WATER QUALITY SURVEY OF SPICER LAKE, ST. JOSEPH COUNTY, INDIANA

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ABSTRACT: Several quantitative physical and chemical parameters were examined to assess the water quality of Spicer Lake, St. Joseph County, Indiana. The objectives of the study were to provide baseline data and to examine the possible effects of runoff entering the lake from the surrounding agricultural areas. Vertical profiles of three locations were collected from July through December, 1990. The parameters studied were temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), pH, Secchi disk transparency, ammonia and nitrate nitrogen, total and orthophosphate phosphorus, and pesticides. Results indicate that the lake is in a dystrophic state. The saturated oxygen and nutrient levels are low except for an accumulation of nutrients at the bottom of the lake. Runoff does not appear to be a problem in the lake, since samples near possible inlets were not significantly different from center samples.

INTRODUCTION

Spicer Lake Nature Preserve is located in the northwest corner of St. Joseph County, Indiana. This swamp forest preserve covers approximately 16 ha and protects several rare plant species. Spicer Lake is circular, covers two ha, and has a maximum depth of 6.1 m (Dineen, 1979). The lake is bordered by a uniform floating vegetation mat, 4-8 m wide, and is surrounded by a red maple swamp forest.

Water quality may be a critical feature in maintaining wetland communities and should be monitored for induced physical or chemical changes that could alter the natural conditions and adversely affect critical species existing in and around the lake. The objectives of this study are to provide baseline data and to determine if the surrounding agricultural operations are affecting the health of the ecosystem. The parameters measured were pH, Secchi disk transparency, dissolved oxygen (DO), temperature, biochemical oxygen demand (BOD), ammonia nitrogen, nitrate nitrogen, total phosphorus, and orthophosphate phosphorus. These were measured from July through December, 1990.

MATERIALS AND METHODS

Samples were collected on 7/2, 7/19, 8/2, 8/21, 9/11, 9/25, 10/11, 11/13, and 12/13 of 1990 approximately 1-2 hours after sunrise. Eight samples were collected to obtain a vertical profile, three at the center (0 m, 2.5 m, and 5 m) and southwest edge (0 m, 2 m, and 3 m) and two at the north edge (0 m and 2 m), for each date except for 12/13/90 when only the center samples were collected. The sampling locations shown in Figure 1 were chosen to determine possible effects of runoff entering the preserve through a culvert west of the southwest edge and the drainage way leading into the north edge of the lake. The farmland to the west of the preserve and pastureland to the north of the preserve caused concern that runoff may contain increased nutrient concentrations. Grab samples were taken at the surface, and a Lab-line Model 4197 sampler was used for all others. DO and temperature were monitored *in situ* at 0.5 m intervals with a portable Yellow Springs (Models 51B and 57) DO meter. Standard air calibration was used to calibrate the DO meter. A pHep Model 0624-00 meter was used to measure pH. A Secchi disk was used for transparency readings. Samples were placed in wet ice for transport back to the laboratory for analyses of BOD, nitrogen, and phosphorous compounds.BOD was obtained by shaking 300 mL of lake water in two BOD bottles for 2 minutes to aerate the sample, measuring the initial DO, measuring the final DO after 5 days of incubation at 20° C, and determining the DO loss. Initial and final DO were measured with a YSI BOD bottle probe. Water soluble ammonia and nitrate nitrogenwere

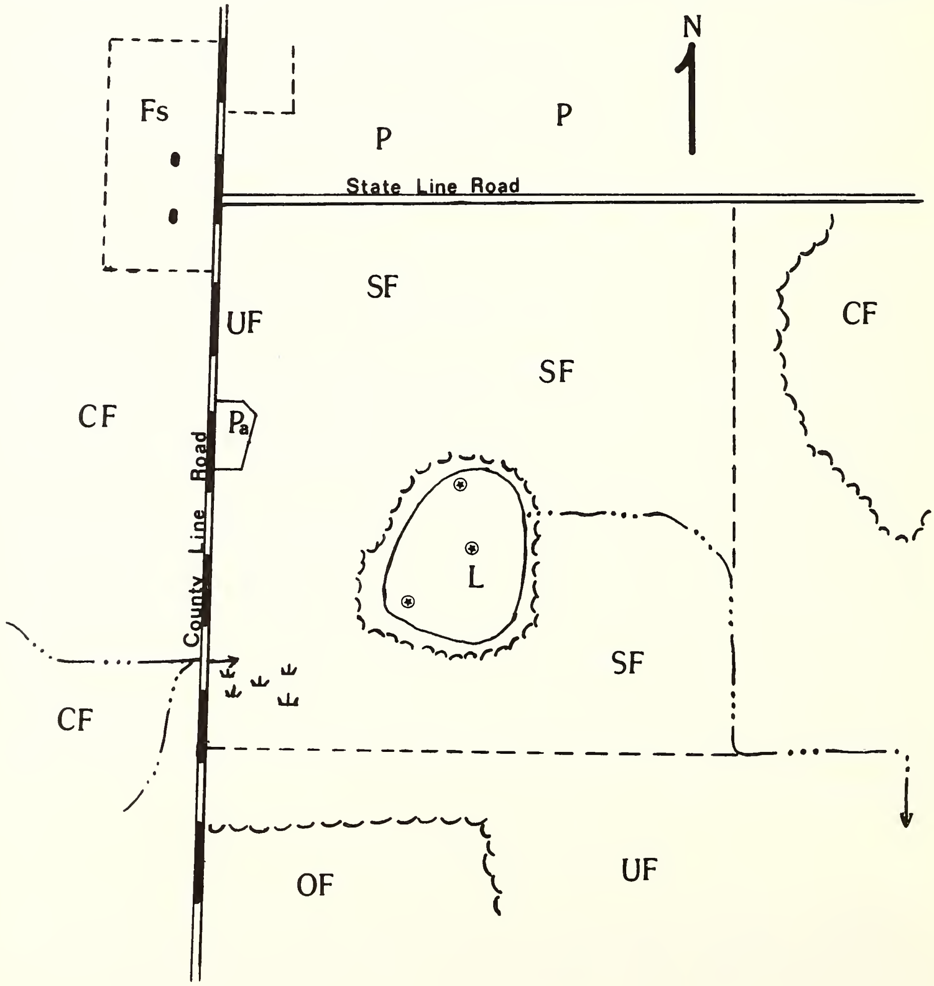

Figure 1. Location of Spicer Lake (L) and surrounding ecosystems, cultivated fields (CF), farmyard (Fs), old field (OF), pasture (P), swamp forest (SF), and upland forest (UF) with the lake sampling locations indicated by stars. The parking lot (Pa) and east and south boundaries (——) of Spicer Lake Nature Preserve, northwest corner of St. Joseph County, Indiana, are shown also.

Table 1. Chemical and physical parameters for Spicer Lake, St. Joseph County, Indiana.

	0m		2-3m		5m	
	Range	Mean	Range	Mean	Range	Mean
pH (standard units)						
7/19-9/11	6.6-7.9	6.9*	6.2-7.6	6.8*	6.2-6.6	6.4*
9/25-12/13	6.1-7.3	6.8*	6.0-7.6	7.1*	5.6-6.8	5.8*
Secchi (cm)						
7/19-9/11	41.0-66.0	55.8				
9/25-12/13	46.0-66.0	58.4				
BOD (ppm O2)						
7/19-9/11	6.0-9.1	7.8	2.8-8.2	4.5	6.7-7.8	6.0
9/25-12/13	2.2-8.0	5.5	1.7-9.0	5.9	2.0-8.2	5.8
NH_3-N (mg N/L)						
7/19-9/11	<0.01-0.06		<0.01-0.07		3.24-4.64	3.97
9/25-12/13	<0.01-0.39		<0.01-0.38		0.38-5.50	2.43
NO_3-N (mg N/L)						
7/19-9/11	<0.01-0.03		<0.01-0.07		0.55-3.09	1.79
9/25-12/13	<0.01-0.01		<0.01-0.09		0.06-2.59	0.84
Total dissolved N (mg/L)						
7/19-9/11	<0.01-0.06		0.01-0.57	0.20	3.79-7.73	5.76
9/25-12/1	<0.01-0.40		<0.01-0.47		0.44-8.09	3.27
Total P (mg/L)						
7/19-9/11	0.044-0.098	0.065	0.031-0.083	0.050	0.233-0.323	0.285
9/25-12/13	0.050-0.099	0.073	0.043-0.119	0.074	0.055-0.148	0.085

*median

measured with an Orion Ammonia Ion Selective Electrode Model 95-12 using the low level procedure (Orion Research Inc., 1987). Persulfate digestion was used for total phosphorus. Total phosphorus and orthophosphate phosphorus were analyzed by the Ascorbic Acid Method (American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1989). A Bausch & Lomb Spectronic 21 spectrophotometer was used for the first three sets of samples and a Perkin Elmer Lambda 6 spectrophotometer was used for all other samples. Pesticide analysis by GC-MS was performed on the samples collected on 10/11/90 by Environmental Health Laboratories using EPA Method 525 (Environmental Protection Agency, 1986).

RESULTS AND DISCUSSION

The results of the sampling indicate slight stratification, low BOD and DO values, and high levels of nitrogen and phosphorous compounds at the bottom center of the lake. The lake water has a brown color and a strong hydrogen sulfide odor. There was no significant horizontal variation of the parameters, although there was variation with respect to depth. Fall turnover began in October and was complete by December. A summary of the results is presented in Table 1.

Temperature and dissolved oxygen. The temperature and DO data demonstrate a slight degree of stratification (Figs. 2 and 3). Although Figures 2 and 3 are for the center location, the same temperature and DO changes occur at the other sampling sites. The effect of the surrounding trees on the lake is evidenced in Figures 2 and 3. Due to the small size of the lake and the forested area close to the edge, there is minimal wind effect, and the epilimnion is shallow.

A close relationship between temperature and DO is evidenced by comparing Figures 2 and 3. Temperature and DO decline rapidly at 1-1.5 m during the summer. The DO values are low below 1.5 m with values of 1-2 ppm oxygen, which restricts the aerobic activity in the hypolimnion. The data from September to November indicate mixing of the lake, or the fall turnover. The sampling on 12/13/90 revealed that the turnover of the lake was complete as the temperature was a constant 4.0° C and the DO was a constant 4.6 ppm oxygen. This indicates that the lake is entering the winter season at 35.1% oxygen saturation. Therefore, after the ice forms on the lake, the oxygen content is expected to go to zero.

Biochemical oxygen demand. The mean BOD values were 7.8, 4.5, and 6.0 ppm oxygen for the surface, middle, and bottom, respectively, in the summer months, and means of 5.5, 5.9, and 5.8 ppm oxygen were recorded for the surface, middle, and bottom, respectively, in the fall. The BOD data versus depth displays a parabolic shape for each of the summer sampling dates. The BOD levels at the surface may be due to the stirred effect resulting in the suspension of more organic matter and the aggregation of plankton in this layer. The middle values are lower than those at the surface, indicating that more of the organic matter has settled out. The bottom BOD values are higher than the middle values, which may be due to very small suspended organic particulate matter. Based on the observation of the vertical homogeneity of the analytical results for December, the BOD values at the bottom are not due to disturbance of the bottom muck by the sampler.

Secchi and pH. There was minimal variation in the Secchi or pH values (Table 1). The Secchi readings averaged 55.8 cm in the summer and 58.4 cm in the fall. The dark color of the water restricted the depth of light penetration which may reduce productivity. The Secchi values observed in this study are less than those reported by Dineen(1979),

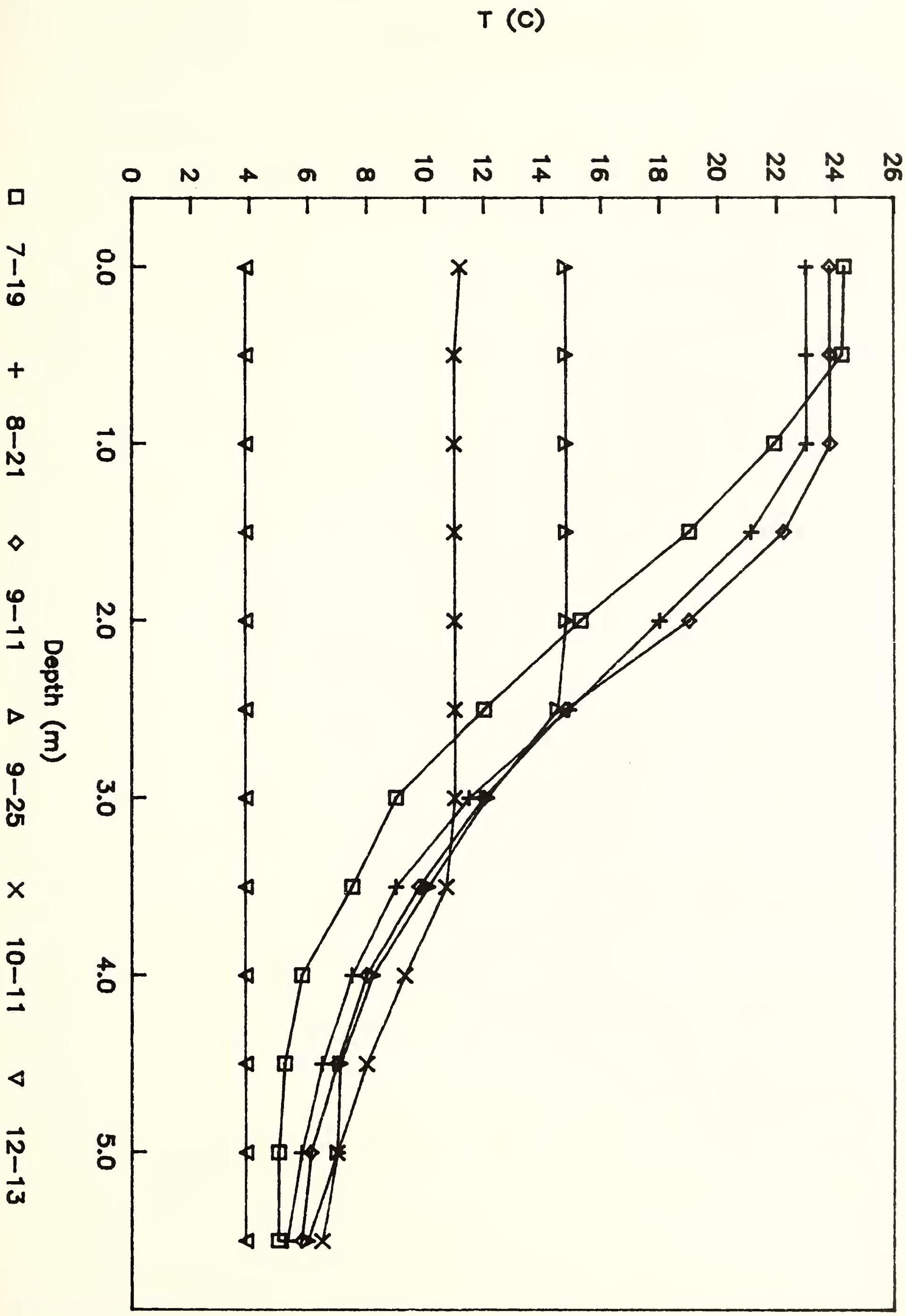

Figure 2. Temperature versus depth profile for the center location at Spicer Lake from 7/19/90 to 12/13/90.

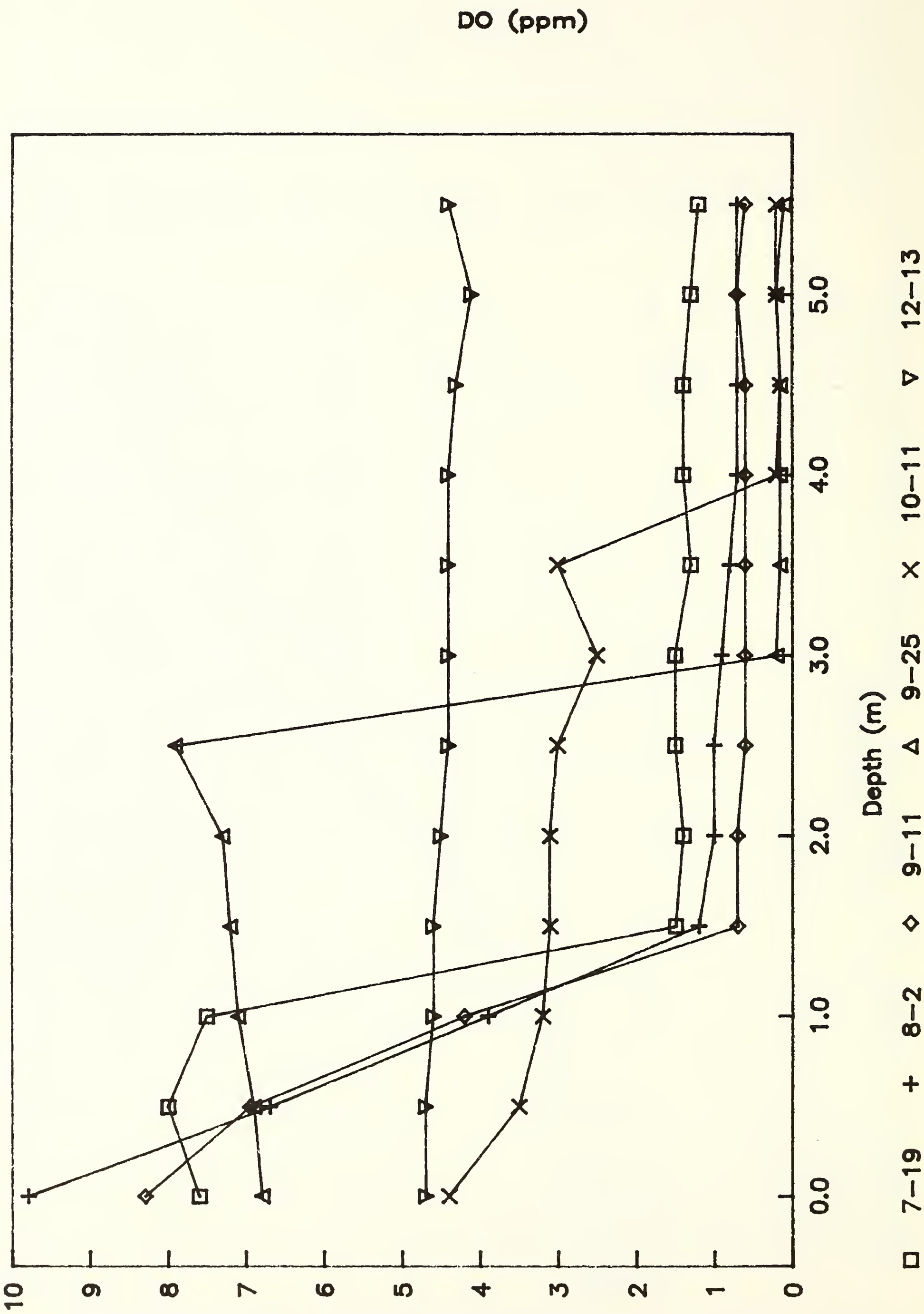

Figure 3. Dissolved oxygen versus depth profile for the central location at Spicer Lake from 7/19/90 to 12/13/90.

which suggests an increase in suspended particulate matter. The pH values ranged from 6.6-7.6, 6.2-7.6, and 6.2-6.6 for the surface, middle, and bottom, respectively, in the summer and 6.1-7.3, 6.0-7.6, and 5.6-6.8 for the surface, middle, and bottom, respectively, in the fall. The median pH values are close to neutral for the surface and middle and are slightly acidic at the bottom.

Phosphorus and nitrogen. The concentration of total phosphorus is low except at the bottom center, where values averaged 0.285 mg P/L in the summer. The only value greater than 0.1 mg P/L occurs at the bottom center. Fall values for total phosphorus exhibit evidence of the mixing of the lake as the means are 0.073, 0.074, and 0.085 mg P/L for the surface, middle, and bottom, respectively. Total phosphorus concentrations of most unpolluted surface waters range from 0.010-0.050 mg P/L (Wetzel, 1983). Orthophosphate phosphorus was measured only on 9/11, 9/25, and 10/11 and was at the limits of detectability (0.005 mg P/L). It follows that essentially all of the phosphorus is contained in organic matter.

Both ammonia and nitrate nitrogen displayed significant concentrations at the bottom center of the lake, but essentially nondetectable levels elsewhere in the lake. The range of ammonia nitrogen (0.38-5.50 mg N/L) is just below or at the level of 4-8 mg N/L which may be present in the anaerobic hypolimnion of a eutrophic lake (Lind, 1979). The high ammonia-nitrogen values at the bottom center could be due to the highly reducing environment at the bottom of the lake and the reduction of nitrate by anaerobic bacteria. The range of nitrate nitrogen in Spicer Lake at the bottom center is 0.06-3.09 mg N/L. Values of nitrate nitrogen under natural concentrations rarely exceed 10 mg N/L and are frequently less than 1 mg N/L (Lind, 1979).

The nutrient values in Spicer Lake are comparable to values obtained in several EPA studies of lakes in northern Indiana: Bass Lake (Starke County), Crooked Lake (Steuben County), Westler Lake (Lagrange County), and Webster Lake (Kosciusko County) (U.S. Environmental Protection Agency, 1976a-d). The nitrogen and phosphorus values obtained at Spicer Lake fall within the ranges of these studies.

The high phosphorus and nitrogen levels at the bottom center may be due to decomposition without utilization, as there is no plant growth and almost no animal growth at the bottom of the lake. Nutrient values of the bottom solids were 23 mg ammonia nitrogen and 60 mg total phosphorus per gram as reported by Dineen (1979), which may indicate that the sediments could be a source of nitrogen and phosphorus in the bottom of the lake.

Pesticides and herbicides. Samples collected on 10/11/90 were analyzed for 25 various chlorinated pesticides and various PCB's. Since the analysis was performed only once, the results are valid only for the date of sampling. No detectable concentrations were found in the samples. From these results there does not appear to be a late fall pesticide input from the neighboring farmland, since the samples were collected just after a heavy rain which had resulted in high runoff and an increase in the water level of the preserve.

CONCLUSIONS

The results indicate that the lake is in a dystrophic state with an accumulation of nutrients, minimal cycling, and a oxygen-limiting environment. The data show sufficient consistency to be considered as baseline data. The data do not indicate evidence of runoff from the surrounding agricultural areas, since the concentrations of nutrients did not vary between the center and edge locations nor between samples collected after heavy rains and rainless periods. The possibility exists that runoff containing high concentrations of nutrients entering the preserve could be filtered by the swamp forest, since this area is typically nutrient poor. Sampling the water in the swamp forest area would be required to determine if this area is receiving excessive nutrient concentrations. The accumulation of nutrients at the bottom of this lake may be due to decomposition without utilization, nutrient release from the sediments, and particle settling from the water column.

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