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Water Quality Assessment Using Physico-Chemical Parameters and Heavy Metals of Lilour Lake, Bareilly, Uttar Pradesh (India)

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ABSTRACT

Water pollution causes severe loss to soil, plants, human and animals and spread epidemics and chronic diseases. Higher concentration of heavy metals and water pollutants can cause biochemical effects such as inhibition of enzymes, genetic damage and hypertension etc. Present study investigates the level of physiological parameters and heavy metals in historically important Lilour lake of Bareilly District of western Uttar Pradesh, India. The samples were collected from three sampling points designated as S_1, S_2 and S_3 for determination of water temperature, pH, total hardness, total alkalinity, dissolve oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), copper (Cu), zinc (Zn), lead (Pb). These parameters were analyzed using slandered protocols. Concentration of heavy metals in water samples were analyzed using atomic absorption spectrophotometer (AAS). Results of multivariate analysis of variance (MANOVA) revealed that, physicochemical parameters and heavy metals were significantly varying among different sampling stations. Concentration of all the physiochemical parameters and heavy metals were found higher than WHO guideline limit for drinking water. This high level of pollutants and heavy metals in study area is expected due to surface runoff of waste water from agricultural activities near Lilour lake. The presence of high level of pollutants and heavy metals in water of Lilour lake give course for concern with time. Continuous and long term monitoring is essential to confirm the robustness of the results obtained in present study and impact of anthropogenic inputs to take remedial measures so as to ensure the health of aquatic life.

Key words: *Lakes, Metal toxicity, Water, Heavy metals, Water pollution*

INTRODUCTION

Water is the major constituent of all living things and needed by them for various purposes. Water for different purposes has its own composition and purity. Availability of different components in water has to be analyzed regularly to confirm its suitability for different purposes[4].

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India is facing the problem of scarcity of water resource[8,16]. Most of fresh water bodies all over the world are getting polluted, thus decreasing the portability of water[10,13,16]. Quality of water is determined by its physical, chemical and biological characteristics. In recent years, water bodies are getting polluted due to human interference in the form of industrialization, urbanization, land use change, agricultural activities etc. To achieve the goal of sustainable development for any country, it is necessary to have adequate quantity and quality of fresh water[12]. FAO[7] noted that the contamination of water supplies from both natural and anthropogenic sources has impacted on the health and economic status of populations. Contamination of aquatic ecosystems with a wide range of pollutants has become a matter of concern over the last few decades[5,16,17,18]. Recent studies estimated that availability of fresh water will be the most important crises in next century[16]. Problem of water pollution is becoming a global concern and deteriorating day-by-day at an alarming rate.

Increase in population, urbanization, industrialization and agricultural practices as well as lack of environmental regulations have further aggravated the situation[9]. Heavy metals cannot be degraded but they are deposited, assimilated or incorporated in water and aquatic biota causing heavy metal pollution in water bodies. Heavy metals in water can originate both from natural sources, industrial, agricultural and domestic activities in the drainage basin of a water system. As the metal levels in many aquatic ecosystems increase due to anthropogenic activities, they raise the concern on metal bioaccumulation through the food chain and related human hazards. In developing countries, trace metals analysis in fresh water is very important because these ecosystems provide drinking water and are habitats for flora and fauna. Contamination of heavy metals in the aquatic environment has attracted global attention owing to its abundance, persistence and environmental toxicity[1,11]. However, anthropogenic activities can effortlessly generate heavy metals in sediment and water that pollute the aquatic environment[14,15]. Lakes can be very large and support a complex ecosystem in which environmental parameters vary widely in all three physical dimensions and with time. Large lakes in the temperate zone often stratify in the warmer months into a warmer upper layers rich in oxygen and a colder lower layer with low oxygen levels. In the autumn falling temperatures and occasional high winds results in the mixing of the two layers into a more homogenous whole. When stratification occurs it not only affects oxygen levels but also many related parameters such as phosphate and manganese which are all changed in their chemical form by change in the redox potential of the environment. Lakes also receive waters often from many different sources with varying qualities; solids from stream inputs will typically settle near the mouth of the stream and depending on a variety of factors in the incoming water may float over the surface of the surface of the lake sink beneath the surface or rapidly mix with the lake water. The majority of lakes on Earth is fresh water and present in the Northern Hemisphere at higher latitudes. Worldwide, most of lakes provide recreational opportunities such as fishing, bathing and tourism. Besides, they are used for irrigation, livestock watering and navigation. A lake is an open system which is connected to its surrounding by the streams (inlets and outlets) and its watersheds. Therefore, the use of the lake associated with population growth and technology development become a threat if the lake utilization and its water body are not well managed. Further, water quality assessment involves, analysis of physicochemical parameters and heavy mental as well as evaluation of abiotic and biotic status of ecosystems[16]. Lakes are inland body of water of considerable size. The lakes of India are active in encouraging tourism and offer several recreational activities like angling, boating, fishing to the tourists. Water quality of lakes is determined by surrounding area, geology, vegetation and soil[6].

The scope of this document is to report the water quality parameters values that have been collected and analyzed within Lilour Lake and to try to conclude its current status. It is our hope that this paper will be helpful toproject managers to delineate a deep modeling of the lake in order to choose appropriate remediation methods and to meet their goals. For assessing appropriateness of lake water bodies for different purposes the characterization of physicochemical parameters and heavy metals are necessary. Regular monitoring of water quality of lake helps to develop strategies related to management and control of pollution of lake. The present study was conducted to understand the status of the physicochemical parameters and concentration of various heavy metals like Cu, Zn, Pb and Cd in historical Lilour lake of Bareilly District.

MATERIALS AND METHODS

Study area

This study was carried out at Lilour lake (Figure-1) which is situated in Bareilly District of Western Uttar Pradesh India ($28^{O}26'50.53"$ N and $79^{O}02'50.22"$ E). The historical evidence of our nearest Mahabharata period can be found on searching, even in the form of anecdotal stories and anecdotes of ancient scriptures. Lilour lake is very important for those, who are living in nearby villages. According to them, this is the same lake where there was a dialogue between the Yakshha and Yudhisthir. Today about 5 km. long Lilour lake is important source of drinking water and agricultural uses. Water of this lake is polluted due to agricultural runoff, sedimentation and cattle. The climate of the study area is tropical monsoonal. The year consists of a cold winter (November - February), a hot summer (April - June) and a warm rainy season (July - September). Summers are dry and hot with temperature ranging between 30 to 42^{o}C. May is the hottest month of the year having an average temperature of more than 40^{o}C. The mean annual rainfall averages 1100 mm, of which 85% falls during the rainy season. There are often long breaks in rainy days even during rainy season.

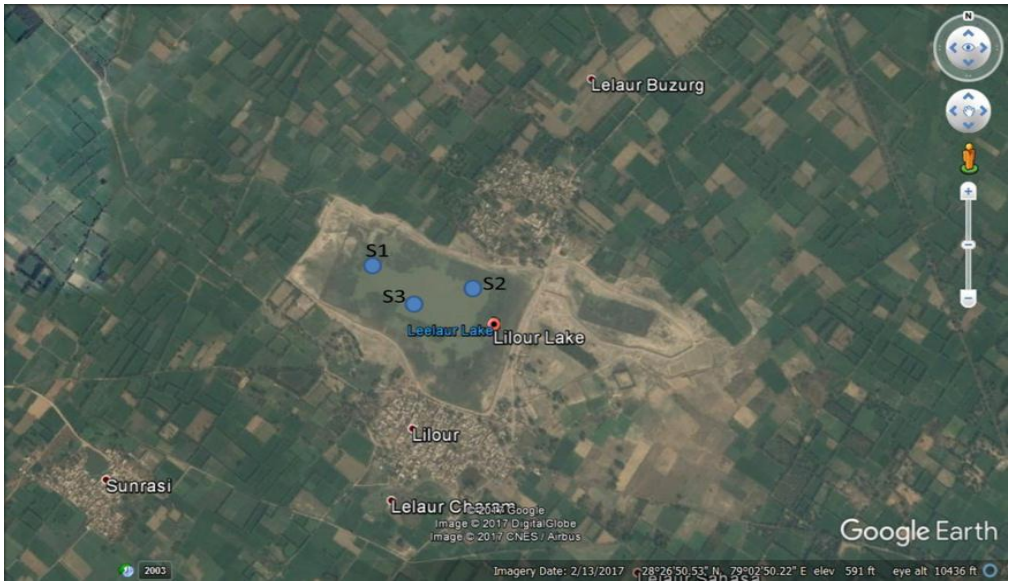

Fig. 1: Satellite image obtained from Google Earth, showing sampling satiations at Lilour lake, Bareilly, UP.

Sample analysis

To analyze the physico-chemical parameters and heavy metal contamination in lake, water samples were collected from three different sampling stations, which were selected on the basis of identified pollution sources designated with S_1 to S_3. The water samples were collected in the polyethylene bottles. Initially, the prewashed bottles were rinsed with sample water. The closed bottle was dipped in the lake at the depth of 0.5 m, and then a bottle was opened inside and was closed again to bring it

out at the surface. The samples collected in three replicates from three different sampling stations, were mixed together to prepare an integrated sample. Samples were collected during morning hours in between 8.00 to 10.00 a.m. using one liter satirized bottles. Almost all cares were taken, so that no bubbling should observe during sampling, which avoids influence of the dissolved oxygen.

Measurements

The physicochemical parameters were analysed according to standard methods[3].

Water temperature was recorded on site, using Mercury Thermometer.

The pH of the water samples was also determined in the field by using Digital pH Meter.

DO was determined by wrinkles Azide Modification Titrimetric Method.

Total Hardness was determined Titrimetrically using EDTA Method[3].

Total Alkalinity was determined by Titrimetric Method[3].

BOD was determined as per standard method[3].

COD was determined by Potassium Dichromate Open Reflex Method.

Statistical analysis

Data collected were subjected to multivariate analysis of variance (MANOVA) by using SPSS software (ver. 17; SPSS Inc, Chicago, Illinois), and were used to assess whether samples varied significantly between sampling stations, possibilities less than 0.05 ($p < 0.05$) were considered statistically significant.

RESULTS

Results of multivariate analysis of variance (MANOVA) revealed that the concentrations of all the physicochemical parameters and heavy metals are statistically significant among the sampling stations (Table-1). The concentrations of some physicochemical parameters and heavy metals in water samples from different three sampling stations in Lilourlake, Bareilly are presented in Table 2. Water temperature ranged from 18.1 to 18.8^{0}C. The values of pH ranged from 7.0 to 9.63; 115 to 124 ppm for total hardness; 119-134 for total alkalinity, 5.43-6.4 ppm for DO; 1.6- 2.23 ppm for BOD; 11.2- 15.63 ppm for COD; 0.88-0.141 µg/ml for Cu; 0.55-0.70 µg/ml for Zn; 0.63-0.80 µg/ml for Pb (Table-2).

Table 1: MANOVA table for the effect of sampling stations on various physicochemical parameters and heavy metals

Source	**Parameter**	***d.f.***	***F***	***P***
Site	**Temperature**	2	20.46	0.002
	pH	2	212.5	<0.001
	Hardness	2	55.23	<0.001
	Alkalinity	2	91.84	<0.001
	DO	2	16.23	<0.001
	BOD	2	15.84	0.004
	COD	2	15.84	0.004
	Cu	2	5506	<0.001
	Zn	2	397.4	<0.001
	Pb	2	15711	<0.001
Error		6		

Table 2: Mean concentration of physicochemical parameters and heavy metals at Lilourlake, Bareilly (at three sampling stations)

				Sampling Stations	
S. No.	**Parameters**	**Unit**	**Sampling Station, S_1**	**Sampling Station, S_2**	**Sampling Station, S_3**
1	**Water Temperature**	°C	18.1±.03	18.17±0.09	18.8±0.08
2	**pH**		7.0±.06	7.03±0.12	9.63±0.12
3	**Total Hardness**	ppm	124.5±.58	125.0±1.00	115.9±0.26
4	**Total Alkalinity**	ppm	134.8±0.72	134.2±1.1	119.6±0.83
5	**DO**	ppm	5.43±0.12	5.53±0.12	6.4±0.15
6	**BOD**	ppm	2.1±0.06	2.23±0.12	1.6±0.06
7	**COD**	ppm	14.7±0.40	15.63±0.84	11.2±0.40
8	**Cu**	ug/ml	0.88±0.003	0.17±0.00	0.141±0.001
9	**Zn**	ug/ml	0.55±0.00	0.70±0.00	0.601±0.00
10	**Pb**	ug/ml	0.80±0.00	1.35±0.00	0.63±0.00

DISCUSSION

Physicochemical Parameters

Temperature

Value of temperature was observed maximum at S3 and minimum at S1. MANOVA results showed statistically significant variation among sampling stations, which might be due to timing of sampling. Higher value of temperature may reduce the amount of DO, which may ultimately affect aquatic lives. Intruding solar radiation brings interesting spatial and temporal changes in temperature of natural waters. The increase in the temperature of water, increases chemical reactions and reduces solubility of gases, increases taste and odour and elevates metabolic activity of organisms.

pH

Most of the lakes in the world were initially basic in nature[2] and becoming acidic due to increase in organic materials. The resultant of decay of organic matter produces carbon dioxide (CO_2), which in combination with water produces carbonic acid (week acid), which lowers pH value of water. The stipulated values of pH according to BIS are 6.5-8.5. At all the sampling stations pH values are within the range except S_3. Statistical analysis using MANOVA, showed that there was significant variation between sampling stations for pH values. pH values obtained in lake fell within the range except S_3. Therefore, this parameter does not give cause of concern in studied lake.

Total Hardness

In the present study water samples of Lilourlake, total hardness was observed in the range of 115.9-125.5 ppm. According to BIS, the maximum permissible limit of hardness for drinking water is 600 ppm. The observed values are within the range. Total hardness of water is not a parameter of pollution, but it indicates the water quality. Total hardness was observed maximum at S_1 and minimum at S_3.

Total Alkalinity

The alkalinity of water is its capacity to neutralize acids. Maximum value of alkalinity was recorded at S_1 (134.8 ppm) and the minimum at S_3 (119.6 ppm). MANOVA results obtained in present study are indicated that, there are significant variations in the value of total alkalinity at different sampling stations. World Health Organization (WHO) has set the maximum permissible limit for alkalinity is 500 ppm, however according to BIS the maximum permissible limit for total alkalinity of drinking water is 600 ppm. The observed values are within the maximum permissible limit; therefore, this is not matter of concern.

Dissolved Oxygen (DO)

The levels of dissolve oxygen (DO) within the three sampling stations varied from 5.43 ppm to 6.4 ppm. The highest value of DO was observed at sampling station S3 and least value at S1. The results show that these values are below the maximum permissible limit

provided by WHO. The statistical analysis using MANOVA showed that there was significant difference between the three sampling stations and this might be due to different sources of pollutants. In general, DO levels less than 3 ppm are stressful to most aquatic organisms. Generally, fishes move away from low DO areas. Water with low DO from 0.2 0.5 ppm are considered hypoxic; Waters with less than 0.5 ppm are anoxic. The standard for sustaining aquatic life is stipulated at 5 ppm, a concentration below this value adversely affects aquatic biological life, while concentration below 2 ppm may lead to death for most fishes.

Biochemical Oxygen Demand (BOD)

BOD is defined as the amount of oxygen required by microbes in stabilizing the decomposable organic materials. BOD gives an idea about extent of pollutants in water bodies. The maximum permissible limit for BOD given by Central Pollution Control Board (CPCB) is 2.0 ppm. In present study values of BOD ranged from 1.6-2.23 ppm as given in table 2. The values obtained are higher the maximum permissible limit, which is matter of concern. Also, MANOVA results show that, significant variations among different sampling stations for the values of BOD.

Chemical Oxygen Demand (COD)

In general, Chemical Oxygen Demand is amount of oxygen required for the oxidation of oxidizable organic matter. COD of Lilourlake varies from 11.2 ppm to 15.63 ppm. The results show that these values are below the maximum permissible limit provided by CPCB for drinking water. Result showed slandered error (Table-2) and statistical significant variation (Table-1) at all sampling stations, which is supposed due to different sources of pollutions at different sampling stations.

Heavy metals

Copper (Cu)

Copper is a widely distributed heavy metal, because most copper minerals are relatively insoluble and is combined to solid phases hence only low concentrations are normally present in natural waters. Values of Cu in Lilour lake 0.14-0.88 ug/ml, which is within the range of maximum permissible limit (1.0 mg/l) provided by Indian council of medical research (ICMR).

Zinc (Zn)

Zinc plays an important role in biochemical processes of all aquatic plants and animals; Therefore, they are essential in the aquatic environment in trace amounts. In the present study we observed the maximum value of Zn at S2 and minimum at S3. Zn obtained in a number of alloys including brass, bronze, batteries, and fungicides and is an essential growth element for plants and animals in trace amount.

Lead (Pb)

Lead is relatively a minor element in the earth's crust but is widely distributed in low concentrations in uncontaminated soils and rocks. Concentration of Pb in Lilourlake ranged from 0.63-1.35 ug/ml, which is very high from maximum permissible limit provided by BIS (0.05 mg/l). The result shows the concentration in lake water is high above the maximum permissible limit. This might be due to atmospheric input of Pb originating from its uses in leaded gasoline and industrial processes. This may be harmful for aquatic life and biodiversity; also for people who are using this water for drinking purposes.

CONCLUSION

On the basis of results obtained from the study, it was observed that level of some physiochemical parameters and heavy metals exceeds the WHO standards, indicating that Lilourlake is contaminated by pollutants and heavy metals. Prolonged presence of heavy metals in water of lake might affect aquatic plant and animal life. Results of the study suggests that, continuous monitoring has to be carried out to ascertain the long term impact of agricultural runoff and human induced contamination to take remedial measures so as to ensure the health of aquatic life in historical Lilour lake of Bareilly district in Western Uttar Pradesh.

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