Ambient Science, 2022: Vol. 09(2); 87-91
DOI:10.21276/ambi.2022.09.2.aa05

Published by: National Cave Research and Protection Organization, India

ambient SCIENCE
Vol. 09(2): 87-91
Year 2022

AMBIENT APPRAISAL

Impact of Anthropogenic Activities on Macrobenthic Biodiversity of Lower Lake Bhopal, Madhya Pradesh

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Study Area: Bhopal, Madhya Pradesh, India
Coordinates: 23°15′N 77°25′E

Keywords: Nutrient Enrichment, Pollution, Arthropods, Molluscs, Annelids

Abstract

The present study was conducted to understand the impact of anthropogenic activities on macrobenthic biodiversity of the Lower Lake which is one among the important water bodies of Bhopal. The study reveals that the water quality of the Lower Lake shows the sign of deterioration at several places due to increasing anthropogenic pressure. Though average values of most of the parameters are within the permissible limit of CPCB however, concentration of BOD (1.2 mg/l to 12 mg/l) and COD (8 mg/l to 31 mg/l) reveals moderate degree of organic pollution at some intervals. All the water samples collected during the period 2019-20 contain significant amount of nitrate and orthophosphate that facilitated growth and development of few indicator species of macro benthic community. On the basis of physical, chemical and macro zoobenthic study, the Lake water can be classified as moderately polluted water body.

Introduction:

Water is considered to be the elixir of life but the impetuous uses and improper management of the water system have caused grave problems in the availability and quality of water all over the world. Pollution of the aquatic environment caused by anthropogenic activities, degradation and misuse of natural resources has been increasing on our planet. Chemical contamination or biological contamination renders water unfit for drinking or other dependent use. Increases in mechanization, urban sprawl, farming and other human activities have caused enormous deterioration of the quality of various natural water bodies, particularly rivers and groundwater in developing countries like India. Water quality can mean many different things to many different people. A farmer may be concerned about salts in water used to irrigate the fields, a fisherman about the types of fish that live in rivers, a swimmer about the harmful bacteria and pathogens or toxic algae, and we all should be concerned about what is in the water we drink and use every day. We study these conditions and processes that affect what is in our rivers and lakes. The process of water quality deterioration is caused by uncurbed nutrients as a result of growing anthropogenic activities. Sewage (or domestic sewage, domestic wastewater, municipal wastewater) is a type of wastewater that is produced by a community of people. Sewage contains macro-pollutants and micro-pollutants, and may also incorporate some municipal solid waste and pollutants from industrial wastewater. The inflow of large quantities of untreated sewage from human settlements and runoff from the agricultural field in the catchment usually results in the buildup of nutrient supply, particularly nitrogen and phosphorus to the water body resulting in the formation of algal blooms or alteration in species composition of flora and fauna and finally water quality deterioration (Pani, 2017). With proliferate defilement, change in water quality is expected to occur in the species composition, appearance of tolerant species, number of species and changes in abundance of species in all the water bodies especially in urban lakes, reservoirs and dams (Pani *et al*., 2007). Hence assessment of water quality is very important to understand the quality of water from prospective primary and secondary uses.

Now, these days water quality is a global problem. A healthy aquatic ecosystem depends on biological diversity and physicochemical characteristics. Various factors like temperature, turbidity, nutrients, hardness, alkalinity, and DO, play an important role in the growth of plants and animals in the water body. On the other hand, BOD, and COD indicate the pollution level of the water body. In a natural aquatic system, various chemical parameters occur in low concentrations.

Hence, understanding the status of water quality of the potable and other water resources through various physicochemical and biological monitoring is essential for determining its best uses apart from preparing a Detailed

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Planning Report (DPR) for conservation and sustainable development of the water resources. Considering this, the water quality assessment of Lower Lake of Bhopal was conducted during the period 2019-20 to understand the impact of anthropogenic activities on the macrobenthic biodiversity of the Lake.

Methodology :

Following sampling, stations were selected for the collection of water and biological samples.

Station -1 Near Banganga (L/1)
Station -2 Dhobighat (L/2)
Station -3 Centre Hamidia College (L/3)
Station -4 Khatlapura (L/4)
Station -5 Jehangirabad (L/5)

Selection of the sampling station was done considering the catchment structure, inflow and outflow channels, degree of pollution, and characteristics of the water in the lake.

Collection, preservation and analysis of various parameters were done as described in APHA (2017).

Results and Discussion

Although there are the numbers of physicochemical parameters to assess the water quality of the lentic resources but based on the present scope of work and available facilities 16 parameters have been studied during the present period of investigation to understand the quality of water in terms of the impact of eutrophication on water quality and macrobenthic community of the lake. Data generated for various physicochemical and biological parameters are discussed below. The result of various Physico-chemical parameters with the range values is summarized in Table-1.

Nutrient over-enrichment (eutrophication) can cause a range of economic and non-economic impacts including anoxia and hypoxia, loss of fishery resources, changes in ecological structure, loss of biotic diversity, and impairment of aesthetic enjoyment.

The study undertaken depicts that the water quality of Lower Lake is deteriorated in many places mainly due to the inflow of raw sewage from two major inlets of the lake. The concentration of BOD (0.8 mg/l to 32 mg/l), Total Phosphorus, Nitrate-nitrogen and Chloride reveal a high degree of organic pollution from these major inlets. Similarly, high concentrations of inorganic constituents like total hardness (104 mg/l to 230 mg/l), total alkalinity (100 mg/l to 290 mg/l), etc also indicate deterioration in water quality. In general water samples analysed during the period of investigation contain a significant amount of nitrate and orthophosphate which release nutrients for excessive growth and multiplication of microorganisms.

In recent times along with physicochemical parameters, bio-monitoring analyses are also being undertaken to define the quantum of pollution and trophic status of a water body. Using macrobenthos as a tool of biomonitoring study can not entirely replace the standard physicochemical water quality methods which provide information on water quality at a particular spatial unit during the time of sampling; however, biomonitoring provides some historic insights into the water quality (Capitulo & Ocon, 2001). Standard physicochemical water quality methods, therefore, are carried out in conjunction with biomonitoring for a comprehensive evaluation of the health of a water body.

Considering this macrobenthic community of Lower Lake, Bhopal was analyzed along with physicochemical observations to obtain a realistic picture of the water quality of the lake. Macrobenthos were collected from identified five sampling stations of the lake to understand the qualitative and quantitative distribution belonging to different families *vis-a-vis* nutrient enrichment and other physicochemical parameters. Macrobenthos recorded in Lower Lake during the period 2019-2020 are depicted in Table-2 & Fig-1.

During the present investigation majority of the macrobenthic species belonged to three phyla viz. Mollusca, Arthropoda and Annelida. A total of 59 species were recorded in which Phylum Mollusca was represented by 17 species whereas phylum Arthropoda and Annelida were represented by 35 and 7 species respectively. As macrobenthic fauna at various stations in Lower Lake during different seasons of 2019-20; 12% of Annelids, 29% of Molluscs and 59% of Arthropods were recorded.

While going through the distribution of different species belonging to various groups during this period, it was observed the contribution of species Culex of Arthropoda was maximum followed by Caenis species.

Among Mollusca, no distinction in the dominance of a particular species was observed during the period of investigation while, among annelids, Tubifex was observed to be dominant over other species during the period of investigation.

The availability of major groups of macrobenthic communities at Lower Lake during the period of investigation is described below:

Mollusca: variation in various groups of Mollusca during different seasons of 2019-2020 is depicted in Fig.-1. A total of 17 species were observed. A maximum number of species were recorded at station-1 & 3 during summer 2019 followed by station-1 in winter 2019 (Fig.-1). A comparatively higher number of species was recorded during the summer season while in monsoon lesser number of species was observed during both the year *i.e.* 2019 & 2020. A distinct fluctuation in the availability of a number of species with respect to different stations was observed in the molluscan community. Most of the species appeared with the receding of water at Station-1 &2 which

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Table 1: Seasonal variations of different parameters with range values at Lower Lake during January 2019 to December 2020

	Parameter		Min.	Station	Month	Year	Max.	Station	Month	Year
1	Air Temperature (°C)	S	27.1	4	Dec	2020	43.9	4	May	2020
2	Water Temperature (°C)	S	24.1	1	Dec	2020	34.2	1	May	2019
		B	19.8	2	Feb	2019	31.9	4	May	2019
3	pH	S	6.4	1	April	2019	8.4	4	Mar, 19; May, 20	2019, 2020
		B	6.1	1,2,5	Mar, Apr, Oct, Nov	2019	9.2	3	Feb, Mar	2019
4	TDS (mg/l)	S	162.3	4	Oc	2020	492.8	1	Jul	2019
		B	154.2	4	Oct	2020	479.3	2	Aug	2019
5	Turbidity (JTU)	S	6.0	2	Apr	2019	97	5	Aug	2019
		B	6.0	3	Dec	2020	89.0	1	Aug	2019
6	DO (mg/l)	S	Nil	1	Jul	2020	9.6	4	May	2019
		B	0.0	1	May	2020	12.4	4	April	2019
7	Chloride (mg/l)	S	34.97	1	Feb	2020	51.95	5	May	2019
		B	21.90	3	Dec	2019	51.95	5	May	2019
8	Total Alkalinity (mg/l)	S	104	5	Mar	2020	240	1	Jul	2020
		B	100	5	Mar	2020	220	1	Aug	2020
9	Total Hardness (mg/l)	S	110	3	Jan	2020	230	1	Jul	2019
		B	104	5	Jan	2020	214	1	Jul	2019
10	BOD (mg/l)	S	1.2	3,4	Dec	2020	32	1	Jun	2019
		B	0.8	2	Oct	2020	22	1,2,5	Mar	2020
11	Nitrate (mg/l)	S	0.44	1	Oc	2020	5.71	2	Jun	2020
		B	0.41	1	Oct	2020	5.31	1	Jul	2020
12	Total Phosphorus	S	1.17	5	Dec	2019	5.40	1	Aug	2020
		B	1.19	3,4	Dec	2019	4.91	3	Jul	2019

S: Surface **B: Bottom**

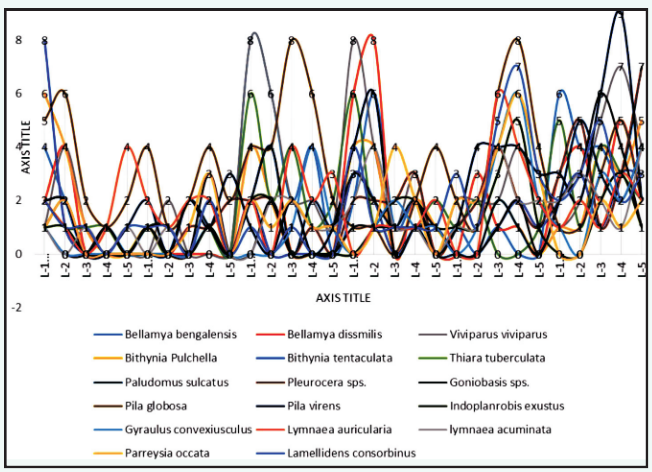

Figure-1: Distribution of the Molluscan species

receive mainly sewage water from the adjoining inlets and during the onset of summer most of these species are visible in the exposed part. Pila was the dominant species at these stations. In the rest of the stations, comparatively lesser number of species was observed. The change in species composition can be on account of the availability of food and vegetation community with respect to nutrient enrichment in these regions of the lake.

Arthropods: distribution of the Arthropodan community during 2019- 2020 is depicted in Fig.-2. A total of 25 species were recorded during the period of investigation. A maximum number of species were recorded at station-1 during monsoon 2019 followed by station-1 in monsoon 2020 (Fig.-2). A comparatively higher number of species was recorded at station 1 during summer 2019 followed by station 2 in summer 2020 while in winter lesser number of species was observed during both the years i.e., 2019 & 2020. A distinct fluctuation in the availability of a number of species with respect to different stations was observed in the Arthropodan community. Most of the species appeared with the receding of water at Station-1 & 2 which receive mainly sewage water from the adjoining inlets and during the onset of monsoon most of these species are visible in the exposed part. The change in species composition can be on account of the availability of food and vegetation community with respect to nutrient enrichment in these regions of the lake.

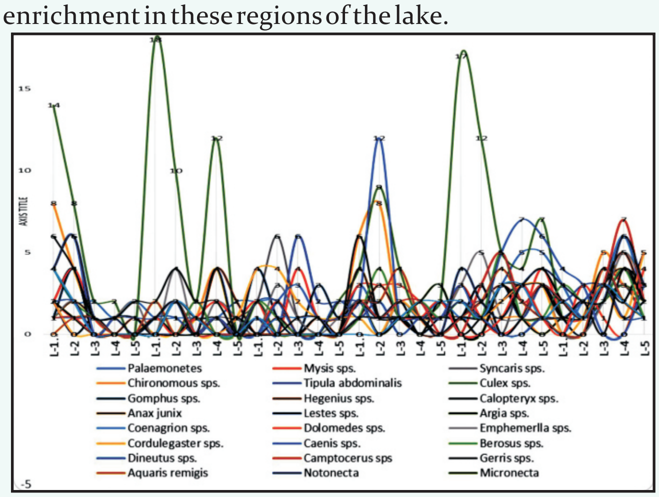

Figure-2: Distribution of the Arthropodan species

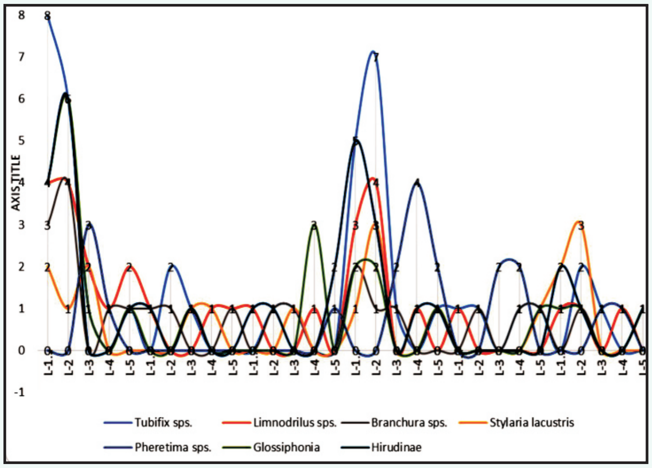

Figure-3*: Distribution of the Annelid species

During the period of investigation, a total no. of 25 species was recorded. The most supreme species found were *Culex* sps. in monsoon 2019 followed by the same species in monsoon 2020. For the rest of the season minimum to average growth of species was observed.

Annelida: the Annelidan community in Lower Lake was represented by six species only (Fig.-3). The maximum number of species was recorded at station-1 during summer 2019 followed by station-2 in summer 2020. A comparatively higher number of species was recorded at station 1 during summer 2019 followed by station 2 in summer 2020 while in monsoons lesser number of species was observed during both the years i.e., 2019 & 2020. A distinct fluctuation in the availability of a number of species with respect to different stations was recorded. The change in species composition can be due to various factors like food and vegetation and nutrient enrichment in these regions of the lake.

During the period of investigation, the macrobenthic community in the Lake exhibited a discontinuous distribution. The density, abundance and occurrence of benthic fauna were lower at stations 3 and 4. In addition to the impact of pollution, the macrobenthic fauna was also found to be influenced by land drainage and hydrodynamics during the periods of the two monsoons. The general composition of the macrobenthos in the five stations of the Lower Lake revealed the fact that the benthic organisms were more abundant at Station-1 & 2 most of the time. A similar finding has been noticed by Pani *et al.* (2007) in Bhopal lakes. The population density of benthic fauna in the lake water was maximum during the summer months (at all stations). This may be due to the changes associated with an increase in nutrients due to inflow of sewage and accumulation of decaying vegetation present in the areas that contributed more food for benthos and it could have resulted in higher numerical abundance and population density of benthos during the post-monsoon period. A similar situation has been reported by Nair *et al.* (1984d) from the Kadinamkulam backwater. Divakaran et al. (1981) and Nair & Abdul Azis (1987) reported a similar situation in the abundance of the benthic fauna from the Ashtamudi estuary. In the present study also temperature did not show any definite pattern of variation during the study period. Kurian (1972) reported a seasonal difference in the temperature of 20 to 40 C that was noticed in the backwater and he also argued that temperature is not a limiting factor for the distribution of the macrobenthic fauna. The present observations were in close agreement with these findings. Levin *et al.* (2000) observed that it was very difficult to distinguish the individual impact of physicochemical parameters on macrobenthic fauna. Almost all environmental parameters had a positive relationship at their optimum level and influence negatively beyond this level. The influence of nutrient exposure on the community structure of benthic fauna was studied by Harkantra *et al.* (1982). According to Harkantra & Parulekar (1991), a single factor could not be considered an ecological factor that affects the community structure of macrobenthos. This has been experienced in the present study also wherein many environmental parameters such as turbidity, dissolved oxygen, water movement, nutrient enrichment etc. were constantly affecting the population density of macrobenthos. This is in close agreement with studies of Mahapatra *et al.* (2011) in the Hamada estuary. Harkantra *et al.* (1982) studied in the shelf region of the Bay of Bengal that not only the Physico-chemical parameters but also the sediment texture and community interactions are the main reasons for the lesser density of macrobenthos. Harkantra & Parulekar (1991) and Mahapatro (2006) stated that sediment composition has no effect on the density of macrobenthos but community interaction involving competition, predation, recruitment and mortality are the main factors which can affect the density of macrobenthos. Similar findings were observed during the present study.

Pollution is the form of environmental stress and it will result in a decrease in the diversity of the macrobenthic community and it depends on the degree of stress suffered by the substrate. Several workers tested the application of diversity indices for biological monitoring. Clarke & Warwick (1994) described that in a healthy environment the diversity indices are higher. During the present investigation, the basic concept of community structure such as diversity, and dominance, has been examined. The diversity indices including diversity and richness of the macrobenthic community at station-3&4 were found to be maximum as compared to the other stations. Macrobenthic community structure has been used as a tool in pollution monitoring studies. During the present study changes in the community trophic structure was noted by describing two groups such as an equilibrium

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group representing the molluscan community and an opportunistic or indicator group representing annelids. These opportunistic species were characterized by a relatively short life span and are very commonly present in environmentally stressed habitats. However, the equilibrium species were characterized by relatively long life spans and were commonly present in environmentally unstressed habitats. The dominance of the molluscan community in the lake further endorses that dam in general enriched with calcium.

Thus, from the present investigation it can be concluded that the water quality, in general, is within the permissible limits of Class – C of CPCB, New Delhi *i.e.*, under designated best uses of water for irrigation and drinking water after conventional treatment. The study confirms that the results of the impacts observed during these studies are not an incidence but it is the characteristics of the water quality. The compilation of data and its relevance with the Dam ecosystem has been invariably confirmed with the available references of the different researchers also who have reported similar findings in their respective studies.

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