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Preliminary Observations on the Limnology of three Freshwater Lakes around Delhi State, India

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Limnological investigations on three lakes around Delhi State have suggested that they differ from each other in their physico-chemical and biological characters though they are situated in a zone with similar geology and climate. Comments have been made on *Microcystis* as an indicator of organically rich waters.

Key Words: Lakes, Limnology, ***Microcystis***

Introduction

Aquatic ecosystems (lentic and lotic) are more stable and relatively more homogeneous in comparison to terrestrial ecosystems and this is so because of peculiar chemical and physical characteristics of water. However, between lentic and lotic, the former is a relatively more closed type of ecosystem. Interestingly, this is because of differences in features of water such as current, thermal stratification and chemical nature. Further, the 'closed' lentic systems follow a distinct pattern of maturation. Any disturbance to this natural ecological balance brings about a rapid deterioration of such an ecosystem. Thus an understanding of lentic ecosystem dynamics has greater significance in contrast to that of lotic systems. It was with this view that three lakes in the vicinity of Delhi state were chosen for detailed investigations. These water bodies are being used for raising fingerlings and irrigation. Additionally, these lakes have attracted the attention of tourists in recent years. Owing to paucity of basic information pertaining to these lakes any data collected now would have significance for evaluating the degree and kind of pollution in future.

Materials and Methods

Location and other morphometric data in respect of these lakes are given in figure 1 and table 1. The main sources of incoming water in these lakes are precipitation and surface drainage, whereas major water loss is through seepage and evaporation from the surface, except during the rainy season, when excess water is regulated by small canals.

Water samples from different depths were collected with a sampler based on Dussart Sampler's principle. Samples were collected from each lake at four sites, approximately equidistant from one another at monthly intervals commencing from January 1976. In this communication, however, only the mean values for the period January to December 1976 are presented. Samples were analysed for the 16 characteristics (table 4), following standard analytical procedures: temperature by mercury thermometer, transparency by secchi disc, *p*H and conductivity by laboratory *p*H meter and conductivity bridge: alkalinity, ammonia, nitrate, o–phosphate, chloride and sulphate by methods detailed in A. P. H. A. (1971); Golterman's (1969) methods were followed for calcium, magnesium, C.O.D. and dissolved oxygen. Sodium and potassium were analysed by Flame Photometric method.

For analysis of biotic components of water, qualitative plankton tows were made with a 25 mesh size plankton net, lowered just beneath the surface for three to five minutes at a medium rowing speed. Sedimentation method using modified Leugol's solution (1 ml/100 ml; Vollenweider 1969), was followed for concentrating the plankton for quantitative estimation.

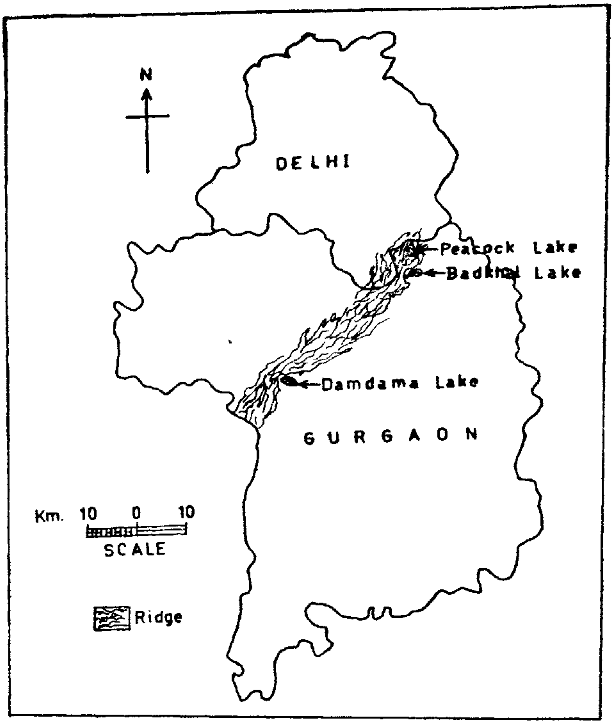

Figure 1 Badkhal, Damdama and Peacock lakes: Locations

Table 1 *Badkhal, Damdama and Peacock Lakes: Morphometric and hydrological data*

Parameter	Badkhal Lake	Peacock Lake	Damdama Lake
Maximum Length	2.13 km	0.96 km	5.25 km
Effective length	1.10 km	0.85 km	1.42 km
Maximum breadth	0.43 km	0.33 km	1.2 km
Catchment area	8 sq. km	11.4 sq. km	24.1 sq. km
Highest flood level	216.70 M	221.29 M	216.75 M
Maximum depth	11.1 M	8.4 M	18.04 M
Geographical location	77°17″ Lon.	77°17″ Lon.	77°2″ Lon.
	28°26″ Lat.	28°29″ Lat.	28°14″ Lat.

Results and Discussion

An evaluation of the morphometric, hydrobiological and water chemistry data (tables 1,2) suggested that even though these lakes existed in a zone with similar geology and climate, the physico-chemical characteristics of each lake were distinct. Following Philipose (1960) Badkhal lake and Damdama lake could be classified as 'moderately alkaline' (alkalinity as $CaCO_3$ <100 ppm) and Peacock Lake as 'alkaline' (alkalinity as $CaCO_3 > 100$ ppm). In all the three lakes, carbonates and bicarbonates dominated over chlorides and/or sulphates (table 4)..

*p*H and dissolved oxygen values for all the three lakes near the bottom were lower than those at the surface (table 3). Hutchinson (1957), McColl (1972) and Brezonic and Fox (1974) attributed such a phenomenon to excessive carbon dioxide production resulting from decomposition of organic material and respiration and lack of photosynthesis in the deeper layers of water near the bottom. Whether this holds true in the lakes under study needs further experimentation.

Conductivity was much higher in Peacock Lake than Badkhal or Damdama Lake (table 4). Further, a perusal of table 4 showed that the Peacock lake had the maximum concentration of nitrogen (NH_4-N+NO_3-N) and soluble phosphorus and thereby suggesting its higher potential for organic production. Interestingly, this fact was substantiated by lowest transparency values (15–65 cm, table 2) and yellowish brown colour of water (table 2); (*see* also Bozniak & Kennedy 1968). Similarly, Peacock lake had much higher concentrations of sodium and chloride contents (table 4) in comparison to Badkhal and Damdama Lake.

The total number of plankton species declined in all the three lakes, after rains (July and August, table 5). By late September, however, the average number was restored.

In Damdama Lake, *Microcystis* spp were found to occur in bloom proportions from October through December and May through July, and during these months they constituted 65–90% of the total plankton population. During the summer months, however, species of *Aphanocapsa*. *Coelosphaerium* and *Merismopedia* also increased their numbers along with *Microcystis* species. Badkhal lake also showed a similar trend (table 5), though the density of planktons remained much lower than that in Damdama lake. Peacock lake, on the other hand, was essentially dominated by blue green algae (table 5). Further in this lake, *Microcystis*

Table 2 *Badkhal, Damdama and Peacock Lakes: Physical features*

Character	Badkhal Lake	Damdama Lake	Peacock Lake
Bottom sediments			
(a) Colour	Greyish black	Greyish black	Dark black
(b) Texture	Fine sandy	Fine sandy	Sludge
Water colour	Bluish green	Bluish green	Yellowish brown
Transparency	60–145 cm	70–130 cm	15–65 cm
Temperature	16–32.2°C	16.95–33°C	17.0–34.2°C

Table 3 *Badkhal, Damdama and Peacock Lakes* : p*H and oxygen*

Location		pH		Oxygen	
		Mean	Range	Mean	Range
Badkhal Lake	Surface	8.66	7.65–9.8	8.45	5.49–11.8
	Bottom	7.57	7.2 –9.7	7.52	3.94–10.57
Peacock Lake	Surface	8.73	7.95–9.8	8.70	6.03–15.08
	Bottom	8.51	7.2 –9.5	7.07	0.00–15.11
Damdama Lake	Surface	8.76	7.4 –9.9	8.42	4.1 –11.18
	Bottom	8.21	6.9 –9.7	6.24	1.15– 9.6

Table 4 *Badkhal, Damdama and Peacock Lakes* : *Physico-chemical characters*
(*All values are in ppm except temperature,* p*H and conductivity*)

Parameters	Badkhal Lake		Peacock Lake		Damdama Lake	
	Mean	Range	Mean	Range	Mean	Range
Temperature, °C	26.64	16.0 – 32.2	25.57	17.0 – 34.2	26.81	16.95 – 33.0
*p*H	8.66	7.65– 9.8	8.73	7.95– 9.3	8.757	7.4 – 9.9
Conductivity, μmho/cm	151.73	102.0 –208.0	647.07	354.96–1015.9	109.892	90.05 –138.72
Phenolphthalein alkalinity	2.456	0.00– 8.2	6.326	0.00– 16.52	5.823	0.00 –13.5
Total alkalinity	70.197	42.8 –101.7	216.179	109.56– 288.7	52.55	42.16 –68.2
O-Phosphate-phosphorus	0.0352	0.00– 0.11	0.0244	0.00– 0.52	0.0154	0.00 – 0.071
Ammonia-N	0.9857	0.217– 2.51	1.266	0.046– 3.715	0.5065	0.0396– 1.9
Nitrate-N	0.0917	0.027– 0.297	0.1312	0.035– 0.345	0.0869	0.0439– 0.17
Dissolved oxygen	8.446	5.49 – 11.8	8.704	6.03 – 15.08	8.418	4.1 –11.18
Chloride	5.05	2.39 – 8.99	96.144	63.24 –133.68	0.5151	traces– 1.606
Sulphate-S	3.4	2.15 – 4.27	7.16	5.53 – 8.11	2.9	2.06 – 3.6
Calcium	17.22	12.8 – 24.3	25.39	18.8 – 32.7	19.16	12.7 –22.5
Magnesium	3.8	2.4 – 6.8	19.1	12.16 – 24.32	3.8	1.22 – 5.4
Sodium	4.1	3.1 – 6.2	102.5	40.0 – 182.0	5.3	2.10 –10.2
Potassium	1.95	1.5 – 2.2	10.1	4.5 – 14.75	3.4	2.06 – 8.64
C.O.D.	3.88	1.1 – 6.5	7.78	2.9 – 13.3	3.50	1.95 – 5.1

spp were characteristically absent for most part of the year, except during summer months when a few colonies were noted (table 5). The common phytoplanktons occurring in this lake were species of *Anabaena*, *Anabaenopsis*, *Oscillatoria* and *Merismopedia*. Diatoms (species of *Melosira*, *Navicula*, *Nitzschia*, and *Synedra*), however, increased during the winter months. Euglenophyta (spp of *Euglena*, *Phacus* and *Trache-*

Table 5 *Badkhal, Peacock and Damdama Lakes : Seasonal variations in the distribution of phytoplankton*

	Winter (Oct.—Feb.)			Summer (March early June)			Monsoon (Mid. June–September)		
	Damdama Lake	Badkhal Lake	Peacock Lake	Damdama Lake	Badkhal Lake	Peacock Lake	Damdama Lake	Badkhal Lake	Peacock Lake
CHLOROPHYTA									
Ankistrodesmus	+	+	+(C)	−	−	−	+	−	+(C)
Botryococcus	+	+	+(C)	−	+	−	−	−	+
Coelastrum	+	+	+	+	−	+	−	+	+
Crucigenia	−	+	+	−	−	−	−	+	+
Pandorina	+	+	+	−	+	+	+	+	−
Pediastrum	+(C)	+(C)	+(C)	+	+	+	+	+	+
Scenedesmus	+(C)	+(C)	+(C)	+	+	−	+	+	+
Staurastrum	−	+	−	+	−	+	+	+	+
CHRYSOPHYTA									
Chrysophyceae									
Dinobryon	+	+	−	−	−	−	−	−	−
Synura	−	+	−	−	+	−	−	−	−
CHRYSOPHYTA									
Bacillariophyceae									
Fragilaria	+	+	+(C)	+	+	+	−	−	−
Melosira	+	+	−	+	+	+	−	+	+
Nitzschia	−	−	−	−	+	−	−	−	−
Navicula	−	+	−	−	−	+	−	−	+
Synedra	−	+	−	−	+	+	−	−	−
EUGLENOPHYTA									
Euglena	+	+	+(C)	−	−	+(C)	+	+	+(SD)
Phacus	+	−	+(C)	−	+	+(C)	−	−	+
Trachleomonas	−	−	+	+	+	+(C)	+	+	+(C)
PYROPHYTA									
Glenodinium	−	+	+(C)	−	−	+	−	−	+
Peridinium	−	−	+(SD)	−	−	+	−	+	+
CYANOPHYTA									
Anabaena	+	+	+(SD)	−	+	+	−	+	+(SD)
Anabaenopsis	−	+	+(SD)	−	+	+(C)	−	−	+
Aphanocapsa	+	−	−	+(C)	+	+	+	−	−
Coelosphaerium	+	+	−	+(C)	+	+	+(SD)	−	+
Merismopedia	+(C)	+(C)	+(C)	+(C)	+	+(C)	−	−	+
Microcystis	+(D)	+(D)	−	+(D)	+(D)	+	+(D)	+(C)	−
Oscillatoria	−	−	+(D)	−	+	+(D)	−	+	+(D)
Spirulina	−	−	+	+	+	+(C)	−	+	+

D, Dominant; SD, Subdominant; C, Common; +, Present; —, Absent *lomonas*) attained maximum densities during summer only when in addition to high temperature (30–33°C), concentrations of free CO_2 and inorganic nitrogen were also higher. Zafar (1959) and Munawar (1972) also reported similar correlations between Euglenophyta and chemical composition of water from lakes and ponds in and around Hyderabad. In view of these observations and those of Nicholls (1976) where *Euglena* spp were found dominating in Holland Marsh, Ontario, Canada, which was deficient in inorganic nitrogen and free CO_2, it may be suggested that *Euglena* spp have very wide ecological amplitude. However, detailed autecological investigations are required before any final comment is made.

A perusal of tables 3,4 and 5 would suggest Peacock Lake to be more eutrophic than either Badkhal or Damdama Lake. Interestingly, *Microcystis*, which had been associated with eutrophic (Ganapathy 1940, 1960, George 1962, Chacko & Krishnamurthy, 1954) and organically rich (Singh 1955, Brook 1959 & Vance 1965) waters, was more or less absent from Peacock Lake. The question therefore arises whether *Microcystis* bloom is in fact an indicator of organic pollution. Gerloff et al. (1950) successfully cultured *Microcystis aeruginosa* and several other blue green algae in a purely inorganic medium. Fogg (1952, 1966, 1971) showed that the bluegreen algae can excrete about 50% of their assimilated product as poly-amino acids and other organic substances into the surrounding medium, and thus suggesting that the presence of organic matter might be an effect rather than the cause of *Microcystis* bloom. Additionally, Kolkwitz and Marson (1908) in their classical paper 'Ecology of plant Saprobia, had even classified *M. aeruginona* and other "*Microcystis* varieties" in the 'Oligosaprobia' zone. In view of these reports as well as our observations, categorization of *Microcystis* spp as an indicator of organically rich waters may not seem justifiable and calls for a critical understanding of the ecology of this phytoplankton. Further investigations along these lines are in progress in our laboratory.

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