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Studies on Phytoplankton with Reference to Ecology and Pollution Status of Upper Lake of Bhopal, India

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In Bhopal under the Lake conservation and management programmes various activities are being implemented on Upper Lake to protect the Lake from further degradation, to restore the water quality including overall up gradation of these two Lakes. The various developmental activities that have been done may have its consequence on the ecological parameters of the Lakes. Thus considering the importance of these factors various relevant parameters such as Phytoplankton have been studied from 2013 & 2014 to assess the ecological status of Upper Lake, with respect to its pollution status so as to delineate the polluted and eco-sensitive zones for mitigative measurements if required.

Key words: Upper Lake, Degradation, Ecological parameters, Phytoplankton, Eco-sensitive zone.

Water is one of the precious gifts of nature for the sustenance of mankind. It is used both in terrestrial and aquatic environment for various activities and balancing the ecological system of global environment. Urbanization has given rise to a number of environmental problems such as water supply, wastewater generation and its collection, treatment and disposal in urban areas. In most cases wastewater is either let out untreated or it percolates into the ground and in turn contaminates the groundwater or is discharged into the natural drainage system causing pollution in down stream areas.

Study area

Bhopal city, the capital of the state of Madhya Pradesh, is endowed with several man-made Lakes created through the centuries.

The two Lakes (Upper and Lower Lake), that lie at the foot of the old city of Bhopal, Out of two Lakes, water from the Upper Lake is supplied for drinking purposes.

The Upper Lake, was created in 11th century AD. The Upper Lake has special significance since it has been a source of piped water supply to the city of Bhopal for over 75 years. Even now, the Lake accounts for some 40% of the city's water supply. Until 1947 the water quality of Upper Lake was so good that it did not require any treatment before being supplied to the public. However, tremendous population growth of the city (about 70,000 in 1951 to about 1.4 million in 2001) and rapid urban development around Lower Lake and on the eastern and northern fringes of Upper Lake (especially during second half of the last century) subjected both the Lakes to various environmental problems resulting in deterioration of their water quality mainly due to inflow of untreated sewage.

The Upper Lake of Bhopal, together called the Bhoj Wetlands fall in this category. Raja Bhoj created the Upper Lake by construction of an earthen dam across the Kolans River, a rain-fed tributary of the Betwa River.

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Objective of the study

During present investigation water quality of Upper Lake was assessed to evaluate the degree of pollution caused due to input of toxic as well as domestic wastewater from its catchment areas.

The Biological study includes comparison of water quality parameters in different stations of the Upper Lake in various months in surface and Bottom waters during the year 2013-2014.

East of the Lake	Fategarh
	Kamla Park
West of the Lake	Bhainsakheri
North of the Lake	Bairagarh
	Khanugaon
South of the Lake	Bhadbhada
	Sewania gond
Central point of the Lake	Shah Ali Shah Island (Takia)

Review of literature

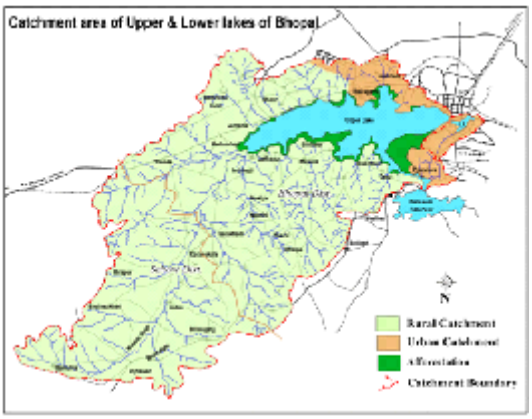
Plankton study in India received some attention in the last few decades. Ganapti[1] studied a permanent bloom of *Microcystis aeruginosa* occurred in a tank in Madras. Gonzalves and Joshi[2] have observed seasonal succession of plankton in a tank of Bandra. Singh[3] studied the distribution pattern and periodicity of phytoplankton in Ramgarh and Suraha Tal. Zafar[4] and Munawar[5] have observed seasonal succession and effects of some environmental factors on the occurrence of phytoplankton in fishponds of Hyderabad.

Khan and Siddiqui[6] while conducting limnological studies of a perennial fish pond at Aligarh. Khan et al.[7] noted the periodicity and seasonal fluctuations of different groups of phytoplankton in a pond at Aligarh.

Pani et al.,[8] have conducted limnological and ecological investigations with reference to periodicity and productivity of phytoplankton at different Lakes and pond at Bhopal.

Zutshi and Khan[9] have studied the distribution pattern and periodicity of phytoplankton at Dal Lake of Kashmir and recorded 58 genera of Phytoplankton belonging to five different groups.

Iqbal et al[10-17] has studied the quality of water and pollution status of various Lake of Bhopal with special reference to Upper Lake.



METHOD AND METHODOLOGY

Water samples were collected by filtering one litre of water through Plankton Net of bolting silk no. 40 (100 mesh/cm) in plankton bottle and preserved in formalin. The volume of Plankton bottle is 50 mL The collection of plankton has been carried out both horizontally and vertically,

In laboratory Plankton's are identified and counted by any of two methods;

Lacky's drop method

A known volume of water, which fits below a 22 mm cover glass, was placed over a glass slide. The volume of one drop was taken by the dropper. Organisms in this drop were counted in a high power micro field of a compound light microscope. Number of species counted as follows;

$$\text{No. of organism's / drop} = \frac{\text{Area of cover glass}}{\text{Area of one microfield}}$$

Sidgewick-rafter cell method

It is a slide, 50mm long, 20mm wide, 1mm deep, volume is 1/cm^2. Exactly 1 mL of sub sample was kept on the slide and a special cover glass was kept over it. After organisms settled, their number was counted under microscope. All organisms present in the cell were counted by moving the cell, till whole area is covered. Another drop was taken and the sample was repeated for ten replicates.

$$\text{No. of Phytoplankton / mL} = \frac{\text{No. of organisms counted.}}{\text{No. of replicates taken.}}$$

Plankton identification where possible was done upto species level, otherwise upto genus level only. Works of the following authors have

Table 1. Variations in total number of Phytoplankton species in Upper Lake during the year 2013 & 2014

S. No	Species recorded during Jan to Dec 2013
1	*Amphora ovalis*
2	*Anabaena spiroides*
3	*Anabaenopsis varians.*
4	*Ankistrodesmus hantzchii*
5	*Arthrospira sp.*
6	*Asterionella sp.*
7	*Caloneis sp.*
8	*Characium limneticum*
9	*Chlorella humicola*
10	*Chlorella sp.*
11	*Chlorococcum sp*
12	*Closteriopsis sp.*
13	*Closterium longissima*
14	*Closterium sp.*
15	*Coelastrum microporum*
16	*Coelastrum recticulatum*
17	*Cosmarium quinarium*
18	*Crucigenia crucifera*
19	*Crucigenia elegans*
20	*Cyclotella sp*
21	*Cymbella sp.*
22	*Diatoma sp.*
23	*Diatomella sp.*
24	*Diatomella sp.*
25	*E. viridis*
26	*Elkatothrix sp.*
27	*Eudorina elegans*
28	*Euglena acus*
29	*Euglena oxyuris*
30	*Eunotia sp.*
31	*Fragillaria sp*
32	*Frustulia sp.*
33	*Gloeotrichia sp.*
34	*Gomphonema sp*
35	K. lunaris
36	Kirchneriella sp.
37	*Lyngbya sp.*
38	*M.pseudofilamentasa*
39	*Melosira granulata*
40	*Merismopodia sp*
41	*Microcystis aeruginosa*
42	*Microcystis flos-aquae*
43	*Mougeotia sp.*
44	*N. accomodata*
45	*Navicula sp.*
46	*Nitzschia sp.*
47	*Oocystis crassa*
48	*Oscillatoria maxima*
49	*Oscillatoria minima*
50	*Oscillatoria tenius*
51	*Oscllilatoria sp*
52	*Pediastrum duplex*
53	*Pediastrum tetras*
54	*Pediastrum simplex*
56	*Peridinium sp.*
57	*Phacus meson*
58	*Phacus sp*
59	*Phormidium sp.*
60	*Pinnularia sp*
61	*Pledorina sp.*
62	*S. alterans*
63	*S.bijugatus*
64	*Scendesmus armata*
65	*Schroederia sp.*
66	*Selenestrum sp.*
67	*Spirulina sp.*
68	*Staurastrum sp.*
69	*Stephanidiscus*
70	*Synedra ulna*
71	*Tabellaria sp*
72	*Tetraedon sp.*
73	*Trachelomonus sp*
74	*Volvox sp.*

S. No	Species recorded during Jan to Dec 2014
1	*Actinastrum sp.*
2	*Chlorococcum sp.*
3	*Cosmarium sp.*
4	*Cyclotella sp.*
5	*Cymbella sp.*
6	*Diatoma sp.*
7	*Lyngbya sp.*
8	*Melosira granulata*
9	*Merismopedia sp*
10	*Microactinastrum sp.*
11	*Microcystis aeruginosa*
12	*Navicula sp.*
13	*Nitzschia sp.*
14	*Oscillatoria sp*
15	*Pediastrum Duplex*
16	*Pediastrum simplex*
17	*Pinnularia sp.*
18	*Scenedesmus sp.*
19	*Sphaerocystis sp.*
20	*Spirulina sp*
21	*Synedra sp.*
22	*Ulothrix sp.*
23	*Zygnema sp*

During 2013 total 74 species of phytoplankton were recorded in Upper Lake which has reduced significantly in the year 2014 as only 23 species were recorded in the Lake **.**

been consulted for identification. Kiefer[18], Smith[19], Desikacharya[20], Lund[21], Subba[22], Fernando[23], Harding[24], Needham & Needham[25], Brooks[26], Pennak[27] etc. Phytoplankton density was expressed as units / L.

The algal biomass was calculated through Lieca Image analyzer.

Description

The species composition and abundance of Phytoplankton in a biotope may be altered by any change in the prevailing environmental conditions. Therefore to assess the changes in the biological characteristics in relation to changes of various environmental parameters, Phytoplankton of the Upper Lake has been regularly monitored during the year 2013 and 2014. The observation recorded during these years is given in following table.

During 2013 total 74 species of phytoplankton were recorded in Upper Lake which has reduced significantly in the year 2014 as only 23 species were recorded in the Lake .

Station - 1 (Bhaisakheri)

This sampling station has a major inflow channels. Prominent fluctuation in different parameters has been observed during monsoon and winter seasons. The western part of the Lake has a wide spread catchment area, which accumulates the water in the Lake through Kolans River.

At this station, total 12 species of phytoplankton, phytoplankton, majority of the species belonged to class bacillophyceae.

Table 2. Variations in numbers of species (phytoplankton) in various stations of Upper Lake during the year 2013 and 2014

Stations Name	Total number of Phytoplanktons species
Bhaisakheri	(12)
Bairagarh	(18)
Khanugaon	(9)
Fatehgarh	(17)
Kamla park	(18)
Bhadbhada	(15)
Sewania Gond	(13)
Center of the Lake	(16)

Station - 2 (Bairagarh)

This station is located near the Sehore Nalla, which has one of the major inlets that remain active through out the year.

The continuous flow of domestic sewage from the northern residential area has resulted in increase in MPN, BOD, COD, NO_3, PO_4 etc. This area is also affected by the Idol immersion activity through which huge quantities of nutrients and decomposable materials are dumped into the Lake. The agricultural activities in the adjoining areas are also responsible for increasing the nutrient and silt load at this station. This area was also infested with submerged, emergent, macrophytes, which are responsible for release of nutrients after decomposition. The deweeding operation resulted in the development of phytoplankton population as 18 species were recorded in this station. The station also depicted comparatively more number of cyanophyceae species were recorded.

Station - 3 (Khanugaon)

Alike to station-2, this station is also grossly polluted with domestic sewage which is being added to the Lake through adjoining *nallas*. This area is also affected by the cattle activities (particularly buffaloes) and anthropogenic interference, which disturb Lake ecosystem.

At this station phytoplankton population depicted poor representation as only 9 species were recorded belonging mostly to cyanophyceae. Presence of cyanophyceae species such as anabaena, spirulina and microcystis aeruginosa further confirms that this station is highly polluted.

Station - 4 (Fategarh)

The water quality of this station is comparatively better. Although, this area is also affected by various anthropogenic activities (bathing, swimming etc.) but these activities do not have much significant role in Lake pollution. This station is also the site of Tajia immersion, but the immersion activity has only temporary effect on water quality (since no silt is added). At this station total 17 species of phytoplankton population were recorded belonging mostly of class Chlorophyceae.

Station - 5 (Kamla Park)

This station is subjected to maximum exposure of anthropogenic activities. High density of algal biomass (particularly Microcystis

aeruginosa) is recorded at this station. This is the major site of Idol immersion activities. Recently, the idol immersion activity at this site has been reduced after developing Prempura Ghat particularly for immersion activity. However, the accumulated silts and nutrients have their impact over the years.

This station is subjected to maximum exposure of anthropogenic activities. High density of algal biomass (particularly Microcystis aeruginosa) was recorded at this station. Total number of phytoplankton species recorded 18 in this station. The nutrients available in the overlying water has encouraged the growth and development of hard varieties of phytoplankton species like Anabaena, Spirulina, Oscillatoria which has a fascination to grow in nitrogen rich environment. The area is still grossly polluted and as the flushing rate is very low, therefore, unless the accumulated silts and soils are removed it will be difficult to restore the water quality at this particular station.

Station - 6 (Bhadbhada) –

At this station, the water quality parameters depicted considerable fluctuations in various parameters.

In this station, the water quality parameters depicted considerable fluctuations in various parameters. Higher concentrations of PO_4^{3-}, NO_3^- were observed which lead to the profuse growth of algal population particularly *Microcystis aeruginosa*. Besides this some other species viz. Spirulina, Anabaena were also recorded that grow in nitrogen rich condition. The sudden increase in algal density can be related to the release of nutrients from the soil from overlying water during rainy season because of deepening and widening activity. Total 15 species of phytoplankton population were recorded.

Station - 7 (Sewania Gond)

This station is highly influenced by anthropogenic and cattle activities. The run-off from the catchment area adds of nutrients to the Lake. The region is covered with high density of emergent / submerged macrophytes.

This region was initially covered with high density of emergent / submerged macrophytes. After deweeding there has been an increase in number of phytoplankton population. At this station 13 species of phytoplankton were recorded.

Station-8 (Central Part of the Lake) Shah Ali Shah (Island)

The deeper zone of the Lake depicted almost similar characteristics in various water quality parameters. The zone is sparsely covered with submerged macrophytes (very poor density). In central part of the Lake total 16 species of phytoplankton were observed.

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