RJC
http://www.rasayanjournal.com

RASĀYAN *J. Chem.*
Vol.4, No.3 (2011), 652-659
ISSN: 0974-1496
CODEN: RJCABP

STUDIES ON THE ECOLOGY AND TROPHIC STATUS OF AN URBAN LAKE AT NAGPUR CITY, INDIA

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ABSTRACT

An urban lake, i.e. Phutala Lake in Nagpur city, was studied for its trophic status and sources of pollution to it during the study made at 15 years interval. All physico-chemical and biological indicator parameters showed that the lake was mesotrophic in 1996 and eutrophic in 2010. Anthropogenic activity in its catchment area and on its bank was observed to be responsible for the rapid eutrophication rate and pollution of lake water. The ecological significance of the plankton diversity and the temporal variation in total plankton are discussed in the light of limnological observations and available literature. As this lake is ecologically as well as aesthetically important because its presence making the urban landscape beautiful, preventive environmental management aspects were suggested for the restoration and conservation of lake.

Key words: Urban Lake, Eutrophication, Plankton Ecology, Diversity Indices.

INTRODUCTION

Most of the lakes, especially near urban or residential areas, are found to be polluted at different levels because of anthropogenic activities. Some examples of such lakes from India are: Bada Talab near Bhopal city[1], Hussain Sagar Lake in the heart of Hyderabad city[2], Dal Lake in Srinagar[3], all affected by organic pollution. The traditional uses of the lake have been disturbed due to deterioration of lake water. Today they are subjected to a great amount of ecological stress and strain in terms of pollution and ecocrisis. Many lakes experience the rapid loss of oxygen from their hypolimnion during summer / winter stratification. In extreme conditions, fish kills and noxious smell may result and transport of reduced substances from the lake sediments may be enhanced. Part of oxygen consumption results from water column deposition process and decay of organics from allochthonous and autochthonus sources, ammonia oxidation by nitrifiers, algal respiration and the rest resulting from the flux of O_2 into sediments.

Eutrophication is also observed in five urban lakes around Udaipur City namely Pichola, Fateh Sagar[4], Rang Sagar, Swaroop Sagar[4] and Dhudh Talai and they are adversely affected due to siltation resulting from deforestation and disposal of liquid and solid waste from 60 surrounding hotels and residential area of 60,000 peoples.

The urban lakes are important in maintaining the surface and ground water balance, in maintaining urban ecosystem apart from its uses for different purposes namely recreational, water supply, fishing etc. Deterioration of lake water is also responsible for public health problems in surrounding area. Therefore, regular monitoring of lake water quality & lake ecosystem is necessary for taking appropriate environmental measures to protect & conserve lake water quality suitable for urban ecosystem.

EXPERIMENTAL

Limnological survey of the lake was carried out during post monsoon of 1996 and pre-monsoon season of 2010 to study the present status of lakes ecosystem (Fig 1) and various impacts, which are responsible for deterioration of lake water quality with special reference to plankton population, which is best indicator of water quality. These observations would be useful in delineating proper environmental management

measures for the protection and conservation of lake in the interest of urban population residing around, fishery purpose, tourist and recreational purposes.

Water samples from Phutala Lake were collected for physiochemical and biological analysis following standard limnological methods[5]. Phytoplankton flora was microscopically analysed by Lackay Drop Count Method while zooplankton fauna was microscopically analysed by using Sedgwick Rafter Cell.

RESULTS AND DISCUSSION

The lake water was observed to be slightly turbid with greenish shade, and without any odour in post monsoon 1996 while bluish green in colour in pre-monsoon 2010 due to dominance of algal bloom in lake water along with slight murky odour (Table 1). The temperature fluctuates from 22.1°C -24.5°C in 1996 while in 2010, it ranges from 30°C-31°C. The Secchi Disc depth in 1996 fluctuates from 115-62 cm and in 2010 from 30-28 cm showing increase in turbidity of lake water. pH value ranged from 7.6-8.3 in 1996 and 8.2-8.3 in 2010 showing alkaline nature of lake. The total hardness fluctuated between 78-156 mg l^{-1} in 1996 and 170-168 mg l^{-1} in 2010. The hardness of the water was observed to be within acceptable limits[6] and significant from view point of domestic uses such as washing, drinking and bathing. The chloride varied from 40.7-46.3 mg l^{-1} in 1996 and 50-55 mg l^{-1} in 2010 that indicated organic pollution. However, BOD ranged from 9.7-19 mg l^{-1} and 25-20 mg l^{-1} in 1996 and 2010 indicating that lake water was slightly polluted in 1996 but in 2010 values indicates high organic pollution. NH_3-N ranged from 1.5-2.6 mg l^{-1} and 5-4 mg l^{-1}, Nitrate-N ranged from 0.26-0.35 mg l^{-1} and 0.6-0.5 mg l^{-1} in 1996 and 2010 and total nitrogen ranged from 36.6-58.6 mg l^{-1} and 65-60 mg l^{-1} in 1996 and 2010.The phosphate ranged from 0.03-0.15 in 1996 and 0.21-0.18 mg l^{-1} in 2010. Total nitrogen and phosphate values increased from 1996 to 2010. For phosphate[7], the suggested values of 31 µg PO_4 l^{-1}, [8]62 µg PO_4 l^{-1} and [9]78 µg PO_4 l^{-1} as the critical point of eutrophication. Increase in nitrogen and phosphorous content leads to algal bloom as both of them act as nutrient limiting factor[10]. Chlorophyll - a content in lake water increased from 3.0-5.2 mg l^{-1} in 1996 and 10.0-8.0 mg l^{-1} 2010 shows continuous and frequent growth of algae.

Fig.-1: Map Showing Study Area

The above observations on physicochemical quality of lake showed rapid eutrophication during 15-year period from 1996 to 2010.

A total of 10-13 phytoplankton species in 1996 while 10 -22 species were observed in 2010 (Fig 2, Table 2) and 6-8 zooplankton species in 1996 and 5-13 species in 2010 were observed (Fig 3, Table 3). On the basis of survey, Bacillariophyceae and Chlorophyceae groups of algae and Rotifera,

Ciliata and Cladocera groups of zooplankton were found to be dominant. Abundance of phytoplankton groups was in decreasing order of Chlorophyceae, Bacillariophyceae, Cynophyceae, Euglenophyceae and Pyrrhophyceae and that for zooplankton was observed as Rotifera, Cladocera, Ciliata, Copepoda, Ostracoda and other forms. Comparative growth representation of plankton in 1996 and 2010 is shown in Fig 4.

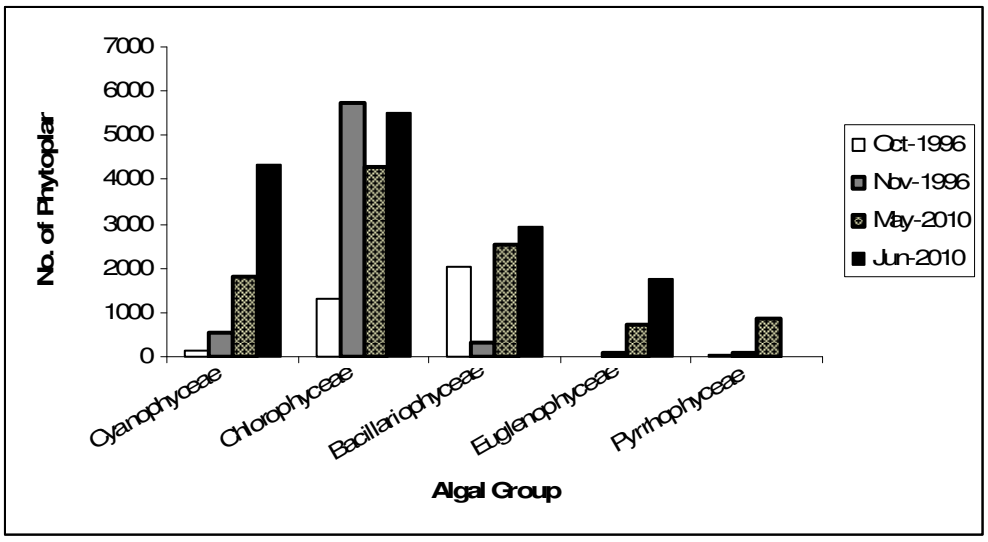

Fig.-2 : Growth rate of Algal Group in 1996 and 2010

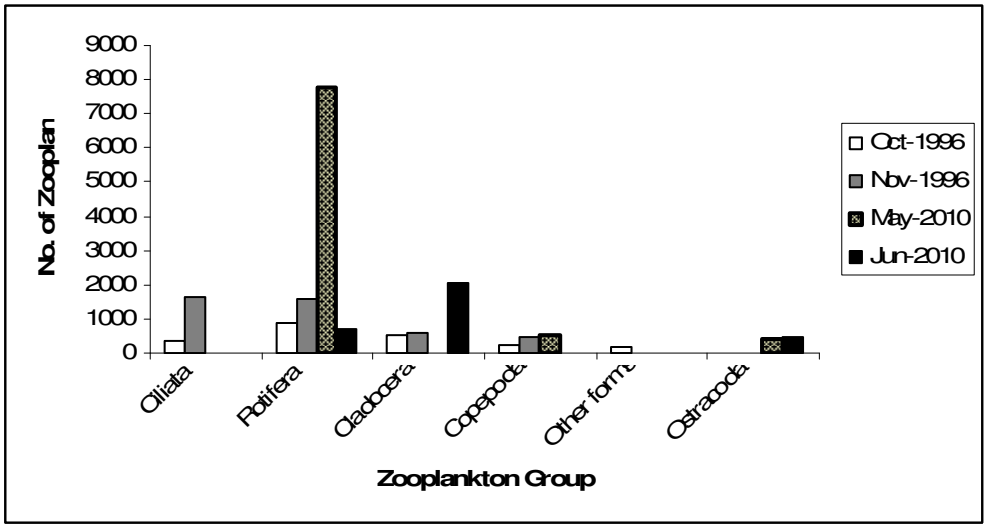

Fig.-3 : Growth rate of Zooplankton Group in 1996 and 2010

Presence of organic pollution indicator algal species like *Euglena acus, Microcystis aeruginosa, Oscillatoria limnetica, Raphidiopsis curjanta, Ankistrodesmus falcatus, Chlorella vulgaris, Navicula schizanema* and *Nitzchia bilobata* and zooplankton species like *Brachionus, Keratella, Lecane* and *Asplanchna* indicated the presence of organic pollution in lake water. Chlorophyceae, Cyanophyceae (algal groups) and Ciliata, Rotifera (zooplankton groups) are the indicators of organic pollution in the lake water. *Diaptomus siciloides*[11,12,13] and *Daphnia longiremis*[14] were generally associated with oligotropic conditions. The relatively high concentration of indicator groups and plankton species indicates the increased level of eutrophication and organic pollution during 15 years from 1996 to 2010 period. This

observation is supported by decrease in species diversity and increase in Palmer's Pollution Index [15] values in 2010.

Environmental survey of Phutala lake surroundings showed that the major sources of pollution to the lake are solid waste disposal in lake, idol immersions during Ganesh festival and Durga festival, disposal of offerings, religious activities, domestic washing, bathing, cattle wading, run off water from catchment area and death and decay of macrophytes.

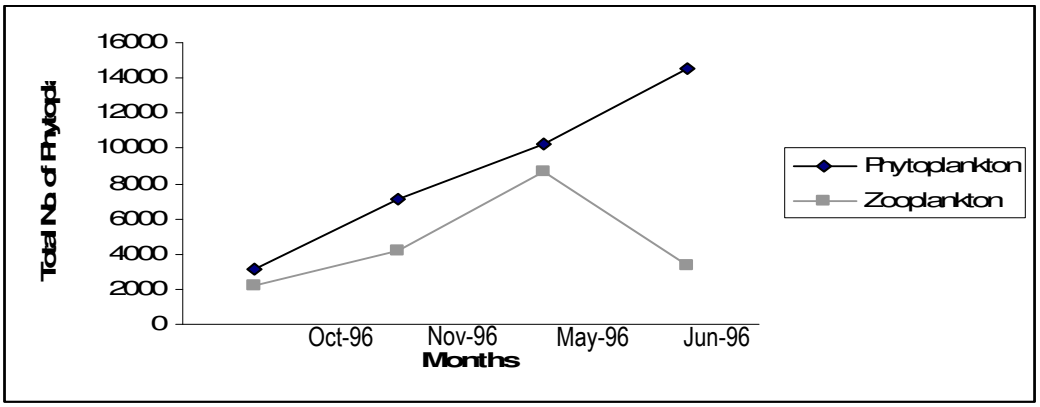

Fig.-4 : Comparative Growth Representation of Plankton in 1996 and 2010

Table-1 : Physico-chemical Quality of Phutala Lake

S. No.	Parameter	October 1996	November 1996	May 2010	June 2010
1.	Colour	Clean	Slightly, Turbid, Greenish	Slightly Greenish	Bluish Green
2.	Secchi depth (cm)	115	62	30	28
3.	Temperature (°c)	22.1	24.5	30	31
4.	pH	7.6	8.3	8.2	8.3
5.	Total Hardness	78	156	170	168
6.	Calcium hardness	44.0	66.90	80	75
7.	Chloride	40.7	46.3	50	55
8.	Dissolved oxygen	6.5	8.5	8.4	8.5
9.	B.O.D.	9.7	19.0	25	20
10.	Total nitrogen	36.6	58.6	65	60
11.	NH_3-N	1.5	2.6	5	4
12.	Nitrate-N	0.26	0.35	0.6	0.5
13.	Phosphate-P	0.03	0.15	0.21	0.18
14.	Chlorophyll-a	3.0	5.2	10.0	8.0

All values in mg l^{-1}except temperature, pH and sechhi depth

Environmental Management Aspects for Restoration and Conservation of Lake

The forgoing discussion shows that the autochthonous and allocthonous (including anthropogenic activities) sources of pollution are responsible for deterioration of lake which needs to be considered during formulating environmental management plan for the restoration and conservation of lake water quality.

Some of the important measures required are listed below:

1. The natural sources of pollution i.e. land erosion should be controlled by bringing more area of catchment under plantation. The selection of diverse local trees for plantation drives would be

useful in controlling soil erosion and pollution load to lake as well as it would beautify the area, promote the biodiversity of plants and birds that would increase the aesthetic value of area for local residents, visitors and tourists.

2. The dumping of solid waste in the lake should be banned with the provision of punishment of such activity
3. The macrophytes in lake should be regularly removed before summer season and may be property disposed off for composting purpose or for biogas preparation
4. Deepening the shallow areas of lake would control the weed growth in lake.
5. Desludging operations during lean period of summer season would be helpful to remove the accumulated pollutants in the lake.
6. Regular physicochemical & biological monitoring of the lake water & lake ecosystem should be done.

Table-2 : Estimation of Phytoplankton in Phutala Lake

			Algal Count (no/ml)			
S. No.	Algal Group and Species	Species	October 1996	November 1996	May 2010	June 2010
1.	Cyanophyceae	*Merispopedia punctata*	-	390	-	702
		Microcystis aeruginosa	-	40	-	-
		Oscillatoria limnatica	72	55	875	675
		Raphidiopsis curjanta	45	38	-	550
		Chroococcus minor	-	-	-	910
		Anabaena iyengarii	-	-	920	690
		Gloeocapsa lacustiis	-	-	-	820
		Total	117	523	1795	4347
		Percentage	3	8	17	30
2.	Chlorophyceae	*Ankistrodesmus falcatus*	-	46	850	710
		Chlorella vulgaris	977	5528	-	800
		Mougeotia capicina	252	100	-	-
		Euastrum pectinatum	95	46	-	-
		Chlorococcum humicola	-	-	1300	525
		Chlosteridium turgidrum	-	-	-	200
		Cosmarium botrytis	-		-	950
		Micractinium pusillum	-	-	1210	415
		Pediastrum boryanum	-	-	950	825
		Scenedesmus quadricauda	-	-	-	770
		Tetraedron caudatum	-	-	-	305
		Total	1324	5720	4310	5500
		Percentage	38	86	42	38
3.	Bacillariophyceae	*Cyclotella planctonica*	80	-	-	-
		Cymbella cistula	630	-	-	-
		Diatoma vulgarae	440	-	-	400
		Navicula schizonema	75	125	-	830
		Nitzchia bilobata	-	105	1220	750

			Algal Count (no/ml)			
S. No.	Algal Group and Species	Species	October 1996	November 1996	May 2010	June 2010
		Synedra ulna	-	70	-	725
		Stephanodiscus hantzchii	-	-	1300	210
		Total	2025	300	2520	2915
		Percentage	58	4	25	20
4.	Euglenophyceae	*Euglena acus*	-	92	720	940
		Phacus pleuronectes	-	-	-	800
		Total	-	92	720	1740
		Percentage		1	7	12
5.	Pyrrhophyceae	*Peridinium tabulatum*	40	80	877	-
		Total	40	80	877	-
		Percentage	1	1	9	-
		Grand Total	3,906	7,111	10,222	14,502
		No. of Species	10	13	10	22
		Shannon Weiner Index	3.06	1.494	2.92	3.97
		Palmer Pollution Index	11	23	15	29

Table-3 : Estimation of Zooplankton in Phutala Lake

		Plankton Count (no/m^3)			
S. No.	Genus and Species	October 1996	November 1996	June 2010	July 2010
1.	Ciliata				
	Halteria grandinella	314	-	-	-
	Tetrahymena pyriformis	-	1614	-	-
	Total	341	1614	-	-
	Percentage	15	38	-	-
2.	Rotifera				
	Asplanchna intermedia	323	-	-	-
	Brachionus falcatus	-	-	2700	-
	B. quadridentata	550	-	1700	-
	B. forficula	-	-	1400	-
	B. havanaesis	-	-	300	-
	B. caudatus	-	-	500	-
	B. formadivergens	-	-	300	-
	Keratella tropica	-	1447	900	-
	K . viregularis	-	-	300	-
	Trichocera	-	-	200	730
	Lepadella ovalis	-	-	100	-
	Lecane luna	-	133	-	-
	Total	873	1580	7800	730
	Percentage	40	38	89	22
3.	Cladocera				
	Ceriodaphnia quadrangula	263	560	-	-
	Chydorus haericus	267	-	-	100

	Daphnia longiremis	-	-	-	1942
	Total	530	560	-	2042
	Percentage	21	13	-	61
4.	Copepoda				
	Diaptomus siciloides	234	69	-	-
	Nauplius	-	375	300	-
	Cyclops vicinus	-	-	200	100
	Total	234	444	500	-
	Percentage	11	11	6	3
5.	Other forms				
	Nematoda	83	-	-	-
	Oligochaeta	109	-	-	-
	Total	192	-	-	-
	Percentage	9	-	-	-
6.	Ostracoda				
	Candona simpsoni	-	-	400	485
	Total	-	-	400	485
	Percentage	-	-	5	14
	Grand Total	2170	4198	8700	3357
	No. of sp.	8	6	13	5
	Shannon Weiner Index	2.82	2.51	2.92	1.63

CONCLUSION

The Phutala Lake was initially mesotrophic in 1996 and showed rapid eutrophication during 15 years period upto 2010 due to anthropogenic activities. The physico–chemical parameters showed deterioration of lake water quality during this period. The phytoplankton showed decreased number of Bacillariophyceae and Desmids, which are indicators of unpolluted water. While the indicators of organic pollution viz. Cyanophyceae, Chlorophyceae and Euglenophyceae have increased showing organic pollution. In zooplankton, the Rotifera, which is indicator of organic pollution, was dominant in 2010. These observations were also supported by Shannon Weiner Index and Palmer Pollution Index indicating the range of eutrophic water in 2010.

Phutala Lake is ecologically and aesthetically important. Therefore, proper management for restoration and conservation of this lake carried out by the methods such as macrophyte removal, deepening of shallow areas, regular water analysis, banning of solid wastes disposal and tree plantation in catchments area is necessary for the sustenance of this urban lake.

ACKNOWLEDGEMENTS

The authors are thankful to Director, National Environmental Engineering Research Institute, Nagpur for providing all necessary facilities to carry out this work.

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[RJC-827/2011]