PHYTOPLANKTON OF SELECTED BORROW PIT PONDS IN NORTHERN ILLINOIS[1]

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Abstract. Hydrobiological characteristics of 7 recent borrow pits resulting from highway construction were studied in 5 northern Illinois counties. Samples were taken from each pond at 10 different dates during the summer period. Half the samples were from the littoral zone and half from the limnetic zone. Measurements of pH, Biological Oxygen Demand, phosphorus, chloride, ammonia, nitrate and chlorophyll values were highly variable among the ponds. Fifty-nine species and varieties of phytoplankters, representing 38 genera and 5 divisions, were recorded. Relative abundance and general distribution of taxa varied considerably among borrow pits, as did the mean algal densities. Younger borrow pits had diversity indices lower than those of older ponds. Three species were present in all ponds. These were: *Eudorina elegans, Navicula cryptocephala,* and *Nitzschia palea.*

Freeways and other super-highways extending from major cities to suburbs are often constructed through a variety of terrains. In order to make these highways as level as possible, large quantities of land-fill are usually purchased from land owners whose parcels lay relatively close to the areas of highway construction. After excavation, large pits or basins remain, which eventually become filled with water. These ponds, are referred to as *borrow-pit* ponds.

The physico-chemical parameters and the types of organisms which inhabit borrow-pit ponds are insufficiently known. Adrian *et al* (1970) and McCarraher *et al* (1974) have studied some hydrobiological characteristics in Nebraska borrow-pit ponds; however, to my knowledge these appear to be the only 2 studies published.

In 1974, the Illinois Department of Transportation extended a portion of an east-west tollway system in northern Illinois, creating new borrow-pit ponds in its wake. This occurrence provided an excellent opportunity to study relatively new borrow-pit ponds and to compare their phytoplankton composition and community structure (in terms of species diversity) to that of ponds in existence for a longer period of time.

1 = Arbor Lake
2 = McDowell Pond
3 = Nichols Pond
4 = Marquardts Pond
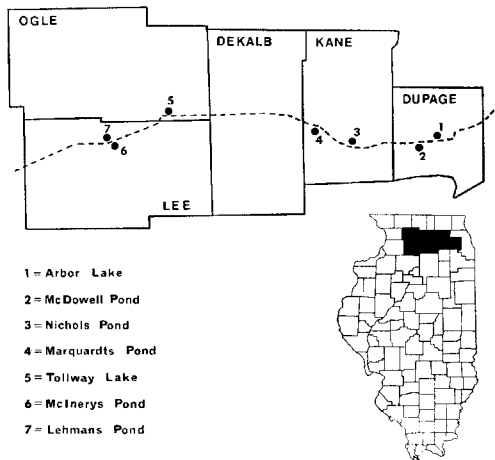5 = Tollway Lake
6 = McInerys Pond
7 = Lehmans Pond

FIGURE 1. Map showing the location of the study. The broken line represents the tollway (Illinois-5). Pond locations are depicted by the blackened circles.

MATERIALS AND METHODS

The borrow-pit ponds chosen for study are located along a 91.8 mi (147.7 km) stretch of the Illinois 5 (East-West) tollway system in northern Illinois. The tollway extends through productive farmland, in general, which spans

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DuPage, Kane, DeKalb, Ogle, and Lee counties (fig. 1). Pond locations and their physical parameters are presented in table 1.

Phytoplankton samples were secured from 7 ponds in 1975 on the following dates: May 16, May 31, June 5, June 10, June 16, June 25, June 27, July 25, August 8, and August 20. Samples were collected at random from 4 or 5 stations in each pond, the number of sampling stations being determined by the pond's surface area (approximately half of the stations were located in the littoral zone and the other half in the limnetic zone). At each station, duplicate samples were collected at the water's surface and approximately one meter off the bottom utilizing a one-liter Kemmerer water sampling device. The samples were drained into polyethylene bottles containing enough formaldehyde to make a 5% solution. In the laboratory, the samples were poured into 1000 ml graduated cylinders, stained with Lugol's solution, allowed to settle down, and then concentrated 10 times.

were counted in terms of units (*i.e.*, unicellular organisms, natural colonies, and 300 μm trichome segments). Data were expressed as the number of units (cells) per liter. The principal taxonomic references used in identifying the various phytoplankton entities included Hustedt (1930), Tiffany and Britton (1952), Prescott (1962), and Patrick and Reimer (1966, 1975).

In order to determine more carefully the diatom species encountered, permanent slides were made of all samples. A glass coverslip (2.2 cm²) containing 5 drops (0.25 ml) of the concentrated sample was heated at 500 °C for 20 min to remove by incineration the organic matter. Following incineration, the coverslip was inverted on a standard microscope slide containing a drop of Carmount mounting medium. The coverslip was heated on a hot plate (at 90 °C) for 2–3 min to remove the mounting medium solvent. The mount was then examined with the oil immersion lens. A horizontal strip on the slide was chosen at random for the counting of and recording of the

TABLE 1
Physical Parameters For Illinois—5 Borrow-Pit Ponds.

Pond Name*	Age(yr)	Co.	Location	Surface Area(ha)	Mean Depth(m)
Arbor Lake	13	DuPage	T–38–N R–10–E Sect. 3	5.2	6.9
McDowell Pond	8	DuPage	T–38–N R–9–E Sect. 2	3.7	1.5
Nichols Pond	2	Kane	T–39–N R–7–E Sect. 4	2.2	3.5
Marquardts Pond	2	Kane	T–39–N R–6–E Sect. 15	1.7	3.6
Tollway Lake	1	Ogle	T–40–N R–2–E Sect. 32	5.3	3.4
Lehmans Pond	1	Lee	T–39–N R–11–E Sect. 6	2.9	3.0
McInerys Pond	1	Lee	T–39–N R–11–E Sect .5	4.5	3.7

*Ponds are arranged in order of age.

One ml of this concentrated sample was transfered into a Sedgwick-Rafter counting cell by means of a 1 ml pipette. The cell was allowed to stand 15 min prior to examination to permit the majority of the organisms to settle to the bottom. It was then placed on the mechanical stage of an Olympus, phase-contrast, light microscope and examined by using a 20× objective and a 10× ocular. Phytoplankters were enumerated, using the strip counting method following the procedures outlined in APHA (1971). Cells containing chloroplasts

respective taxa. Examination of the slide was considered complete when a count of 300 cells was obtained. The number (n) of any given species per liter was determined by the relationship: $n = \%$ in diatom count × total diatom count per liter (obtained from the Sedgwick-Rafter cell count).

Various chemical parameters were monitored throughout this study. These included: pH, Biological Oxygen Demand (B.O.D.), total phosphorus, chloride, ammonia, nitrate, and chlorophyll *a*. Concentrations were deter-

mined by following the procedures outlined in APHA (1971). Water samples for chemical analysis were tested on the same day of their procurement in the laboratory.

Shannon species diversity indices and evenness values were calculated following the procedures described by Zar (1968).

RESULTS

Mean biological oxygen demand (B.O.D.), phosphorus, chloride, ammonia, nitrate, and chlorophyll a values were highly variable among the ponds studied (table 2). Each pond also tended to possess a wide range of pH (see table 2), suggesting that each individual pond possessed its own unique chemical environment. Other chemical parameters were monitored occasionally during the study (i.e., alkalinity, conductivity, and silica), and their values also showed a high degree of variability. (The additional data can be made available upon request. It was excluded from table 2 due to its incompleteness for many ponds.)

and general distribution of the taxa were quite different among the borrowpit ponds. Noteable was the variability among the mean algal densities calculated for the respective ponds (table 4). Phytoplankters were placed into one of 4 categories depending on their mean relative abundance within a given pond's community: rare = phytoplankton species comprising less than 1%; uncommon = species comprising from 1 to 5%; common = species comprising from 5 to 10%; abundant = species making up more than 10%. This general scheme was previously applied to attached diatom communities by Lowe and McCullough (1974).

A total of 41 taxa were recorded from Arbor Lake. *Asterionella formosa*, *Stephanodiscus hantzschii*, and *Trachelomonas volvocina* were found to be abundant. Other species found to be common were *Fragilaria vaucheriae* and *Merismopedia glauca*. These 5 species

TABLE 2

*Chemical Parameters For Illinois—5 Borrow-Pit Ponds.**

Pond Name*	pH (range)	B.O.D.** (ppm O_2)	Total Chloride (mg/l)	Total Phosphorus (mg/l as PO_4)	Nitrate (mg/l)	NH^3 (mg/l)	Chlorophyll a (mg/m^3)
Arbor Lake	7.7–8.4	1.0	65.56	0.13	0.44	0.02	12.37
McDowell Pond	7.9–8.4	1.7	63.64	0.23	0.15	0.28	6.62
Nichols Pond	7.7–8.2	1.0	8.02	0.23	0.18	0.00	1.81
Marquardts Pond	7.5–8.7	1.7	53.49	0.15	1.03	0.01	3.95
Tollway Lake	7.7–8.0	1.2	16.43	0.26	4.57	0.14	38.05
Lehmans Pond	7.4–8.1	1.8	49.19	0.18	0.21	0.10	7.28
McInerys Pond	7.8–8.1	0.6	7.64	0.59	0.23	0.26	7.65

*Ponds are arranged in order of age.   Data within the table represent mean concentrations.
**B.O.D. = Biological Oxygen Demand.

Representing 38 genera and 5 divisions, 59 species and varieties of phytoplankters were recorded from the borrowpit ponds (table 3). Diatoms (Chrysophyta, Bacillariophyceae) were represented by the greatest number of species. Species of Chlorophyta, Euglenophyta, Cyanophyta, Chrysophyta (Chrysophyceae), and Pyrrophyta followed in abundance, respectively.

Species found to be abundant in one pond were not always found in abundance in the other ponds. One can see from table 3 that the relative abundance

account for 70.7% of the mean summer density observed for this pond (table 4).

From McDowell Pond, 36 species were recorded, 7 of which were found to be common or abundant: *Cyclotella operculata, Cocconeis pediculus, Eudorina elegans, Melosira granulata* var. *angustissima, Nitzschia sigmoidea, N. sublinearis*, and *Scenedesmus* sp. Together they account for 80.6% of the mean summer density depicted within table 4.

Nichols Pond contained 16 phytoplankters, 6 of which were found to be common or abundant: *Achnanthes micro-*

TABLE 3

Phytoplankton From Illinois—5 Borrow-Pit Ponds.

Phytoplankton Taxa*	AL	MD	NI	MA	TL	LE	MI
CHLOROPHYTA							
Closterium sp.	—	—	—	—	R	—	—
C. moniliferum	—	—	R	—	—	—	—
Cosmarium sp.	R	—	R	—	R	R	R
Eudorina elegans	R	A	U	R	R	U	A
Gonium pectorale	—	R	—	—	—	—	—
Pediastrum duplex	R	R	—	-	—	—	—
P. simplex	—	R	—	—	—	—	—
Scenedesmus sp.	—	C	—	—	R	—	—
Staurastrum sp.	R	R	—	—	—	—	—
CHRYSOPHYTA							
(Chrysophyceae)							
Dinobryon sertularia	R	—	—	R	—	—	—
CHRYSOPHYTA							
(Bacillariophyceae)							
Cyclotella meneghiniana	U	R	—	—	A	—	—
C. operculata	R	A	A	A	—	—	—
C. pseudostelligera	—	U	—	A	—	A	A
Melosira granulata	—	U	—	—	—	—	—
M. granulata var. angustissima	—	U	—	—	—	—	—
M. varians	U	—	—	R	—	—	U
Stephanodiscus hantzschii	A	—	—	C	—	—	—
Achnanthes lanceolata	—	U	—	—	—	R	—
A. microcephala	R	U	C	U	—	—	R
Amphora ovalis	R	—	—	—	—	—	—
A. ovalis var. pediculus	—	—	—	—	R	—	—
Asterionella formosa	A	—	—	—	—	—	R
Cocconeis pediculus	R	C	—	—	—	—	—
C. placentula	U	R	—	—	—	—	—
Cymatopleura elliptica	—	—	—	—	R	—	—
C. solea	R	—	R	U	R	—	R
Cymbella sp.	—	—	—	R	—	—	R
C. affinis	—	—	—	R	—	R	—
C. minuta	—	—	—	—	R	—	—
Eunotia curvata	R	—	—	—	—	—	—
Fragilaria construens	—	R	—	—	—	—	—
F. crotonensis	U	—	—	—	—	—	—
F. vaucheriae	C	U	—	—	—	—	R
Gomphonema olivaceum	R	R	—	—	—	—	—
Gyrosigma	U	U	U	R	R	U	—
Navicula sp.	—	—	—	—	—	R	—
N. arvensis	—	—	—	U	—	—	—
N. capitata	R	R	—	—	—	—	—
N. cryptocephala	U	U	U	U	C	A	C
N. cryptocephala var. veneta	U	R	R	U	R	U	—
N. cuspidata	—	—	—	R	—	—	—
N. decusis	R	—	—	—	—	—	—
N. graciloides	—	—	—	R	R	—	—
N. pupula	—	R	—	—	—	—	—
N. pupula var. rectangularis	—	—	—	—	R	—	—
N. rhyncocephala	—	—	—	U	—	—	—
N. tridentula	—	—	U	—	—	—	—
Nitzschia acicularis	—	R	—	U	R	—	—
N. amphibia	—	U	C	—	R	—	—
N. hungarica	R	R	—	—	R	—	—
N. palea	U	U	A	U	U	U	A
N. sigmoidea	R	A	C	—	R	—	—
N. sublinearis	R	A	A	U	—	A	U

TABLE 3.—*Continued.*

Phytoplankton Taxa*	AL	MD	NI	MA	TL	LE	MI
N. vermicularis	R	R	—	—	—	—	—
Pinnularia sp.	R	U	—	—	R	—	—
Rhoicosphenia curvata	U	—	—	—	—	—	—
Rhopalodia gibba	R	R	—	—	—	—	—
Stauroneis phoenicenteron	—	R	—	—	—	—	—
Surirella angustata	R	—	R	—	—	R	—
S. ovata	R	—	—	R	—	—	—
Synedra acus	—	—	—	C	—	—	—
S. ulna	R	R	—	—	—	—	—
CYANOPHYTA							
Anabaena sp.	R	—	—	—	—	R	—
Merismopedia glauca	C	—	—	R	R	—	—
Microcystis sp.	R	—	—	U	—	—	—
Oscillatoria sp.	—	R	—	—	—	—	—
EUGLENOPHYTA							
Euglena sp.	—	R	—	C	—	R	U
Phacus pleuronectes	—	—	—	—	R	—	—
Trachelomonas robusta	—	—	—	—	—	R	—
T. volvocina	A	—	—	—	U	—	U
PYRROPHYTA							
Ceratium hirundinella	U	—	—	—	—	—	—
Glenodinium sp.	R	—	R	—	—	—	—

*The arrangement of the taxa follows a plan previously used by Prescott (1970).
A=abundant, relative abundance greater than 10%.
C=common, relative abundance 5–10%.
U=uncommon, relative abundance 1–5%.
R=rare, relative abundance less than 1%.
—=not observed.

AL =Arbor Lake   TL=Tollway Lake
MD=McDowell Pond   LE=Lehmans Pond
NI =Nichols Pond   MI =McInerys Pond
MA =Marquardts Pond

cephala, *Cyclotella operculata, Nitzschia amphibia, N. palea, N. sigmoidea,* and *N. sublinearis.* Over 77.7% of the calculated mean summer density (table 4) was attributed to the presence of these taxa.

Marquardts Pond possessed 25 phytoplankton species. Two taxa were found to be abundant (*Cyclotella operculata* and *C. pseudostelligera*), and 3 were common (*Euglena* sp., *Stephanodiscus hantzschii,* and *Synedra acus*). These taxa accounted for 74.0% of this pond's mean summer density (table 4).

Out of the 23 species identified from Tollway Lake, only *Cyclotella meneghiniana* was found to be abundant. The other common taxon encountered in this pond was *Navicula cryptocephala.* To-

gether they account for 88.1% of this pond's mean summer density (table 4).

Cyclotella pseudostelligera, Eudorina elegans, and *Nitzschia palea* were found to be abundant in McInerys Pond. The only other taxon common to this pond was *Navicula cryptocephala.* The remaining 11 species found in this pond's flora accounted for only 9.3% of the mean summer density (table 4).

TABLE 4

Mean Summer Algal Densities For Illinois—5 Borrow-Pit Ponds.

Pond Name*	Mean Summer Density (10⁴ cells/ℓ)
Arbor Lake	139.96
McDowell Pond	63.54
Nichols Pond	57.63
Marquardts Pond	103.06
Tollway Lake	1636.75
Lehmans Pond	142.18
McInerys Pond	27.89

*Ponds are arranged in order of age.

Although only 3 species were found to be common or abundant, *Cyclotella pseudostelligera, Navicula cryptocephala,* and *Nitzschia sublinearis,* 15 species were found in Lehmans Pond. Considering the mean summer density calculated for this pond (table 4), 90.0% of it is accounted for by the presence of these 3 species.

Shannon species diversity indices and evenness values were calculated and employed to compare the ponds' community structure. The species diversity indices depicted in table 5 revealed that younger borrow-pit ponds (*i.e.,* Lehmans Pond, McInerys Pond, and Tollway Lake) had diversity indices that were lower than those of the older ponds. In addition, species diversity tended to increase with pond age. Table 5 shows that ponds with lower diversity indices also possessed the lower evenness values (evenness describes how homogeneously the individuals are apportioned among the species). Ponds containing the lower evenness values were not generally rich in species numbers, and their communities were being dominated by a relatively few number of species. Zooplankton taxa

collected from these same ponds showed the same general trends.

TABLE 5

Mean Shannon Species Diversity Indices and Evenness Values For Illinois—5 Borrow-Pit Ponds.

Pond Name*	Species Diversity	(Evenness)
Arbor Lake	1.2	(7.1)
McDowell Pond	1.1	(7.2)
Nichols Pond	0.9	(7.8)
Marquardts Pond	0.9	(7.0)
Tollway Lake	0.4	(3.1)
Lehmans Pond	0.5	(4.5)
McInerys Pond	0.6	(5.8)

*Ponds are arranged in order of age.

DISCUSSION

Of the 59 taxa identified in this study, only *Eudorina elegans, Navicula crytocephala,* and *Nitzschia palea* were present in the floral lists of all 7 ponds. These species are considered perhaps by many investigators to be cosmopolitan in their distribution. The eurytopic nature exhibited by these organisms (the ability to exist in a wide variety of chemical environments) may permit them to colonize borrow-pit ponds more readily than the more selective species.

The appearance of certain phytoplankters in one pond and their apparent absence in another pond is probably attributed to differences in physico-chemical features and to the phenomenon of chance. The former would not only include variations in water chemistry parameters and local land use features (*i.e.,* urban *vs* agricultural areas), it could also include geological differences. The element of chance is perhaps more complex, and there are numerous factors that govern it in ponds (Talling 1951) such as:

1. the frequency of occurrence of the organism in nature,

2. the ability of the organism to form resistant reproductive bodies,

3. external agencies of dispersal (*i.e.,* wind, birds, animals, insects, etc.),

4. local factors (*i.e.,* age and area of ponds and/or the distance of separation from other water bodies).

Invasion rate is probably an important factor controlling phytoplankton diversity in borrow-pit ponds. In the newer ponds, depending upon their geographical location, there is a limited number of species capable of colonizing any given pond. Out of the original colonizers, it is apparent that only a few species were forming significant populations in the phytoplankton community. Evidence for this assumption is the low diversity indices and evenness values found within the newer ponds. As the borrow-pit ponds became older, continuous invasion (making changes in the numbers of species) along with other phenomenon increased the diversity (*i.e.*, changes in the distribution within the species, increases in the variety of niches, more stable environments, and succession; Monk 1967). One can only speculate at present that diversity indices in the borrow-pit ponds are asociated with invasion rates. Patrick (1967) has shown, however, that diversity indices obtained from diatoms colonizing glass slides were attributable to invasion rates.

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