms. The increased diversity at night may have been due to the fact that some algae migrated downwards during the day due to the high intensity of sunlight reaching the water surface (it was a sunny day) or the increased warmth of the surface water. Maximum sunlight does not naturally imply maximum efficiency of algal photosynthesis. It was also possible that wind stirred up water currents which redistributed the algae throughout the lake.

Softwater drainage lakes like Kickapoo Lake have algal flora with a predominant green algal component. In the presence of adequate concentrations of nitrate and phosphorus, productivity is high (Table 2.A). Of the green algae listed, Volvox is common in nitrogen-rich water. Of the blue-greens, Aphanizomenon has pseudovacuoles in its cells which gives them great buoyancy (Prescott, 1973). An abundant growth of Aphanizomenon was concentrated at the water surface. Asterionella was abundant in Kickapoo Lake samples, but is often associated with hardwater lakes; availability of nitrate and phosphorus increased its chances for survival in Kickapoo. The flagellate Raciborskiella was only found in the A.M. sample and may migrate down at night to avoid predation by zooplankton.

The algal diversity was much lower in more acidic and less nutrient-enriched Ed's Bog (Tables 5.A; 5.B). Acid bog lakes are characterized by a variety of desmids and few blue-green algae (Prescott, 1973). Ed's Bog follows this trend notably in that the desmid Tetmemorus was found in Ed's Bog but not in Kickapoo Lake. This particular desmid is confined to highly acid situations as were found in Ed's Bog (Prescott, 1970). Desmids as a group were higher in concentration in Ed's Bog than in Kickapoo Lake.

In summary, in low pH situations there is a corresponding increase in green algae (especially desmids) and a decrease in blue-green algae as was seen in Ed's Bog. Under conditions of higher pH, nitrates, phosphorus and shallow water as were found in Kickapoo Lake, more blue-greens were found, and diversity was higher.

B. Zooplankton

Increased phytoplankton makes possible a larger microfaunal foraging population which can then support a more numerous macrofauna (Prescott, 1973). This microfaunal foraging population constitutes the animal component of the plankton or zooplankton. The major groups dominating the zooplankton are the Rotatoria, the Cladocera, the Copepoda and, to a lesser extent, the Protozoa.

Of the rotifers, only Brachionus was found in high numbers in Kickapoo Lake in both A.M. and P.M. samples (Tables 4.C; 4.D). The rotifers are filter feeders and are found in high numbers in association with submerged macrophytes as were found in Kickapoo Lake (Wetzel, 1975). Rotifers move slowly and do not demonstrate any clearcut migration pattern. No difference was seen between daytime and nighttime plankton tow concentrations of rotifers.

Cladocera and copepoda are also filter feeders and demonstrate vertical migration patterns. Migrations have evolved for several reasons:

1. Low light intensities allow avoidance of predatory pressure due to fish.
2. Protein synthesis of photosynthetic algae is greatest at night and thus cladocerans and copepods feeding at night have a more efficient energy uptake.
3. Growth efficiency of these zooplankters is greatest at low temperatures therefore they would tend to avoid warm surface waters during the day. (Wetzel, 1975)

Nauplius larvae migrate more readily than the adults and this was seen in the great abundance of nauplii present in the P.M. sample from Kickapoo Lake.

Several genera of rotifers were found in Ed's Bog, but not in the abundance that were seen in Kickapoo Lake (Tables 5.C; 5.D). Several genera of cladocera and copepoda were found, being more abundant in the P.M. sample. These zooplankters can live under conditions of very low oxygen (< 1ppm) as is found in bogs, and migrate through density discontinuities in water. A known Daphnia population in Lake Michigan migrated 24 meters through a thermal discontinuity at a rate of 10 m/hour (Wetzel, 1975). Migration has also been found to occur under the less transparent conditions and strong thermoclines of bogs. Two species of Daphnia were observed in both A.M. and P.M. samples, which was an unusual find. The two species were only able to coexist if they had different vertical and seasonal migration patterns and different food preferences. A significant addition to the zooplankton of Ed's Bog was the overwhelming abundance of the dipteran Chaoborus americanus which is predatory on crustaceans and aquatic insects (Johannsen, 1933). It aided in keeping numbers of other zooplankters down.

Summary and Conclusions

Kickapoo Lake was a softwater drainage lake whereas Ed's Bog was a softwater seepage bog. Due to its large surface area to volume ratio and openness to the wind, Kickapoo Lake remained well-oxygenated throuthout and supported an abundant growth of submerged macrpohytes and diverse phytoplankton. Its pH was maintained in the alkaline range due to the CO_2-HCO_3^--CO_3^{-2} buffering system. Ed's Bog had a very low surface area to volume ratio and its waters remained permanently stratified. The thermocline fell between 0.5 and 1.5 meters and below this depth, no oxygen was present in the water. Seepage of humic acids into the bog water and active exchange of hydrogen ions for calcium ions by the cell walls of Sphagnum kept the pH low. Ed's Bog was very unproductive in comparison with Kickapoo Lake due to its acidity, little transparency to light and very shallow epilimnion. Ed's Bog did have more of a variety of desmids and fewer blue-green algae than Kickapoo Lake, which is characteristic of low pH waters.

lo nutrients
Ca^{++}

Rotifers were present in both Kickapoo Lake and Ed's Bog, but were more abundant in Kickapoo Lake where they were associated with the submerged macrophytes. Nocturnal vertical migrations to the surface waters were seen among the cladocera and copepoda of both lakes, with the most abundant migrating form being the nauplius larva. The larval form of the dipteran Chaoborus americanus which is predaceous on crustaceans and aquatic insects comprised the bulk of the zooplankton of Ed's Bog; none were found in Kickapoo Lake. Temporary ponds and bogs are among the favorite habitat sites for Chaoborus sp. (Johannsen, 1933). The zooplankton of Ed's Bog must have resistant cyst or egg stages in which they can survive a six-month ice cover and depletion of oxygen.

Kickapoo Lake will most likely continue its succession toward a broad, marshy area as it becomes shallower due to sediment buildup. Ed's Bog is not quite as far along the road to terrestrial succession as Kickapoo Lake. Most of the productivity of Ed's Bog is confined to the bog mat and as the mat continues to encroach on the surface area of the water, the bog will continue to fill up with sediment until it too becomes a part of the terrestrial landscape.

Figure 1.A. Sketch of shape of Kickapoo Lake.

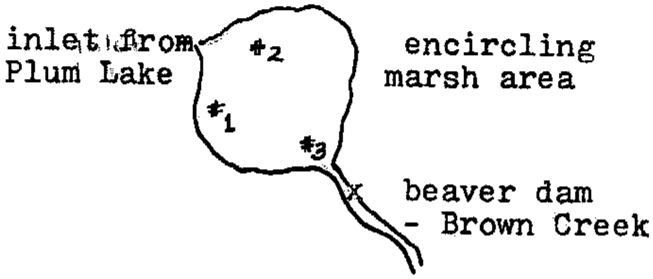

Figure 1.B. Sketch of shape of Ed's Bog.

Note : Size difference between the two lakes is drawn to scale.

Table 1.A. Morphometric data and surrounding vegetation of Kickapoo Lake.

Surface Area - 5×10^4 m^2.

Mean Depth - 3 m.

Elodea sp. - waterweed

Nyphaea sp. - water lilly

Typha sp. - cattail

plus unidentified hardwoods and conifers farther away from the lake.

Table 1.B. Morphometric data and surrounding vegetation of Ed's Bog.

Surface Area - 1×10^4 m^2.

Mean Depth - 6 m.

Andromeda glaucophylla - bog rosemary

Chamaedaphne calyculata - leatherleaf

Sphagnum sp. - moss

plus unidentified conifers (possibly Larix sp. - tamarack pine) and some small hardwood trees.

Note: Table 1 is incomplete and represents only that data that were easily collectible.

Table 2.A. Some chemical and physical parameters of Kickapoo Lake waters.

	Surface 1	
Acidity		130 mg/l.
Alkalinity		20 mg/l.
Hardness:	Calcium	20 mg/l.
	Magnesium	10 mg/l.
	Total	30 mg/l.
Specific conductivity		65 µmhos/cm.
Color :	Apparent	50 units
	True	10 units
Nitrate		0.25 mg/l.
Phosphorus		0.39 mg/l.
pH		7.2
H_2S ⊖		
	Surface 2	
Acidity		130 mg/l.
Alkalinity		30 mg/l.
Hardness:	Calcium	20 mg/l.
	Magnesium	10 mg/l.
	Total	30 mg/l.
Specific conductivity		62 µmhos/cm.
Color:	Apparent	30 units
	True	0 units
Nitrate		0.25 mg/l.
Phosphorus		0.46 mg/l.
pH		7.2
H_2S ⊖		
	Surface 3	
Acidity		100 mg/l.
Alkalinity		20 mg/l.
Hardness:	Calcium	20 mg/l.
	Magnesium	10 mg/l.
	Total	30 mg/l.
Specific conductivity		61 µmhos/cm

Con't. on following page

Table 2.B. Some chemical and physical parameters of Ed's Bog waters.

	Epilimnion	
Acidity:	Methyl red	10 mg/l.
	Phenolph.	110 mg/l.
Alkalinity		2.5 mg/l.
Hardness:	Calcium	5 mg/l.
	Magnesium	0
	Total	5 mg/l.
Specific conductivity		15.5 µmhos/cm.
Color:	Apparent	240 units
	True	225 units
Nitrate		0.25 mg/l.
Phosphorus		0.41 mg/l.
pH		4.2
H_2S ⊖		
	Hypolimnion	
Acidity		96 mg/l.
Alkalinity		2.5 mg/l.
Hardness:	Calcium	5 mg/l.
	Magnesium	5 mg/l.
	Total	10 mg/l.
Specific conductivity		20 µmhos/cm.
Color:	Apparent	300 units
	True	288 units
Nitrate		0.60 mg/l.
Phosphorus		0.37 mg/l.
pH		4.4
H_2S ⊕		

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Secchi disc reading 0.85 m.

Weather: Air Temp. = 16°C overcast with some brief showers; little wind.

Table 2.A. Some chemical and physical parameters of Kickapoo Lake waters, con't.

	Surface 3
Color: Apparent	40 units
True	40 units
Nitrate	0.60 mg/l.
Phosphorus	0.25 mg/l.
pH	7.2
H_2S ⊖	

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Note: See Figure 1.A for location of sample sites.

No secchi disc reading was taken since the bottom of the lake was visible at all times.

Weather: Air Temp. = 16 C
sunny and windy;
no rain.

Figure 2.B. Temperature-stratification graph of Ed's Bog.

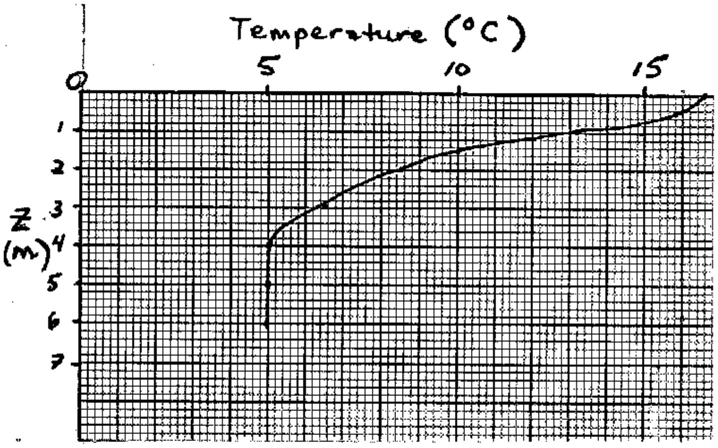

Table 3.A. Comparison of some 1979 and 1975 chemical data on Kickapoo Lake.

	1975	1979
pH	8.2	7.2
Specific conductance	100 μmhos/cm.	61-65 μmhos/cm.

Table 3.B. Comparison of some 1979 and 1975 chemical data on Ed's Bog.

	1975	1979
pH	5.05	epi- = 4.2
		hypo- = 4.4
Specific conductance	14.2 μmhos/cm.	epi- = 15.5 μmhos/cm.
		hypo- = 20 μmhos/cm.

Note: 1975 data taken from Greene, 1976.

Table 4.A.

Qualitative
PHYTOPLANKTON COUNT DATA

Sample No. Kickapoo Lake, A.M.
Date ~~Analyzed~~ Sample taken 6/5/79
Analyzed By SJ Fleming
Volume Filtered ____ ML

ORGANISM		TALLY	C/ML	TOTALS
Anacystis	many different types			
Total coccoid blue-green algae per ml.				
Anabaena	many			
Aphanizomenon	many			
Total filamentous blue-green algae				
Volvox				
Nannochloris				
Desmids: Staurastrum Cosmarium				
Total coccoid green algae				
Total filamentous green algae				
Raciborskiella				
Total green flagellates				
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml
Asterionella		
Fragilaria		
Nitzchia		

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

Table 4.B.

Qualitative
PHYTOPLANKTON COUNT DATA

Sample No. Kickapoo Lake, P.M. Date Sample taken ~~Analyzed~~ 6/5/79

Analyzed By S.J. Fleming Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Gloecapsa				
Anacystis	many			
Total coccoid blue-green algae per ml.				
Anabaena	many			
Aphanizomenon	many			
Oscillatoria				
Total filamentous blue-green algae				
Sphaerocystis				
Volvox				
Desmids:				
Cosmarium				
Total coccoid green algae				
Mougeotia				
Total filamentous green algae				
Dinobryon	many			
Total green flagellates				
Ceratium				
Total other pigmented flagellates				

Centrics		c/ml
Pennates		**c/ml**
Fragilaria		many
Diatoma		
Synedra		
Asterionella		many
Tabellaria		many

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

Table 4.C.

Qualitative

ZOOPLANKTON COUNT DATA

Sample No. Kickapoo lake, A.M. Date ~~Analyzed~~ Sample taken 6/5/79

Analyzed by S.J. Fleming Sample Volume ________ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella		
Brachionus	many	
Polyarthra		
Synchaeta		
Trichocera		
Total Rotifers per liter		
Cladocera		
Bosmina		
Daphnia		
Moina		
Ceriodaphnia		
nauplii	many	
Copepoda		
Nauplii	many	
Cyclops & related genera	many	
Diaptomus		
Total Crustacea per liter		
Nematodes (per liter)		
Other Invertebrates (per liter)		

Ciliata

Vorticella

Table 4.D.

Qualitative

ZOOPLANKTON COUNT DATA

Sample No. Kickapoo Lake, P.M. Date ~~Analyzed~~ Sample taken 6/5/79

Analyzed by S.J. Fleming Sample Volume ____ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella		
Brachionus	many	
Polyarthra		
Synchaeta		
Trichocera		
Total Rotifers per liter		
Cladocera		
Bosmina	few	
Daphnia		
Moina		
Ceriodaphnia		
nauplii	very many	
Copepoda		
Nauplii	very many	
Cyclops & related genera	many	
Diaptomus	many	
Total Crustacea per liter		
Nematodes (per liter)		
Other Invertebrates (per liter)		

Ciliata

Vorticella

Table 5. A.

Qualitative

PHYTOPLANKTON COUNT DATA

Sample No. Ed's Bog, A.M.

Date ~~Analyzed~~ Sample taken 6/7/79

Analyzed By S.J. Fleming

Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Gomphosphaeria	many			
Total coccoid blue-green algae per ml.				
Total filamentous blue-green algae				
Protococcus	many			
Desmids:				
Cosmarium	Many			
Tetmemorus	several			
Total coccoid green algae				
Mougeotia	many			
Total filamentous green algae				
Total green flagellates				
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml
Fragilaria		many
Synedra		
Navicula		
Nitzchia		

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				
Total live centric				
Pennate shells				
Live Pennates				
Total live pennate				
TOTAL LIVE ALGAE (c/ml)				

Table 5.B.

Qualitative

PHYTOPLANKTON COUNT DATA

Sample No. Ed's Bog, P.M

Date ~~Analyzed~~ Sample taken 6/7/79

Analyzed By S.J. Fleming

Note: not much algae; sample dense w/ zoop.

Volume Filtered ______ ML

ORGANISM		TALLY	C/ML	TOTALS
Gomphosphaeria	several			
Total coccoid blue-green algae per ml.				
Total filamentous blue-green algae				
Protococcus	several			
Desmid				
Cosmarium	many			
Total coccoid green algae				
Total filamentous green algae				
Dinobryon	many			
Total green flagellates				
Total other pigmented flagellates				

Centrics		c/ml

Pennates		c/ml
Fragilaria		Several

Diatoms

	Centric	Melos.	Other	c/ml
Shells				
Live				

Total live centric

Pennate shells

Live Pennates

Total live pennate

TOTAL LIVE ALGAE (c/ml)

Table 5.C.

Qualitative
ZOOPLANKTON COUNT DATA

Sample No. Ed's Bog A.M. Date Sample taken ~~Analyzed~~ 6/7/79

Analyzed by S.J. Fleming Sample Volume ______ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	several	
Brachionus	several	
Polyarthra		
Synchaeta		
Trichocera		
Kellicotia	several	
Total Rotifers per liter		
Cladocera		
Bosmina		
Daphnia pulex + longispina	many	
Moina		
Ceriodaphnia		
nauplii	many	
Copepoda		
Nauplii	many	
Cyclops & related genera		
Diaptomus	many	
Total Crustacea per liter		
Nematodes (per liter)		
Other Invertebrates (per liter)		

Diptera

Chaoborus americanus many

Table 5.D.

Qualitative

ZOOPLANKTON COUNT DATA

Sample No. Ed's Bog, P.M. Date Sample taken ~~Analyzed~~ 6/7/79

Analyzed by S.J. Fleming Sample Volume ____ ML

ORGANISM	TALLY	C/LITER
Rotifera		
Keratella	several	
Brachionus	several	
Polyarthra		
Synchaeta		
Trichocera		

Total Rotifers per liter

Cladocera		
Bosmina	several	
Daphnia pulex+ longispina	many	
Moina		
Ceriodaphnia	many	
nauplii	very many	
Copepoda		
Nauplii	very many	
Cyclops & related genera		
Diaptomus	many	

Total Crustacea per liter

Nematodes (per liter)	
Other Invertebrates (per liter)	

Diptera

Chaoborus americanus - very many ; various larval forms.

Literature Cited

Cole, G.A. 1979. Textbook of Limnology. C.V. Mosby Co., St. Louis, Mo. 426 pp.

Greene, R.W. 1976. A Brief Guide to the University of Notre Dame Environmental Research Center. Dep't. of Biology, UND, 22 pp.

Hach Chemical Co. 1975. Procedures, Chemical Lists and Glassware for Water and Wastewater Analysis. 2nd ed. Hach Chem. Co., Ames, Iowa. 127 pp.

Hutchinson, G.E. 1957. A Treatise on Limnology. Vol. I, Part I: "Geography and Physics of Lakes" and Part II: "Chemistry of Lakes". John Wiley and Sons, New York. 1015 pp.

Johannsen, O.A. 1933. Aquatic Diptera. Entomological Reprint Specialists, Los Angeles.

Prescott, G.W. 1973. Algae of the Western Great Lakes Area. William C. Brown Co. Pub., Dubuque, Iowa. 977 pp.

Prescott, G.W. 1970. How to Know the Freshwater Algae. 2nd ed. William C. Brown Co. Pub., Dubuque, Iowa. 348 pp.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Co., Philadelphia. 743 pp.