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ALGAL BIODIVERSITY AND TROPHIC STATUS OF SOME TEMPORARY WATER BODIES OF KANPUR

D. Tiwari and M. Shukla
Department of Botany, A.N.D.N.N. Mahila Mahavidyalaya, Kanpur-208 012, U.P., India

ABSTRACT

Some rain-fed temporary ponds of the southern Kanpur were surveyed in post-monsoon period from October 2003 to March 2004 to examine their algal flora and ambient water characteristics. From the data obtained algal biodiversity and trophic status of these lentic water bodies were assessed using standard indices.

INTRODUCTION

Algae, a heterogeneous assemblage of photoautotrophs, are ubiquitous, cosmopolitan and play a pivotal role as pioneers leading to the establishment of higher plant community. They inhabit diverse habitats ranging from lentic to lotic, aquatic to subaerial or aerial, xeric, snowy, polluted and unpolluted and are endowed with the capability to survive in hostile environments. They have a tremendous potential to trap atmospheric carbon dioxide and nitrogen. Approximately 40% of atmospheric CO_2 and equally good amount of nitrogen fixed annually on the planet is fixed by them (Goyal 1997). They have revealed tremendous scope for environmental management as soil conditioners, biofertilizers, bioindicators, biomonitors, amelioraters, feed for animals, protein supplement and rehabilitators of degraded ecosystems through bioabsorption of pollutants (Whitton & Potts 2000). Though, algae of lentic and lotic habitats of Kanpur have been studied by other workers (Nair 1965, Shukla 1971, Jha 1982, Gupta & Shukla 1994, Tiwari et al. 1996, 2001a & b, Tiwari 2004) yet algae of rain-fed temporary bodies of water have not received enough attention. The present study is a preliminary attempt to explore the algal biodiversity in relation to water quality in such habitats.

MATERIALS AND METHODS

Five temporary rain-fed ponds from different localities of southern Kanpur namely, Panki, Meharban Singh Ka Purva (MSP), Gujaini, Naubasta and Barra were selected for the study. All of these were shallow 3 to 6 feet deep water bodies formed during monsoon (July/August) as a result of pooled rainwater, and dried up during the summer. Besides the run-off rainwater, they also receive some domestic as well as industrial sewage from the nearby settlements of the respective locality.

Water and algal samples from the selected ponds were collected, analyzed and preserved as per standard procedure for qualitative and quantitative assessments (APHA 1976). Taxonomic identification of algae was done using pertinent literature (Smith 1950, Desikachary 1959, Tiffany & Britton 1959 and Philipose 1967). Algal population was assessed using Sedgwick Rafter counting cell. Algal biodiversity was computed employing the information theory equation of Shannon & Weaver (1963). Trophic status of these waters was assessed using Nygaard's Compound Quotient Index (Nygaard 1949). Degree of taxonomic similarity among the algal species was computed by the expression of Sorenson (1948).

RESULTS AND DISCUSSION

Algae, the prime and natural component of natural waters, are the main primary producers in aquatic ecosystems. However, their diversity, population and abundance are related to certain environmental factors. Palmer (1980) opined that size, shape, depth, sediment characteristics, physiography, soil of watershed, amount and rate of precipitation, sunlight and physico-chemical characteristics of water exert a pronounced effect on their growth and development in waters.

The physico-chemical composition (Table 1) of these waters depend mainly on the type and quantity of pollutants in relation to the dilution available. Water of these bodies of water was alkaline with pH values ranging between 7.2 and 8.1, suitable for algal growth (Beadle 1966). Colour of water in these waters was either muddy or murky in the beginning but gradually changed with the growth of algae assuming green or bluish green colour depending on the dominance of algae in them. This adversely affected the transparency of the waters. The changes in colour and transparency of water may also the attributed to the quality and quantity of the waste effluents received by these waters in addition to precipitation and run-off water during monsoon. Lowest transparency, noticed in MSP waters, was partly due to the bloom of green algae *Chlorella* and *Scenedesmus* in addition to the factors mentioned above. Addition of domestic sewage from the village enhanced the nutrient status of the waters, which supported the luxuriant growth of *Chlorella* and *Scenedesmus* resulting in their blooms in January, which persisted till February end. Both the algae are well-documented pollution tolerant forms (Palmer 1969) and have been frequently encountered in sewage-contaminated waters (Sarojini 1994).

Dissolved oxygen concentration in these waters varied from 3.0 mg/L to 5.0 mg/L. Lowest concentration was recorded in MSP pond and maximum in Naubasta pond, which also showed the minimum values of total solids and dissolved solids. Biochemical oxygen demand was in the range of 5.5 mg/L to 10 mg/L in different waters, which indicate that they are quite rich in biodegradable matter. Minimum DO and maximum BOD in MSP water body may be attributed to the addition of sewage,

Table 1: Physico-chemical characteristics of the water bodies.

Characteristics	Ponds				
	Panki	MSP	Gujaini	Naubasta	Barra
Colour	Murky	Murky	-	Green	Murky
Temperature	31.3	32.0	29.2	30.6	30.8
Transparency	9.0	6.0	15.0	18.0	14.6
Total solids	680.0	710.0	480.0	475.0	623.0
Dissolved solids	597.0	611.0	370.0	310.0	417.0
pH	7.4	8.1	7.3	7.2	7.9
Total alkalinity	297.0	290.0	220.0	150.0	300.0
Dissolved oxygen	4.2	3.0	4.8	5.0	4.7
BOD	8.0	10.0	8.8	5.5	7.6
COD	89.9	20.0	16.0	10.2	18.0
Total hardness	300.0	240.0	232.0	190.0	250.0
Chloride	211.0	197.0	176.0	133.0	142.0
Phosphate	1.4	1.9	0.1	0.1	0.1
Nitrate	-	-	0.03	0.05	-
Ammonia	1.2	1.8	0.7	0.5	1.4

All values in mg/L except colour, temperature (°C), pH and transparency (cm).

Table 2: Algal community of various water bodies.

Algae	Ponds				
	Panki	MSP	Gujaini	Naubasta	Barra
Cyanophyceae					
Anabaena sp.				+	++
Anacystis sp.			+		+++
Arthrospira sp.				+	
Gloeotrichia sp.				+	
Lyngbya sp.				+	
Merismopedia glauca		+	+		+
Merismopedia punctata			+		
Nostoc sp.			+		+
Oscillatoria acuminatus		+			
Oscillatoria curviceps		+			
Oscillatoria limosa	++		+		
Oscillatoria princeps		+	+		
Oscillatoria tenuis	+++				
Phormidium sp.	+			+	+
Bacillariophyceae					
Cyclotella meneghiniana				+	+
Cyclotella sp.				+	+
Diatoma sp.					+
Gomphonema lanceolatum		+			
Gomphonema parvulum		++			+
Gyrosigma sp.			+	+	
Navicula cuspidata			+		
Nitzschia palea		+	++		
Synedra ulna				+	+
Chlorophyceae					
Actinastrum sp.			+		+
Ankistrodesmus falcatus			+		+
Chlorella sp.		+++	+		
Closterium acerosum		+		++	+
Closterium moniliforme			+	+	
Coelastrum microsporum		+	+		
Cosmarium biculatum			+	+	
Cosmarium reniforme				++	+
Gonium sp.		+			
Hydrodictyon reticulatum		+	+++		
Pediastrum boryanum		+	+		
Pediastrum simplex		+			
Scenedesmus bijuga			+		+
Scenedesmus dimorphus		++			+
Scenedesmus quardicauda		+++			
Sirogonium sp.				+	
Spirogyra sp. a				+++	
Spirogyra sp. b				++	
Spirotaenia sp.				+	
Stigeoclonium tenue	+	+		+	
Pithophora sp.					+++
Euglenophyceae					
Cryptoglena sp.			+		

Table cont...

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Euglena acus	++			
Euglena polymorpha	+			
Lepocinclis sp.				+
Phacus acuminatus		+		+
Phacus pleuronectus			+	
Trachelomonas sp.		+	+	+

No. of + indicate their relative dominance in increasing order.

which depleted the DO content of the water due to enhanced bacterial oxidation of biodegradable matter (Warren 1971). Low nitrate and high ammonia concentration points to the oxygen stressed condition of the waters as well as discharge of sewage into them though in different proportions. Sewage, a rich source of nitrogenous organic matter and chloride may be held responsible for the higher values of ammonia and chloride reported in these waters. Total alkalinity, hardness and chemical oxygen demand in these waters varied from 150-300 mg/L, 190-300 mg/L and 10-80 mg/L respectively (Table 1). Certain physico-chemical parameters like total alkalinity (Vollenweider 1966), phosphorus (Ohle 1955), nitrogen and phosphorus (Palmer 1980) and chloride (Beeton 1965) have been reported to have a bearing on the trophic status of the waters. In the present study, concentration of nitrogen and phosphorus usually remained much above the eutrophication level, i.e., 0.3 mg/L and 0.015 mg/L respectively (Palmer 1980). Beeton (1965) opined that increased concentration of chloride and phosphate could be used as an index of eutrophication. High values of alkalinity, phosphate, ammonia and chloride reported in the present study, thus, indicate the eutrophic nature of these waters.

The data on the occurrence of algal taxa are shown in Table 2, while species diversity in Table 3, and coefficient of similarity in Table 4. In all, 51 taxa representing Cyanophyceae (14), Bacillariophyceae (9), Chlorophyceae (21) and Euglenophyceae (7) were encountered. *Oscillatoria* dominated the Cyanophycean group both in number of species (5) and population (622 inds/mL). Frequently encountered forms amongst the Chlorophyceae were *Chlorella, Scenedesmus, Spirogyra, Stigeoclonium* and *Pithophora.* Their respective dominance in different waters is depicted in Table 2. *Euglena* and *Phacus* dominated over the other euglenoids whereas *Nitzschia, Navicula, Gomphonema* and *Synedra* were the common representatives of the Bacillariophyceaen group. Dominant flora of Panki pond was *Oscillatoria.* Chlorococcales dominated over other algae in MSP and Gujaini ponds. Blooms of *Chlorella* and *Scenedesmus* were a common sight in MSP pond during February and March whereas Gujaini pond was characterized by the presence of water net (*Hydrodictyon reticulatum*) from January till February end. Algal profile of the Naubasta pond was mainly composed of the members of conjugales dominated by *Spirogyra.* Cyanobacterial bloom, mainly composed of *Anacystis nidulans* followed by *Anabaena* was the chief contributor to the algal flora and population of the Barra pond. Desmids, however, were more frequent in Naubasta pond in comparison to the rest. Van Oye (1937) attributed paucity of desmids to eutrophic nature of water. Similar observation was made in the present study. Algal spectrum of the Panki and Gujaini waters showed the least taxonomic similarity (0.083). Though the coefficient of similarity index value between Panki and MSP ponds and between Panki and Barra ponds was the same (0.086) yet the algal spectrums of MSP and Barra ponds were quite different. The maximum taxonomic similarity existed between the algal spectrum of Naubasta and Barra ponds but the value recorded (0.410) indicated that not even the 50% species were common in these waters.

Table 3: Numerical profile of species, species diversity and trophic status.

Species	Panki	MSP	Gujaini	Naubasta	Barra
Cyanophyceae	3	4	6	5	5
Bacillariophyceae	-	3	3	4	5
Chlorophyceae	1	10	9	9	6
Euglenophyceae	-	2	3	2	3
Total number of species	4	19	21	20	19
Shannon index value	1.6	2.8	4.1	4.4	3.9
Nygaard's index value		16.2	11.2	5.8	9.7

Table 4: Coefficient of similarity values among the water bodies.

Pond	Panki	MSP	Gujaini	Naubasta	Barra
Panki	-	0.086	0.083	0.166	0.086
MSP	-	-	0.358	0.102	0.210
Gujaini	-	-	-	0.201	0.358
Naubasta	-	-	-	-	0.410

A comparison of nutrient status and species diversity revealed an inverse relationship. Lowest diversity value (1.6) was recorded for Panki pond whereas maximum for Naubasta pond (4.4). Nygaard's index value computed for these ponds ranged from infinite ($\propto$) to 5.8, maximum for Panki pond and minimum for Naubasta pond (Table 3). Nygaard's index value > 6 indicted the eutrophic status of the waters (Nygaard 1949). Panki pond with highest nutrient status, as is evident from physico-chemical characteristics and Nygaard index values has lowest number of species. It is possible that the presence of toxic metals in the industrial effluents of Panki (Handa et al. 1985 & Tiwari et al 1996) might have an effect on the algal population. The findings of the present study clearly suggest the presence of toxicants in the ambient water that could support a scanty flora comprising only four species. The presence of Cyanophycean members alone along with *Stigeoclonium tenue* further pointed out to the grossly polluted condition of the pond. Addition of domestic sewage as a result of anthropogenic activities of the nearby inhabitants enriched the MSP pond with optimal concentration of the nutrients that propped the luxuriant bloom of *Chlorella* and *Scenedesmus*. Both the algae are well documented pollution tolerant forms with reported dominance in sewage contaminated waters (Palmer 1969, Rai & Kumar 1979, Tiwari et al. 1996). High water temperature, high organic matter and low DO influence the periodicity of Cyanophyceae (Venkateswarlu 1970). Philipose (1960) opined that species of *Scenedesmus, Merismopedia, Nitzschia, Navicula, Oscillatoria* and some Volvocales and Chlorococcales occur abundantly in sewage-fed waters. The presence of these forms in these ponds avers his findings. It seems that high alkalinity, moderate transparency and nutrients enriched favoured the algal growth in these waters except the Panki water where despite highest nutrient concentration algal diversity as well as population was remarkably low (196 Inds/mL) probably either due to the presence of inhibitory substances or due to some synergistic interaction amongst the pollutants.

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