Some Effects of Sewage Effluent upon Phyco-periphyton in Lake Murray, Oklahoma

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Although phyco-periphyton has generally been overlooked in limnological and fisheries research, recent investigators (Prowse, 1955, 1959; Castenholz, 1960; Grezenda and Brehmer, 1960; and Foerster and Schlichting, 1965) have demonstrated its importance in primary productivity. The latter investigators previously studied an oligotrophic lake in Canada, free of pollution and supporting an excellent lake trout population, to discern the major role played by the phyco-periphyton in the productivity of the lake. As a result it was deemed desirable to conduct a similar study, preliminary to a more detailed investigation, of the effects of domestic pollution upon the standing crops of phyco-periphyton in Lake Murray, a clear water, eutrophic, man-made lake of about 6,000 acres.

MATERIALS AND METHODS

Lake Murray was an excellent area to conduct a field study of this type as Station #1 was located about 4.5 miles downstream from the Ardmore sewage treatment plant, which consists of a trickling filter, a

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sedimentation tank and an activated sludge unit. The effluent from the treatment plant constituted approximately 80-90% of the stream flow entering Lake Murray. Station #2 was located at the end of another arm of the lake which did not have sewage effluent entering it and station #3 was located in the same area as Station #1 approximately 4 miles closer to the dam.

Weekly samples were collected from the following stations: (1.) with domestic sewage effluent prevalent, (2.) with water free of any domestic sewage effluent, and (3.) with sewage effluent greatly diluted by the lake water. Weekly water analyses for sulfates, chlorides, nitrates, nitrites and ortho— and metaphosphates were made to indicate the relative degree of domestic pollution. A Hach portable water chemistry laboratory was used to evaluate chemical parameters (Fig. 1 and Table II). All tests followed procedures as described in *Standard Methods* (1955). Biweekly coliform tests were made using Millipore filter techniques to determine the presence of coliform bacteria in the natural water and as a relative indication of domestic pollution between stations.

During June and July, 1964, aquatic angiosperms, determined by us as *Potamogeton* sp., *Nelumbo lutea* and *Typha domingensis*, were sampled to discern their qualitative phyco-periphyton populations (Table III). Samples of submerged and floating leaves of *Potamogeton* were obtained by skin diving in water depths up to 15 feet. The samples were taken by placing a vial, completely filled with 5 ml of 6-3-1 solution and 10 ml of distilled water, over the submerged leaf, cutting the leaf free from the plant with scissors and replacing the vial cap underwater. Triangular pieces, approximately 15 cm^2 in area, were cut from the *Nelumbo* leaf and placed in a vial.

Typha domingensis was also sampled quantitatively by carefully cutting the plant just above the surface of the water, placing a vial into the water over the severed end and cutting the stem with scissors (Table I).

Phyco-periphyton was removed from the surface of the higher aquatic plants by agitation. Each vial was vigorously shaken 250 times and the liquid filtered through a Millipore type HA filter. Methods of analyses followed techniques described by McNabb (1960) using oil immersion objectives for the enumerations. Filamentous algae were not randomly distributed on the filters so the entire filter was examined under low power and filament lengths recorded. The numbers of algae per cm^2 of leaf surface were compared to water chemistry and the degree of general domestic pollution at the sampling station.

Study of the washed leaves indicated that 70-90% of the algae were removed from the *Typha* leaves, about 90% from *Potamogeton* leaves and only 20-70% from the *Nelumbo* leaves. Actual counts were recorded for *Typha* (Table I.).

TABLE I. NUMBERS OF PHYCO-PERIPHYTON CELLS PER SQUARE CENTIMETER OF *Typha domingensis* LEAF.

Date	Stations 1	Stations 2	Stations 3
6/18/64	21,322	526	1189
6/25	18,534	—	2847
7/2	24,533	—	1866
7/9	5,900	598	668
7/16	—	200	5843

Qualitative studies were also made of *Nitella, Cladophora,* bottom soil, wood and rock substrata (Table III). These substrata were sampled either by placing a portion of the substratum in a vial or when sampling rock, scraping the algal slime into the vial.

RESULTS

Station #1 consistently showed chemical values higher than the other two stations (Fig. 1 and Table II). The arm of the lake where Station #1 was located can be classified as a recovery zone as there were no objectionable odors or visible signs of pollution. Station #1 was protected from the wind while Stations #2 and #3 were exposed to winds in all directions except due west. Water samples for dissolved oxygen were taken at a depth of two feet at all stations to eliminate variations due to wind and wave reaeration. Station #1 was lower in dissolved oxygen (Table II). Nitrogen compounds are probably assimilated quickly by bacteria and so quantities of nitrates and nitrites at Station #1 were not large although significantly higher than at the other stations. Nitrates were approximately seven times greater at Station #1 than Station #2 and three times greater than at Station #3.

Sulfates and chlorides did not seem especially significant in explaining differences in the phyco-periphyton populations. Phosphates, however, differed greatly. Orthophosphates were about 20 times greater and metaphosphates about two times greater at Station #1 (Table II). The difference between the amounts of orthophosphates and metaphosphates is probably due to the large quantity of syndets added above Station #1.

As expected, coliform counts were lowest at Station #2 and highest at Station #1.

The average water chemistry data over a 6-weeks period are given in Table II. The qualitative phyco-periphyton compared to specific substrata is given in Table III. Submerged rocks had fewer algal genera present than any other substratum sampled. The Chrysophyta, Chlorophyta and Cyanophyta made up the mass of the phyco-periphyton in the order listed (Table III). The Euglenophyta in the preserved samples were not often identifiable.

TABLE II. AVERAGE WATER QUALITY OVER A SIX-WEEKS PERIOD FOR EACH STATION.

	#1	#2	#3
Dissolved oxygen	5.3 ppm	10.25 ppm	6.5 ppm
Carbon dioxide	12.0	0	0
pH	7.98	8.5	8.25
Alkalinity	138.	155.	157.
Chloride	35.97	32.82	31.0
Ca hardness	82.	81.	85.1
Total hardness	121.	171.	115.
Copper	0.18	0.1	0.11
Nitrate nitrogen	0.83	0.11	0.27
Chromate, hexavalent	0.05	0.03	0.07
Iron	0.23	0.17	0.12
Nitrite nitrogen	0.107	0.006	0.006
Sulfate	30.	22.	22.
Turbidity	111.	15.	11.
Silica	6.34	1.11	1.32
Fluoride	1.03	1.86	0.66
Manganese	0.42	1.87	0.144
Orthophosphates	4.2	0.21	0.15
Metaphosphates	0.43	0.18	0.15
Specific conductivity	392.	356.	350.

TABLE III. SUMMATION OF THE PREDOMINANT PHYCO-PERIPHYTON GENERA FOUND IN LAKE MURRAY, OKLAHOMA, JUNE AND JULY, 1964.

Genera	1 Cladophora sp.	2 Bottom soil	3 Wood	4 Rock	5 Nitella sp.	6 Typha domingensis	7 Potamogeton sp.	8 Nelumbo lutea
CHLOROPHYTA								
Bulbochaete						x	x	
Cerasterias							x	
Characium	x							
Chlorella							x	
Cladophora		x	x	x		x	x	x
Cosmarium			x		x		x	
Eudorina							x	
Gloeocystis				x	x	x	x	
Microspora	x							
Mougeotia	x		x	x			x	x
Oedogonium			x		x	x	x	
Palmella			x			x		
Scenedesmus		x				x		
Spirogyra			x			x	x	x
Staurastrum	x					x		
Stigeoclonium	x							
Ulothrix	x					x		x
CHRYSOPHYTA								
Amphora	x						x	
Caloneis		x	x			x	x	
Cyclotella			x		x		x	x
Cymbella			x		x	x	x	x
Diatoma	x					x	x	x
Epithemia							x	
Fragilaria	x		x			x	x	x
Gomphonema	x	x	x			x	x	x
Gyrosigma					x	x	x	
Meridion	x		x	x		x	x	x
Navicula	x	x			x	x	x	x
Nitzschia	x	x	x		x	x	x	
Pinnularia					x	x	x	
Stauroneis	x	x					x	
Surirella				x		x		
Synedra		x			x	x	x	x
Tabellaria	x		x		x	x	x	x
Tribonema							x	
CYANOPHYTA								
Anabaena		x	x				x	
Aphanizomenon			x			x		
Chroococcus			x		x			
Eucapsis	x							
Gomphosphaeria	x	x						
Lyngbya	x	x	x					
Merismopedia	x							
Nostoc		x					x	
Oscillatoria		x		x		x	x	x
Phormidium	x		x	x				
Rivularia			x	x				
Schizothrix			x					

TABLE III (Contd.)

Spirulina					x	x	x
EUGLENOPHYTA							
Euglena	x						x
Phacus						x	
Trachelomonas						x	

Taxonomy after Elmore (1921), Muenscher (1944), Waterfall (1960), and Prescott (1962).

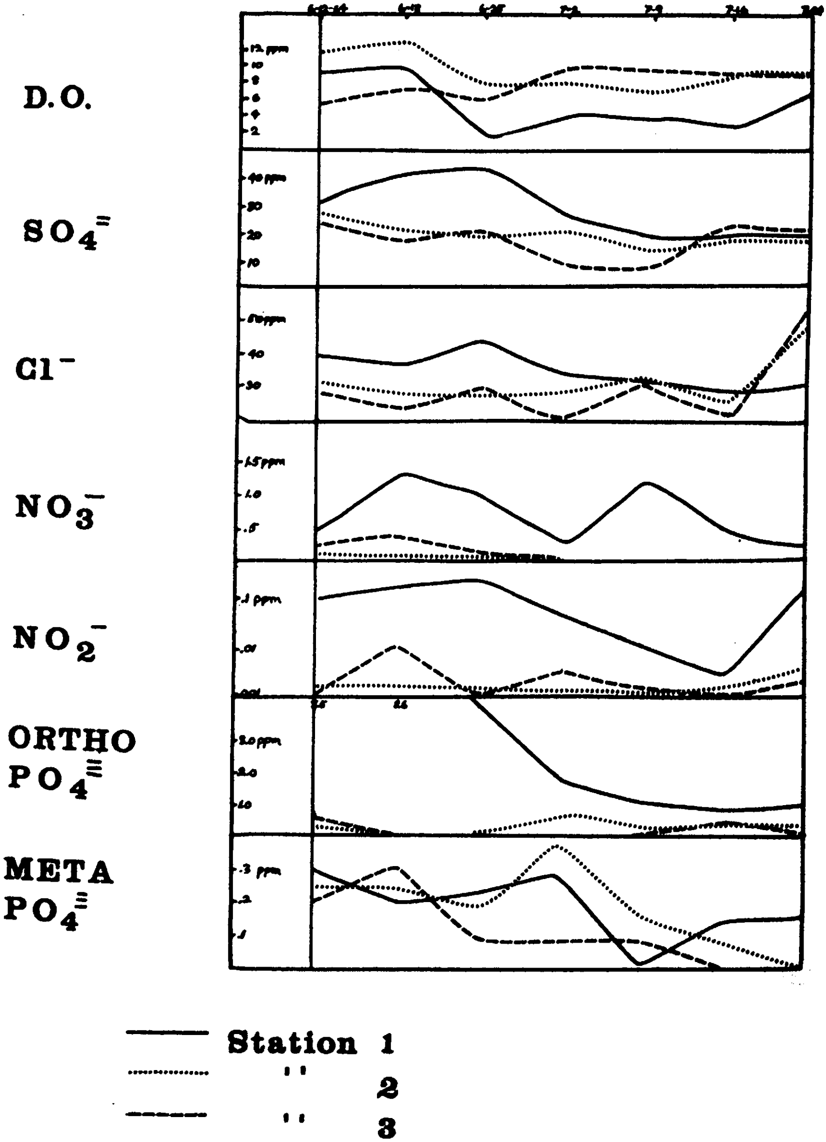

Fig. 1. Chemical Data

These preliminary findings support the hypothesis that domestic sewage effluent can be beneficial to the basic productivity of a lake. If the effluent is added gradually and well distributed to different areas of a lake, pollution will not occur and basic productivity, with increased invertebrate and fish populations, can be expected. The importance of diluting sewage effluent with stream or lake water to avoid gross pollution was stressed by Fair, Geyer and Morris (1954).

In the future it is feasible that tourists can be attracted to our lakes by the proper use of sewage effluent. It is hoped that this preliminary basic research will aid in the formulation of future practices in the control and use of sewage effluent which will benefit the tourist industries of the Southwestern United States.

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