THE

ONTARIO WATER RESOURCES

COMMISSION

BIOLOGICAL SURVEY

of

LAKE ST. JOHN

1967

BIOLOGICAL SURVEY
OF
LAKE ST. JOHN
1966 - 1967

by

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SUMMARY AND CONCLUSIONS

In September of 1966, a general biological survey of Lake St. John was carried out to determine the pollution status of the lake. This information indicated that the lake was not grossly altered by waste discharges from Chemical Developments of Canada Limited; however, toxic conditions were evident at the sampling site most proximal to the chemical plant.

A more intensive sampling programme was undertaken in September of 1967 in order to define the zone of toxic pollution. Both chemical and biological parameters indicated a graduation of water quality extending outward from the main discharge. The zone of toxic pollution established by biological parameters extended 600 feet east, 600 feet north-east and 900 feet north of the main effluent outlet.

The blue-green algae *Anabaena* and *Aphanizomenon* were present in extremely high numbers in Lake St. John. Both these forms of algae are capable of collecting in large masses sufficient to form algae blooms. Nutrients present in the surface water of the lake were sufficient to foster high algae populations.

RECOMMENDATIONS

1. As agreed to by Chemical Developments of Canada Limited and the Division of Industrial Wastes, stage two of the waste treatment system proposed for this industry should be installed and made operational by August 1, 1968.

2. A survey of the adequacy of septic tank installations at cottage sites should be undertaken.

3. Further studies should be undertaken to evaluate the possible relationship between nutrient inputs from Mud Lake and the nutrient budget of Lake St. John in order to determine whether diversion of the flow from Mud Lake would significantly reduce nuisance algal production.

BIOLOGICAL SURVEY OF LAKE St. John - 1966 - 1967

INTRODUCTION

During the summer of 1966, a minor fish kill and several nuisance algae blooms occurred in Lake St. John. These problems resulted in a number of enquiries concerning the pollution status of the lake. As a result, a biological survey was undertaken to determine the effects of industrial wastes being discharged to the lake from Chemical Developments of Canada Limited.

Biological parameters provide direct evidence of water quality impairment and because of the extended cycle of bottom dwelling animals, standing populations reflect water quality over a period of several months prior to the investigation.

GENERAL DESCRIPTION OF LAKE St. John

Lake St. John, situated in Rama Township near Orillia, is a lake of approximately 1300 acres with depths of 25 feet or less. During the spring thaw and runoff, a shallow productive lake to the south-east known as Mud Lake overspills into Lake St. John. The only discharge from Lake St. John is via St. John Creek, which joins the Black River flowing into Lake Couchiching. The Trent Canal Authority controls the lake level by stop logs at the head of the creek. During the summer months there is neither inflow nor outflow to or from the lake.

The northern and eastern shores of the lake lie within the Rama Indian Reserve. The southern shores support approximately 70 cottages. Chemical Developments of Canada Limited and the village of Langford Mills are situated at the south-western corner of the lake. This industry was producing ABS, the basic cleaning component of synthetic detergents, at the time of the 1966 survey.

METHODS

A general survey of the bottom fauna, phytoplankton and water chemistry of Lake St. John was carried out in September, 1966. A perusal of these data indicated that more intensive sampling would be required in the immediate vicinity of the waste inputs from Chemical Developments of Canada Limited in order to allow an accurate assessment of the effects of these wastes on the water quality of Lake St. John. A second survey of the lake was carried out in September, 1967 to provide this additional evaluation. Sampling techniques were employed as outlined hereafter.

Chemical characteristics of sewered wastes

Information on waste loadings to Lake St. John from Chemical Developments of Canada Limited were obtained from files of the Division of Industrial Wastes. Grab samples of wastes from each of the three discharge sewers from this industry were collected September 27, (6 p.m.) and September 28, (10 a.m.), 1966, to complement surface water sampling on Lake St. John.

Chemical characteristics of surface waters

In 1966, a single surface water sample was collected from each of the 14 sample locations illustrated in Figure 1. Sampling in 1967 was intensified in the vicinity of the chemical plant. Three transects designated as east, north-east and north were sampled at distances of 50, 100, 200 300, 600 and 900 feet from the central discharge sewer. Analyses performed on the 1966 water samples included: BOD, COD, suspended solids,

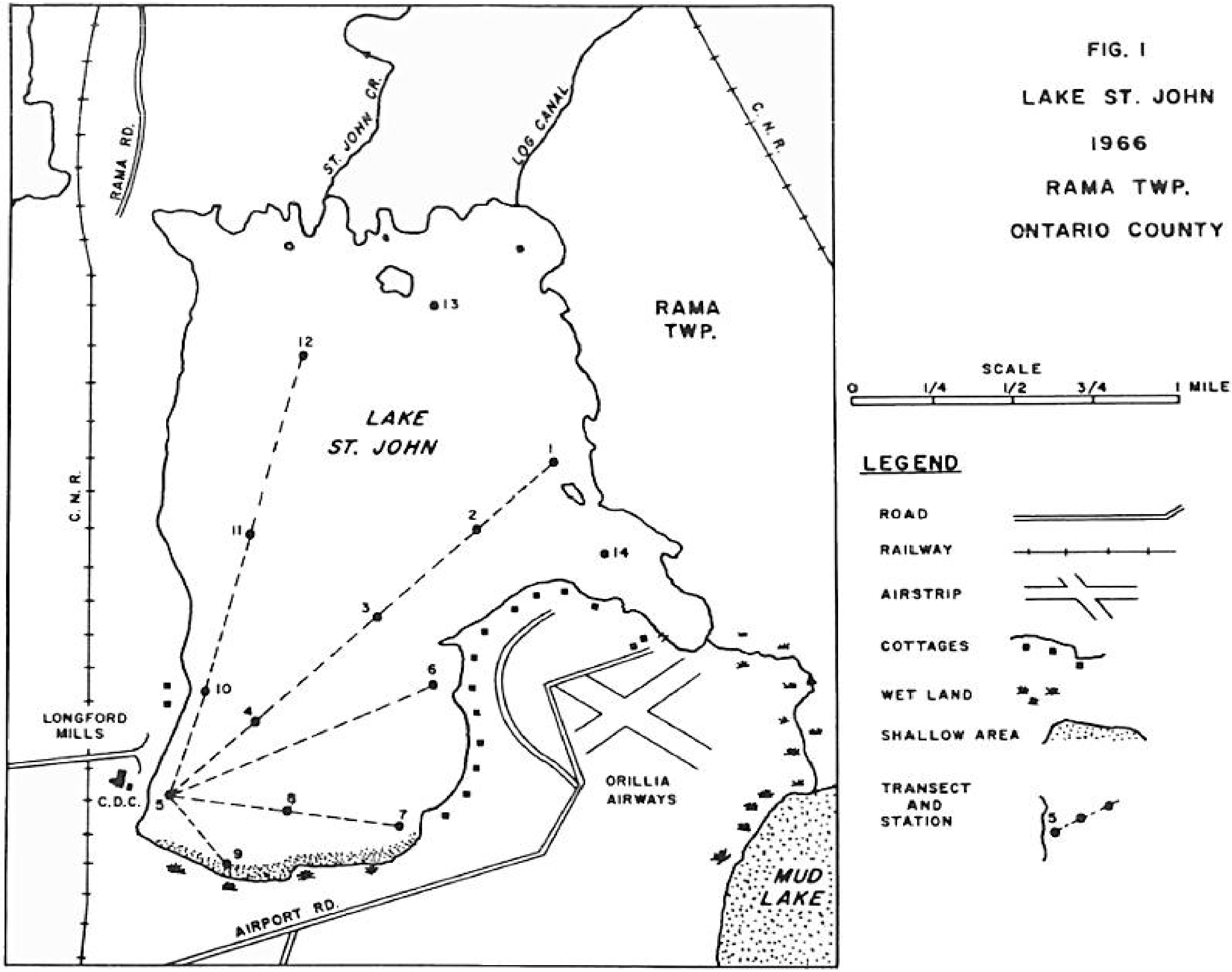

FIG. I

LAKE ST. JOHN

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ONTARIO COUNTY

dissolved solids. Kjeldahl nitrogen, total phosphorus, phenols and ether solubles. Solids determinations were not requested for the 1967 water samples.

Bottom fauna

In 1966, animals living in or on the bottom sediments were examined at each of the 14 stations illustrated in Figure 1. In 1967, more intensive sampling of the bottom fauna was carried out in the immediate vicinity of the chemical plant. The transects designated as east, north-east and north were sampled at distances of 50, 100, 150, 200, 250, 300, 400, 600, 900. 1200 feet from the central discharge outlet.

All bottom fauna samples were secured with an Eckman dredge (9 x 9 inches). Invertebrates were removed from the sediments, preserved in 95% alcohol and returned to the laboratory for subsequent identification and enumeration.

Phytoplankton

Five near-surface water samples were collected from Lake St. John, which were analysed at the laboratory for composition and abundance of microscopic plant life (algae).

RESULTS

Chemical characteristics of sewered wastes

In 1966, waste loadings from Chemical Developments of Canada Limited were calculated by the Division of Industrial Wastes to be 262 lbs. BOD., 19 lbs. ether solubles and 22 lbs. suspended solids in a total estimated daily flow of 232,000 gallons. Chemical characteristics of the wastes being discharged during the 1966 biological investigation are presented in the following table.

Table 1. Chemical characteristics of wastes present in three discharge sewers from Chemical Developments of Canada Limited, Langford Mills, September, 1966.

	Northern Discharge	Central Discharge	Southern Discharge
BOD	185 (2)	177 (2)	2.1 (2)
COD	763 (2)	757 (2)	47 (1)
Suspended solids	55 (2)	50 (1)	(0)
Dissolved solids	812 (2)	462 (1)	(0)
pH	7.2 (2)	5.0 (2)	7.4 (1)
ABS	166 (2)	86 (1)	(0)
Total Kjeldahl	47.7 (2)	14.0 (2)	1.2 (1)
Total Phosphorus	0.24 (2)	0.45 (2)	0.13 (1)
phenol (ppb)	4,500 (20)	1150 (2)	0.0 (2)
Ether solubles	118 (2)	109 (2)	0.0 (2)

(1) Number of determinations indicated in parentheses.

(2) All parameters except pH and phenols are recorded in (ppm) parts per million.

The southern discharge appeared to contain relatively unaltered water. Extremely high concentrations of BOD, COD, dissolved solids and phenols were being discharged through the northern and central sewers.

Chemical characteristics of surface water

In 1966, the water chemistry of Lake St. John was examined at 14 widespread stations (Figure 1) encompassing all sections of the lake. Water quality was not markedly different at any of these stations and there was no apparent change in quality which could be related to discharges from Chemical Developments of Canada Limited. These results appear in Table 2. Concentrations of nutrients throughout the lake were exceptionally high. Total Kjeldahl nitrogen averaged 0.94 ppm and the average concentration of phosphorus was 0.10 ppm. The significance of these concentrations will become apparent in a following section of this report dealing with phytoplankton.

In 1967, more intensive sampling was performed in the immediate vicinity of the chemical plant. These results (Table 3) revealed distinct decreases in levels of BOD, COD, and phenols with increased distance from the main sewer.

Table 2. Chemical characteristics of the surface waters at 14 locations on Lake St. John, September, 1966.

Station	BOD	COD	Suspended Solids	Dissolved Solids	pH at Lab.	Total Kjeldahl	Total Phosphorus	Phenol (ppb)	Ether Solubles
1	3.0	66	-	-	-	-	0.12	0.0	0.0
2	2.6	31	-	-	7.6	-	0.10	0.0	-
3	3.0	31	-	-	7.8	-	0.10	0.0	0.0
4	1.8	34	-	-	6.8	0.78	0.12	0.0	-
5	1.8	38	15	167	7.5	1.10	0.12	6.0	15
6	1.6	27	11	153	7.2	0.91	0.10	0.0	0.0
7	5.2	23	-	-	7.4	1.05	0.12	2.0	0.0
8	5.2	38	-	-	7.5	0.98	0.12	2.0	0.0
9	2.2	8	-	-	-	1.05	0.10	0.0	0.0
10	4.0	23	-	-	7.8	0.98	0.05	0.0	0.0
11	3.2	34	-	-	7.6	1.30	0.05	0.0	0.0
12	3.2	31	-	-	-	0.98	-	0.0	0.0
13	3.2	31	-	-	-	1.05	0.05	0.0	0.0
14	3.8	31	-	-	-	1.15	0.14	0.0	2.2

(1) (-) Test not performed

(2) All parameters except pH and phenol are recorded in (ppm) parts per million.

Average levels of BOD at 50, 100, 200, 300, 600 and 900 feet were 15, 18, 6.4,4.8, 4.0 and 2.2. Concentrations of COD at the same locations were 73, 64, 42, 44, 43 and 38 and average phenol levels were 8, 6.9, 3.9, 4.3, 3 and 4.

Table 3. Chemical characteristics of the surface waters of Lake St. John at six ranges from the central discharge from Chemical Developments of Canada Limited, September, 1967. Results express averages for three samples.

	BOD (ppm)	COD (ppm)	Phenol (ppb)	Total Phosphorus (ppm)	Total Kjeldahl (ppm)
50 feet	15	73	8.0	0.89	1.20
100 feet	18	64	6.9	0.08	1.06
200 feet	6.4	42	3.9	0.13	1.11
300 feet	4.8	44	4.3	0.10	1.06
600 feet	4.0	43	3.0	0.19	0.93
900 feet	2.2	38	4.0	0.33	0.64

Biological assessment of water quality

In 1966, collections of bottom fauna were made at each of the 14 stations illustrated in Figure 1. From these data (Table I of the Appendix) Lake St. John appears to be divided into two discrete environments, the differences bearing no relationship to water quality. The northern two-thirds of the lake is relatively deep and unproductive whereas the southern third of the lake is a shallow, highly productive environment containing a varied and abundant fauna.

An impairment of water quality was indicated at station 5 which was devoid of life. Toxic conditions at this station would not be surprising, in view of its proximity to the chemical plant. In order to permit a more definite appraisal of this condition, bottom fauna sampling in 1967 was intensified in the vicinity of Chemical Developments of Canada Limited. Results of this survey are listed in detail in Table II of the Appendix and are presented diagrammatically in Figure 2.

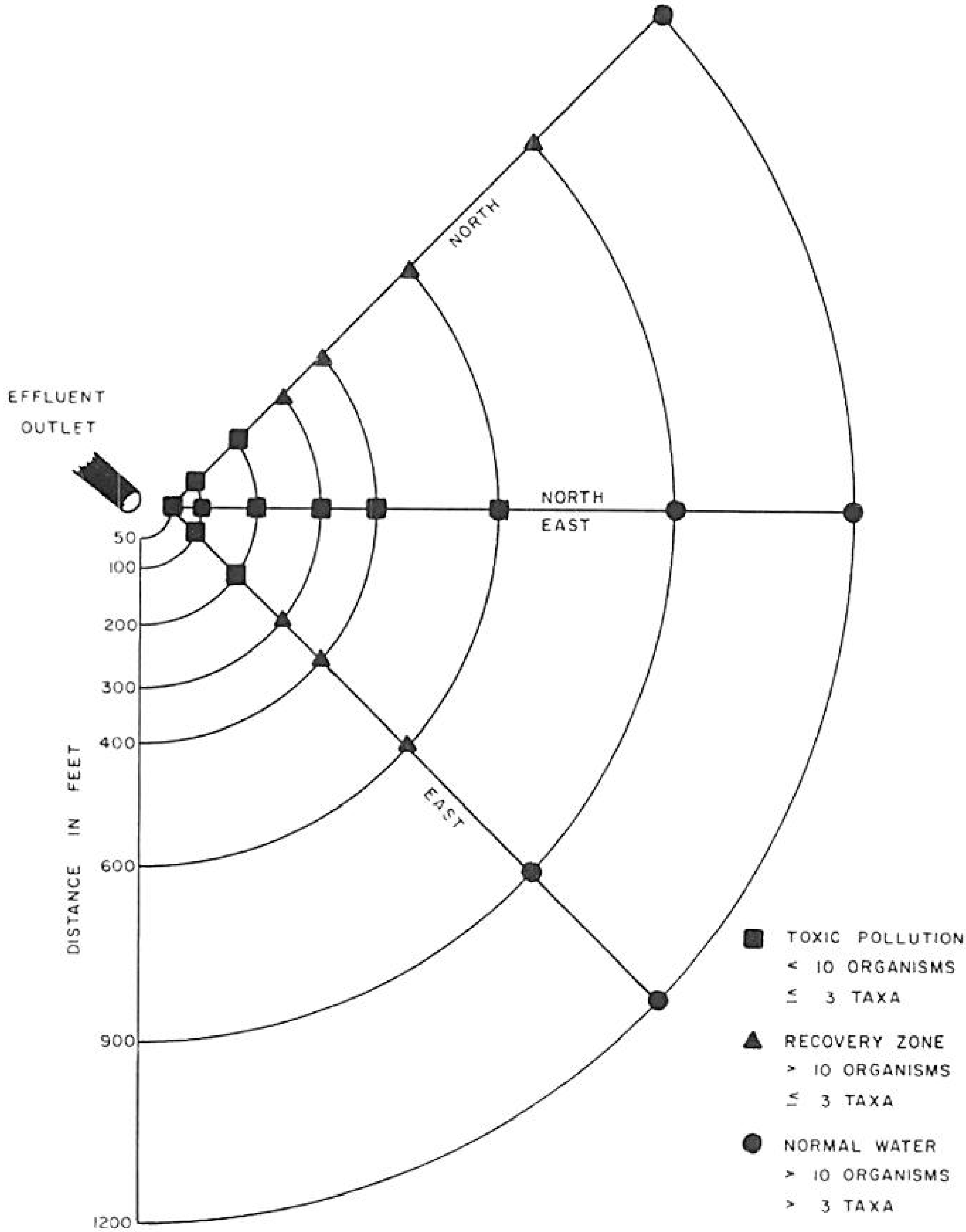

FIG. 2. Pollution status at 22 stations on Lake St. John in the immediate vicinity of main wastes discharge from Chemical Developments of Canada Limited September, 1967.

Toxic pollution alters bottom fauna communities towards fewer taxa and decreased numbers of organisms. Applying this principle, three zones of water quality were suggested, defined arbitrarily as: toxic — having three or fewer taxa and less than 10 organisms; recovery — having three or fewer taxa but more than10 organisms; and normal — having more than three taxa and greater than 10 organisms.

Generally, the results indicated a progressive change in bottom fauna similar to the previously described graduation in water chemistry. Toxic conditions existed up to 200 feet east, 600 feet north-east and 200 feet north of the central discharge. The zone of recovery was indicated between distances of 200 to 900 feet on the east transect, 600 to 900 feet on the north-east transect, and 200 to 1200 feet along the north transect. Normal water was indicated at distances of 900 feet south, 900 feet north-east and 1200 feet north of the central discharge from Chemical Developments of Canada Limited.

Phytoplankton

Five surface water samples from Lake St. John were analyzed to determine the standing crop of phytoplankton. These results appear in Table III of the Appendix. A distinctive feature of these samples was the presence in very high numbers of the nuisance blue-green algae *Anabaena* and *Aphanizomenon*. Also identified were the akinetes of *Aphanizomenon*. These cells are a modification of the vegetative cell and are better adapted to carry the alga over unfavourable conditions. Probably even higher numbers of *Anabaena* and *Aphanizomenon* would have been present under more favourable environmental conditions.

Aphanizomenon and *Anabaena* in late summer and fall periods are capable of collecting in large masses sufficient to form "algae-blooms". These blooms develop because millions of the tiny plants are buoyed to the surface by gas bubbles and oily degradation products which have a lower specific gravity than water. Foul odours develop when large numbers of blue-green algae accumulate along shorelines and in embayment areas of lakes. The malodorous conditions develop from products of decomposition as the algae begin to die, and fish kills sometimes materialize in shallow bays where dissolved oxygen is depleted by the decomposing plant mass.

Aphanizomenon and *Anabaena* are two forms that are able to fix atmospheric nitrogen. Therefore. the presence of phosphate alone is sufficient to initiate blooms in waters where all other aspects of the environment are favourable. It has been stated that a concentration of 0.01 mg/L of soluble phosphorus (p) at the start of the growing season is sufficient to produce nuisance algae blooms. (Sawyer). The mean concentration of total phosphorus (13 samples) from Lake St. John was 0.10 mg/L

These samples were collected in September. It is reasonable to assume that much of the available phosphorus had already been tied up by algae and carried to the lake bottom over the summer months. In any event, the concentration of phosphorus in Lake St. John was sufficient to suggest continued nuisance problems. The situation is particularly acute due to the nature of Lake St. John. As explained previously, the lake is virtually a closed system during the summer months. There is very little inflow or outflow of water.

Any input of nutrients into the lake remains trapped and becomes available for algae production. Nutrients which are fixed by the algae and carried to the lake bottom during the productive season are re-cycled in the aquatic environment after decomposition occurs over the winter months.

To properly assess the nutrient problem of Lake St. John, consideration should be given to the standing levels of nutrients present in the lake, as well as an understanding of nutrient inputs and outputs. Outputs are limited to spring overflow through St. John Creek, as well as removal as fish flesh and emerging aquatic insects. Inputs include overflow from Mud Lake, discharge from the chemical plant, seepage from cottage sanitary facilities, land drainage, precipitation, leaves, pollen, and bird excrements.

Probably the greatest single source of nutrients entering Lake St. John is the discharge from the highly eutrophic Mud Lake, and the absence of water exchange is the most important factor controlling the nutrient budget of the lake.

REFERENCE

Sawyer, C.N.1952.Some New Aspects of Phosphates in Relation to Lake Fertilization, Sewage and Industrial Wastes, Vol. 24, No. 6, pp. 768 - 776.

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APPENDIX

Table I. Macroinvertebrates collected at 14 locations on Lake St. John, September, 1967.

Table II. Bottom fauna collected from three transects on Lake St. John in the immediate vicinity of main discharge from Chemical Development of Canada Limited, September, 1967.

Table III. Standing crop of phytoplankton (Areal Standard Units) at five locations on Lake St. John, September, 1966.

Table I. Macroinvertebrates collected at 14 locations on Lake St. John, September, 1966.

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CADDISFLIES														
Leptocella							1		6					
Oecetis									3					
MAYFLIES														
Hexagenia											1		1	1
Caenis									47					
Ephemerella									42					
Paraleptophlebia									2					
DRAGONFLIES														
Epicordulia									3					
DAMSELFLIES														
Ischnura							1		12					
Enallagma									10					
MOLLUSCS														
Pisidium				2		1	2						2	2
Unionidae									1					
Physa							2		8					
Amnicola							5		9					
Valuata							1		1					7
Helisoma								1	2					
Gyraulus						1								
FLIES														
Chironomidae	1	10	2	19		3	8	1	128	7	6	11	4	30
Chaoborus	1	56	9	6				2		6	19	163	25	8
Palopomyia		14		2				3	2			11	1	1
WORMS														
Oligochaeta		33	5	1		1		7	19		2	12	12	4
AMPHIPODS														
Hyalella						8	34		75					
MITES														
Unidentified							1		6					
TURBELLARIA														
Macrostomum						1								
LEECHES														
Unidentified							1							
TOTAL ORGANISMS	2	113	16	30	0	15	56	14	376	13	28	197	45	53
TOTAL TAXA	2	4	3	5	0	6	10	5	18	2	4	4	6	7

Table II. Bottom fauna collected from three transects of Lake St. John in the immediate vicinity of main discharge from Chemical Developments of Canada Limited - September, 1967.

		MAYFLIES	*Caenis*	ALDERFLIES	*Sialis*	DIPTERANS	Tendipedidae	*Chaoborus*	*Palpomyia*	MOLLUSCS	*Pisidium*	Unionidae	*Helisoma*	*Amnicola*	*Valvata*	*Physa*	SLUDGEWORMS	Tubificidae	TRICLADS	*Curtisia*
50'							1													
	E						1													
100'	NE		1				1											1		
	N						5						1					2		
	E																	1		
150'	NE						7													
	N						7													
	E						1											1		
200'	NE						1													
	N																			
	E						7											42		
250'	NE																			
	N						5											17		
	E						22											104		
300'	NE						1													
	N						34													
	E						42						2					76		
400'	NE																			
	N						98		2									11		
	E						40											41		
600'	NE																			
	N						63		2									4		
	E						121	8	5					3				40		
900'	NE				1		54		1		1							15		
	N						44		3									7		
	E						7		2				1	2	9	7		16		1
1200'	NE						99	2	2									13		
	N						36				1	1						1		

Transects: E - East NE - North-east N - North

Table III. Standing crop of phytoplankton (Areal Standard Units) at 5 locations on Lake St. John - September, 1966.

Station		5	7	10	13	14
BLUE GREENS						
Anabaena		712	339			
Aphanizomenon		12,335	9,287	11,474	9,258	14,544
Gomphosphaeria				28		
Oscillatoria		50	118	28	98	
Spirulina		40				
GREENS						
Ankistrodesmus		8	4			
Closterium					51	
Oocystis		40		10		
Pediastrum			79			
Scenedesmus			4			
FLAGELLATES						
Chlamydomonas		28	18	24	16	
DIATOMS						
Asterionella			17		50	
Melosira		875	537	158	327	
Navicula			19			
Pinnularia				30		
Stephanodiscus		41	103	257		
Synedra			6	32	8	
Cyclotella					64	308
Rhizosolenia					117	
Total	a.s.u.	14,094	10,532	12,045	9,487	14,852