LIMNOLOGICAL STUDY OF SHAHPURA LAKE, BHOPAL, INDIA AND ITS IMPACT ON GROUND WATER QUALITY OF NEARBY HUMAN HABITATION

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ABSTRACT

Pollution of water bodies is one of the areas of major concern to environmentalists. The paper is intended to analyse the water quality by studying various physicochemical parameters of Shahpura Lake of Bhopal, India, situated in the heart of the city surrounded by the closed human habitation. Encroachment in surrounding areas is leading to improper waste disposal, dumping of garbage, entry of flowing untreated sewage as well as household and industrial effluents into the lake, leading to the deterioration of water quality. For estimation of pollution, a study was conducted during the period of pre-monsoon (March-May 2018) and post monsoon (October-December 2018) determine parameters such as nutrient salts, organic matters, pH, Conductivity, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Suspended Solid (SS), Total Dissolved Solids (TDS) and microbiological study. Samples were collected from four different locations (point sources) and all four sites of bore wells of adjacent colonies around the water body in question. By observing the results, it can be concluded that the parameters which were studied for the examination of water quality exceeded the permissible limit indicating water body as highly polluted and unsafe for aquatic ecosystem. This could also lead to the contamination of nearby ground water resources. The situation is alarming and therefore immediate action is required to provide healthy ecosystem in the lake and water quality of nearby ground water as well.

Key Words: Limnological study, Ecosystem, Dissolved Oxygen, Biological Oxygen Demand, Total Dissolved Solids

INTRODUCTION

Lakes and ponds are highly valued for their recreational, aesthetic and scenic qualities and the water they contain is one of the most treasured of our natural resources. They constitute important habitats and food resources for aquatic life and wildlife, but their ecosystems are fragile which can undergo rapid environmental changes often leading to significant declines in their functions. Due to the industrialization, there is growth in the population, residential and commercial buildings, roads, power consumption, vehicles, increase in water demand and drainage problems. Amongst the Bhopal lakes, the Shahpura lake is commonly known as the third lake of Bhopal.1,3 It has a catchment area of 8.29 km² and a submergence area of 0.96 km². This lake is surrounded by human habitation and receive untreated sewage from various point and non point sources.4,6

The man made water impoundment was constructed in the Southern part of the city near Chunna Bhatti, Village in 1974-75 under the Betwa irrigation scheme. Although irrigational use of reservoir became secondary but 1975 onwards fisheries and recreational activities have been promoted the lake was constructed on a small stream, which used to bring the overflow of the oxidation pond situated near mata mandir, which is about 3 km in the upstream of the lake. After the closing down of the oxidation pond in the year 1977-78 now the stream carry only the storm water and sewage drainageing in the lake.7,8 Besides this the lake also receive sewage
and waste water though number of drains. The water quality of the lake is deteriorating on account of untreated sewage inflow, siltation, encroachments, excessive growth of aquatic plants, grazing in the fringe area, washing of clothes, idol immersion, unmanaged fisheries and out flow through spill way. Present status of Shahpura lake is an advanced state of eutrophic. Changes in the water quality affect the biotic community of the aquatic ecosystem which ultimately reduces the primary productivity. Decrease in water quality increases the risk of water borne diseases and is critically concerned with the public health also. Therefore it has been a growing concern for conservation and management of the available water resources by keeping check at regular time intervals. In the present study quality of water is assessed by the analysis of physical, chemical and biological characteristics of water. On 19 September, 2014 in the case of Dr. Subhash C. Pandey Vs Municipal Corporation Bhopal & Others (original application number 34/2013 (CZ)) National Green Tribunal, Bhopal in its judgment had clearly directed to the respondents for a time bound cleaning conservation and beautification of Shahpura lake. Therefore, a time bound plan had to be executed by the Respondents in the financial year 2015-16. Therefore it was essential to find out factual and physical status of the Shahpura lake after the compliance of NGT’s Order in this behalf.

AIMS AND OBJECTIVES
To investigate the water quality of Shahpura lake, Bhopal, India which is deteriorating day by day, its adverse impact on aquatic, biotic living system and ground water quality in nearby human habitation so that steps could be taken to provide clean and healthy environment for aquatic and biotic living system.

MATERIAL AND METHODS
Pre-monsoon (March-May 2018) and Post Monsoon (October-December 2018) samples from Shahpura lake were collected from six sampling stations namely 1. Amrapali Nala, (JR1) 2. Panchsheel Nala (JR2) 3. Oxidation pond outlet (JR3) 4. Shahpura Nala (JR4) 5. Chunna Bhatti Nala, (JR5) and At the Centre of the lake (JR6). Similarly samples were collected from all four residential sites of the lake where boring water was used for sample from 1. Amrapali Enclave (KS1) 2. Shahpura C sector (KS2) 3. Adminstration Academy Campus (KS3) 4. Paryavarn Parisar (KS4). A Collected water samples were brought immediately to the laboratory for estimation of various physicochemical parameters like pH, Total Coliform (TC), TDS, TSS, COD, BOD, DO. Physico-chemical parameters were analysed as per standard methods of APHA and compared with maximum permissible limits given by CPCB, BIS and WHO with in this behalf.

Geographical location of experimental site
Bhopal city of India lies on the geographical coordinates of 23.2031° N, 77.4229° E on the South of Bhopal City. Google image of Shahapura lake, Bhopal and sampling stations from where the samples were collected are shown in Fig. 1 which is rectangular in shape and most part of the bank faces diverse human activities like washing, bathing and also receives sewage as well as domestic waste water from surrounding area through open drains.

RESULTS AND DISCUSSION
Turbidity
The American Public Health Association (APHA) defines turbidity as the optical property of water. Clay, silt, organic matter, phytoplankton and other microscopic organisms cause turbidity in pond water. Greater the amount of suspended solids higher will be the turbidity of water. All 6 water samples of Shahpura lake, Bhopal were found to be turbid in nature. Their greenish appearance indicated the presence of higher amount of phytoplankton and microorganisms in the water samples. Increase in turbidity might also be due to the growing aquatic vegetation. Higher turbidity affects aquatic life indirectly, as it cuts off light penetration through water surface which is utilized by plants for photo-synthesis and thus indirectly reduces the primary productivity. Results of physicochemical parameters of each site along with standard values are reflected in Table 1.
Fig. 1: Google map of Shahpura lake situated at middle of Bhopal, India

Table 1: Water quality of point sources of Shahpura lake

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameter</th>
<th>Pre monsoon session</th>
<th>Post monsoon session</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JR1</td>
<td>JR2</td>
</tr>
<tr>
<td>1</td>
<td>pH</td>
<td>8.9</td>
<td>8.6</td>
</tr>
<tr>
<td>2</td>
<td>DO</td>
<td>1.2</td>
<td>Nil</td>
</tr>
<tr>
<td>3</td>
<td>TDS</td>
<td>784</td>
<td>818</td>
</tr>
<tr>
<td>4</td>
<td>TSS</td>
<td>286</td>
<td>264</td>
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<tr>
<td>5</td>
<td>BOD</td>
<td>102</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>COD</td>
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<td>344</td>
</tr>
<tr>
<td>7</td>
<td>TC</td>
<td>&gt;1000</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>

Notes: Parameters other than pH are measured in mg/L; TC = MPN/100mL.
Notations: Same as described in Fig. 1.

Water quality of Shahpura lake, Bhopal

The pH serves as index to denote the extent of pollution. The pH of water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity. The factors like photosynthesis, respiratory activity, temperature, exposure to air, disposal of industrial wastes etc. bring out changes in pH. Variation in pH is mostly due to photosynthesis and community respiration of the biota which influences aquatic production. Higher value of pH is correlated with higher temperature and higher decomposition activities. pH value of all samples was found to be alkaline (pH>7.0) and is greater than the standard value indicating higher risk for aquatic life inhabiting it. pH value of sample 4(JR4) was found to be acidic (6.5) which may be due to higher discharge of domestic waste by surrounding community. Accumulated organic matter and vegetation on biological oxidation releases carbon-dioxide which ultimately lowers the pH.

Dissolved Oxygen

Dissolved oxygen is the most crucial and important water quality variable for most
aquatic life. DO analysis measures the amount of gaseous oxygen dissolved in an aqueous medium. Oxygen dissolves into water via atmospheric exchange and through photosynthetic activity carried by aquatic plants and algae. Oxygen is essential for the metabolism of aerobic organisms and also influences inorganic chemical reactions. Oxygen is considered a limiting factor, especially in water body with a heavy load of organic material. Organisms have specific oxygen requirements. The higher level of nutrient load, algal growth as well as some other types of pollution can consume oxygen faster than it is produced, robbing dissolved oxygen of water. Low dissolved oxygen may prove fatal for many organisms for their survival as is evident in the study area. DO was observed to be Nil mg/L in some of the samples from the study area, imposing a high threat for aquatic life. However, it was observed less than 5 in all samples is also a cause of concern. This oxygen depletion might be due to high temperature, addition of sewage, other waste and algal growth.

Total Dissolved Solids
Total Dissolved Solids (TDS) depend upon various factors such as geological character of watershed, rainfall, amount of surface run off and indicates the degree of dissolved substances in water. TDS refers to presence of any minerals, salts, metals, cations or anions. Salts like carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron etc. are dissolved in natural water. Total dissolved solids of all six samples of the lake were recorded of which minimum was 675 mg/L in sample no. 6 (JR6) and maximum was 862 mg/L in sample no. 3 (JR3). Due to contamination by domestic waste water, garbage, fertilizer, etc. in the surface water, the value of TDS was reported to be high. High concentration of TDS reduces the solubility of gases (like oxygen) in water and increases density of water. Indeed, high concentration of TDS enriches the nutrient status of water body which results into eutrophication of aquatic ecosystem, indicative of pollution.

Total Suspended Solids
Total suspended solids in the water samples of the pond varied from a minimum of 122 mg/L in sample no 6 (JR6) to a maximum of 287.0 mg/L in sample no 4 (JR4). Water high in suspended solid may be aesthetically unsatisfa-ctory. Suspended solids result in turbidity due to silt and organic matter. The higher concentra-tion of total suspended solids is an indicator of pollution in water. The high TSS values are responsible for gastrointestinal irritation also.

Biochemical Oxygen Demand
BOD is a measure of determining the amount of dissolved oxygen needed by aerobic biological organisms present in a water body to break down the organic material present in the given water sample at a certain temperature over a specific time period. It is widely used as an indication of the organic quality of water. It is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water. Value of BOD for the pond water samples was found to be above the permissible limits with minimum of 88 mg/L in sample no 6 (JR6) and maximum of 112 mg/L in sample no 5 (JR6). Higher values of BOD reflect input of organic wastes and enhanced bacterial activity in water. At high BOD values, the aquatic life, both plants and animals are adversely affected.

Chemical Oxygen Demand
Chemical Oxygen Demand determines the oxygen required for chemical oxidation of organic matter. COD values convey the amount of dissolved oxidisable organic matter including the non-biodegradable matters present in water. The minimum permissible limit for COD is 152 mg/L in sample no. 6 (JR-6) while the maximum COD recorded from the water samples in present study was 364 mg/L in sample no 1 (JR1). Hence the value of COD from all water samples falls within the prescribed limits. This may be because no industry is present in the nearby areas and the pond doesn’t receive any industrial effluent.
Total Coliform Bacteria
Total coliform bacteria in the water of studied pond for all samples was >100000 MPN index/100mL. However it was found more than 48000 MPN/100 mL in two samples (i.e JR-4 and JR-6). The fairly high value of total coliform is indicative of high level of pollution of pond water by organic means, particularly through the discharge of sewage and domestic effluents. Due to the presence of plenty of microbial pathogens, the risk potential for health of biotic living system arises. This is how a lake has changed into a sewage tank.

Post monsoon results
Sample analysis results in post monsoon session for all six sample are similar and identical to that of results obtained in Pre monsoon session for the same. Similarly, presence of other prominent contaminants / parameters can easily be estimated from the observation. Moreover, due to idol immersion in the lake, presence of potential amount of heavy metal can not be ignored.

Ground water quality of nearby human habitation
Four samples namely KS1, KS2, KS3 and KS4 were taken from borewell sides of all four sides of nearby human habitation of the lake. Samples were analysed wrt all parameters as same as taken for Shahpura lake in pre monsoon and post monsoon session. (Table 2) It was disappointing that similar results were obtained as in lake water samples. Concentration was found low in all parameters but above permissible limits. Results clearly indicating that water of lake is percolating to all the sides in the ground and badly deteriorating quality of residential ground water like anything.

Table 2: Water quality of samples collected from residential colonies near Shahpura lake

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameter</th>
<th>Pre monsoon samples</th>
<th>Post monsoon samples</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>KS1</td>
<td>KS2</td>
</tr>
<tr>
<td>1</td>
<td>pH</td>
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</tr>
<tr>
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<td>DO</td>
<td>5.8</td>
<td>4.4</td>
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<td>TDS</td>
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<td>4</td>
<td>TSS</td>
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<tr>
<td>5</td>
<td>BOD</td>
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<td>40</td>
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<td>68</td>
</tr>
<tr>
<td>7</td>
<td>TC</td>
<td>&gt;2400</td>
<td>&gt;1600</td>
</tr>
</tbody>
</table>

Notes: Parameters other than pH are measured in mg/L ; TC = MPN/100mL

Notations: KS1= Amrapali Enclave; KS2=Shahpura C sector; KS3= Administration Academy Campus; KS4 = Paryavarn Parisar

CONCLUSION
The present study revealed that water of the studied pond is highly polluted with reference to all the physicochemical parameters. Certain human activities like washing, recreational, surface runoff from rainfall, domestic waste, house hold industrial waste and sewage discharge contribute considerable pollution in the pond. Water quality from studied pond is very unsafe for human use and therefore needs serious attention. Some effective measures are urgently required to stop the ongoing deterioration and improve the water quality. Respondent have not even complied NGT’s judgement for cleaning of the lake. Eventually percolation of contaminated lake water is continuously taking place into nearby housing colonies around the lake. That is why quality of borewell water of said colonies are found equally contaminated. If similar conditions continue for a longer period, the pond will soon become biologically inactive. A periodical survey, which is essential to maintain the water quality is highly recommended.

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CONFLICT OF INTEREST

The author(s) declare that there is no potential conflict of interest with respect to research, authorship and / or publication of this article.

REFERENCES


We have modified our environment so radically that we must now modify ourselves to exist in this new environment.

Norbert Wiener