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COMPARATIVE ANALYSIS OF PHYSICO-CHEMICAL PROPERTIES OF WATER OF FIVE LAKES OF BHOPAL, INDIA

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ABSTRACT

Water is an important component of life of every living being. Aquatic environment is considered as important factor affecting health of flora and fauna. In the present study, the physico-chemical analysis of water of five different water bodies of Bhopal region viz. Upper Lake, Lower Lake, Sarangpani Lake, Shahpura Lake and Kolar Lake was done to determine the suitability of water. The parameters analyzed were Temperature, Conductivity, pH, Total Dissolved Solids (TDS), Turbidity, Dissolved Oxygen, Hardness, Chloride content, free CO2 and Total Alkalinity. All the parameters were ranged within the desirable limit accounting for healthy status of water bodies of Bhopal region.

KEYWORDS: Physico-chemical analysis, Water, Lakes of Bhopal.

1. INTRODUCTION

The seasonal variations and Anthropogenic stresses such as introduction of chemicals into water domestic sewage, agriculture, urbanization etc in or near the catchment area of water bodies often results in the decline of Physico-chemical properties of the water and water quality on the whole (Khan *et al.*, 1988; Mohapatra and Singh 1999). The physico-chemical parameters of water provide the present information about the solute concentration at a given time (Singh and Shrivastava (2016). Imbalance in Physico-chemical properties of the water may adversely affect many species of aquatic flora and fauna that are dependent on both abiotic and biotic conditions (Santhosh and Singh, 2007). In India five water quality classes have been designated (A-E) on the basis of the water quality requirements for a particular use (UNECE 1993). Class A waters recommended as drinking water source straight without

treatment but after disinfection. Class B waters categorize for outdoor bathing. Class C waters considered as drinking water source with conventional treatment followed by disinfection. Class D waters to maintain aquatic life (i.e. propagation of wildlife and fisheries) and class E waters for use for irrigation, industrial cooling and controlled waste disposal.

Parameters of water quality of concern are traditionally Temperature, turbidity, nutrients, hardness, alkalinity and dissolved oxygen are some of the important parameter that play a significant role for the growth of biota or living organisms in the water body (Chiaudani and Premazzi, 1988). The deviation in the physicochemical properties of water unswervingly influences the biotic communities and primary productivity of the water bodies. Aquaculture contributes to economy in many developing countries like India therefore, there is crucial need of monitoring the water quality to maintain healthy aquatic ecosystem to ensure proper yield of cultures. For the optimal performance, aquacultures including fishes need tolerable limits of water parameters (Kiran, 2010). Planktons and other organism may be affected by poor quality water causing impaired growth and death. Variables of concern include nitrates, sulphates, total dissolved solids (salinity), a number of metals and organic micropollutants such as pesticides. In addition, bluegreen algae and pathogens in water can present problems. The lakeside constructions in Bhopal affect water quality of Upper Lake (Khan and Ganaie, 2014). The quality of water in Lower Lake in Bhopal has also been exaggerated than Upper Lake (Pani and Mishra 2000). The water quality of Kolar Lake of Bhopal is reported to be relatively good (Shukla 1996).

The objective of the current study is to provide information on physico-chemical analysis of water of five lakes of Bhopal i.e. Upper Lake, Lower Lake, Sarangpani Lake, Shahpura Lake and Kolar Lake to assess the water quality in order to confer its ecological suitability for aquatic flora, fauna and human consumption. A study finds that freshwater fishes in these lakes have remarkable proportion of Enterobacteriaceae and these bacteria constitute a potential risk for fish population and public health (Borkar *et al.*, 2017). It is worth mentioning that upper lake and Kolar Lake are major source of drinking water supply and considered as life line of Bhopal.

2. MATERIAL AND METHODS

2.1 Study Sites

Five fresh water lakes were selected for analysis of quality of water. All these lakes are man-made and are located in different localities of Bhopal. Upper Lake is situated at 23.25°N 77.34°E; this sampling site receives domestic wastes. Lower Lake is located at 23°16′0″N and 77°25′0″E. This lake receives the waste from the temple including polythene bags and the flowers and other solid waste at some point. Sarangpani Lake is situated in BHEL area of Bhopal. The inflow of sewage water over the years has resulted in deterioration of the water quality of the lake. Shahpura Lake is one of the important lake of Bhopal and its coordinates are 23°12'17"N and 77°25'35"E. The lake shows the marshy vegetation growing at the bank of the lake along with drains and pools that quantify pollution cost by municipal and industrial waste. Kolar Lake is situated 29°14'N 79°10'E. This Lake is comparatively less polluted and favorable destination for fishing.

2.2. Sample Collection

The samples were collected in uncontaminated sampling bottles of I liter capacity. Monitoring was performed during June 2015 to May 2016. For unsteady parameters such as temperature, electrical conductivity (EC), pH, were measured at the sampling site. Samples were brought to the laboratory for analysis of other physico-chemical parameters like Conductivity, pH, Total Dissolved Solids (TDS), Turbidity, Dissolved Oxygen, Hardness, Chloride content, free CO_2 and Total Alkalinity.

2.3. Laboratory Methods

Physical analysis was done for coloure and odour of water. Colour was measured by visual comparison method. Odour was determined by sniffing water manually. Temperature was measured with the thermometer (Philips) by immersing it directly into the water body sufficient time period to get constant reading.

Conductivity: Conductance was measured by conductometer (215K, Elite Scientific Co. India). The electrode of the conductivity meter is dipped into the sample, and the readings are noted for stable value shown as ms/cm.

pH: pH value of water sample was determined by pH meter (LT-PH57, Elite Scientific Co. India) using standard buffer solutions.

Total Dissolved Solid (TDS): It was determined by evaporation method. A known volume of the well-mixed sample (50ml) was measured into a preweighed dish and evaporated to dryness at 103^0C on a steam bath. The evaporated sample is dried in an oven for about an hour at 103-105^0C and cooled in a desiccators and recorded for constant weight.

Turbidity: Turbidity was determined by Turbidity meter (CL 880, Accumax India). The electrode was dipped into the sample, and the reading noted.

Dissolved Oxygen (DO): It was measured by dissolved oxygen meter (CL 930, Accumax India). The electrode was dipped into the sample, and the reading noted.

Total Hardness: The hardness of water body was determined by titration. Exactly 50ml of the well-mixed sample is pipetted into a conical flask, to which 1ml of ammonium buffer and 2-3 drops of Eriochrome black -T indicator is added. The mixture is titrated against standard 0.01M EDTA until the wine red colour of the solution turns pale blue at the end point.

Chloride: Chloride measured by Argentometric titration method with standard silver nitrate using potassium chromate as an indicator. A known volume of filtered sample (50ml) is taken in a conical flask, to which about 0.5ml of potassium chromate indicator is added and titrated against standard silver nitrate till silver dichromate (AgCrO4) starts precipitating.

Free CO2: free CO_2 was determined by Coulometric Titration. 100 ml of water was acidified with HClO4 and boiled vigorously for at least 15 min to remove dissolved CO2.

Total Alkalinity: Total alkalinity was determined with titration with standard H_2SO_4 or HCI solution. Titration to pH 8.3 or decolourisation of phenolphthalein indicator will indicate complete neutralization of OH^- and 1/2 of CO_3^{2-}, while to pH 4.5 or sharp change from yellow to orange of methyl orange indicator will indicate total alkalinity.

3. RESULTS AND DISCUSSION

The results of physico-chemical parameters of the water samples from Upper Lake, Lower Lake, Sarangpani Lake, Shahpura Lake and Kolar Lake are represented in Table-1. The physico-chemical quality of water is one of the most important parameter. The health, growth and productivity of the fish are directly influenced by quality of water. The various physic-chemical parameters of water such as temperature, conductivity, pH, total Dissolved Solids (TDS), turbidity, Dissolved Oxygen (DO), hardness, chloride content, free CO_2 and total

alkalinity may influence the density of bacterial populations. The disturbance in these parameters can affect adversely the fish production by decreasing the rate of food conversion, reducing the weight gain and availability of soluble nutrients into the water body (Sapkota *et al*., 2008; Gorlach-Lira *et al*., 2013). Human and animals excreta are considered to be one of the common sources of pathogenic microorganisms in any ecosystem (Servais *et al*., 2005). The excreta reach to water bodies through run off during rainy season and make them polluted.

Water temperature play an important role in the physico-chemical and physiological behavior of the aquatic system (Welch, 1952). Fish being a cold blooded animal its body temperature is likely to vary according to fluctuations in temperature of water which affects its metabolism and physiology. This ultimately affects the fish production. The high temperature and bright sunshine accelerates the process of organic matter decay resulting into the liberation of large quantities of CO2 and nutrients (Vasile, 2017). The acceptable temperature tolerance limit to fish can be 28 to 35^0C for tropical major carps (Delince, 1992; Bhatnagar *et al*., 2004). We noticed a range of temperature from 26^0C to 31^0C in 5 different stations studied which is within the suitable range (Table-1). These observations are in line with those of the study reported by Salla and Ghosh (2014) who reported 31.5^0C temperature at Lower Lake of Bhopal during pre monsoon, 29.5^0C monsoon temperature and 28^0C post monsoon temperature. Other investigators suggested 30 to 35^0C (Delince, 1992) and 28-32^0C (Bhatnagar *et al*., 2004).

Conductivity is a measurement of the ability of an aqueous solution to carry an electric current. The acceptable limit of conductivity of freshwater varies between 50 to 1500µs/cm (Boyd, 1979). In the current study the conductivity was ranged between 644µs/cm ± 0.30 to 248µs/cm ± 0.41 (Table-1). We observed maximum conductivity 644µs/cm ± 0.30 in water of Shahpura Lake. Increased value of conductivity might be due to increased concentration of salts at the bottom by sedimentation. This finding is in agreement with Shivhare *et al*. (2013) who recorded the average conductivity 614µs/cm.

Any change in the pH of water is accompanied by the change in other physic-chemical parameters. Maintenance of pH is one of the most important factors of any aquatic system since all biochemical activities depends on the pH. According to Santhosh and Singh (2007) the ideal pH level is 7.5 to 8.5 and below this is stressful to the fishes. We recorded highest pH 8.1 ± 0.15 of water at both Lower Lake and Kolar Lake and the lowest pH 6.78 ± 0.13 of

water in Sarangpani Lake (Table-1). These values are in agreement with results of Singh and Shrivastava (2016) who recorded pH value of Upper Lake ranging 6.72 to 8.32. This could be due to accumulated organic matters possibly because of decay and decomposition of religious waste which on biological oxidation gives off CO_2 which ultimately reduces the pH (Vyas *et al*., 2006).

Total dissolved solids (TDS) may indicate increased organic matter within the water body from wastewater discharge and effluents (Phiri *et al*., 2005; Tay, 2008). A recommended level of TDS for most freshwater fish is less than 400ppm (Terry Fairfield, 2000). We observed maximum TDS 398ppm ± 1.37 from Sarangpani Lake, 386ppm ± 4.32 from Shahpura Lake, 209ppm ± 1.28 from Kolar Lake, 178ppm±2.16 from Lower Lake and 145ppm ± 2.42 from Upper Lake which is in the acceptable range (Table-1). Our results are in agreement with Singh and Shrivastava (2016) mentioned the TDS range between 94t o 158 ppm. According to them the high content of total dissolved solids elevates the density of water and influences osmoregulation in fresh water organisms.

Turbidity accounts for the pollution by a wide variety of material, such as silt, decaying, animal and plant matter, industrial wastes and sewage. In majority it decreases the water clarity. Suspended sediments can clog fish gills, reduce the growth rates. Ramama *et al*. (2008) reported higher turbidity is unacceptable for bathing, industrial and other purposes. Boyd and Lichtkoppler (1979) suggested that the clay turbidity in water should be 30 to 60 cm. We observed the highest turbidity 49cm± 2.12 from Sarangpani Lake, 45cm ± 1.21 for Lower Lake, 43cm±1.42 for Upper Lake, 37cm ± 2.01 for Shahpura Lake and 32cm ± 3.16 for Kolar Lake (Table-1). The range of turbidity was acceptable and also in line with Singh and Shrivastava (2016) who noticed the turbidity in the range 37.6-53.2cm. We noted that maximum turbidity from Sarangpani Lake may be due to lot of religious waste disposed in the lake.

Dissolved oxygen (DO) illustrates the physico-chemical and biological processes which take place in water. The tolerable limit of DO for Cyprinids is 6 to 8 mg per litre (Svobodova, 1993). The level of DO in all 5 water stations was in acceptable range (Table-1). In the present study we observed highest DO 6.8mg/l ± 1.42 from Kolar Lake. However other lakes showed DO 6.5mg/l±1.21 from Shahpura Lake and 6.1mg/l±2.01 from Upper Lake, 4.9mg/l ± 2.14 from Sarangpani Lake and DO 6.8mg/l ± 1.42 from Lower Lake. Our range of DO

4.5mg/l to 6.8mg/l was acceptable. Similar results were reported by Salla and Ghosh (2014) demonstrating DO in the range of 2.2 to 2.4mg/l in Lower Lake of Bhopal.

Hardness is the characteristics of water which prevents the foaming of soap. This is due to the presence in water of certain salts of calcium and magnesium dissolve in it. Also the addition of sewage, detergents and large scale human use might be the cause of elevation of hardness (Mohanta and Patra, 2000). The recommended ideal value of hardness for fish culture is in a range of 30-180 mg/l (Santhosh and Singh, 2007). We observed maximum hardness 286 mg/l±18.26 from Sarangpani Lake, 114mg/l ± 8.29 from Lower Lake, 161.6mg/ l± 10.23 from Shahpura Lake, 126mg/l±13.58 from Kolar Lake and 112.6±11.41 from Upper Lake . The values for hardness were in range which is acceptable (Table-1). We observed maximum hardness from Sarangpani Lake where the addition of religious waste is the major cause of hardness of water. These observations are lower than those reported by Salla and Ghosh (2014) who registered variation in the total Hardness of Lower Lake of Bhopal and reported values as 685mg/l at the pre monsoon, 620mg/l monsoon temperature and 635mg/l post monsoon temperature.

The presence of chlorides in natural waters can mainly be attributed to dissolution of salt deposits in the form of ions (Cl-). Higher concentrations may indicate pollution by sewage, industrial wastes, intrusion of seawater or other saline water. According to Stone and Thomforde (2004) the desirable range of chlorides for commercial catfish production is above 60 mg/l. We observed chloride content 177mg/l ± 3.52 from Lower Lake, 86mg/l±8.05 from Upper Lake, 77 ± 2.19 from Kolar Lake, 67mg/l ± 5.29 from Shahpura Lake and 66mg/l ± 3.28 from Sarangpani Lake. The hardness was recorded in the range 186 mg/l±18-112.6mg/l ± 11.41 (Table-1). The highest values at Lower Lake was due to inflow of different types of religious waste as well as sewage pollution nearby this lake which is similar to results noted by Vass and Zutshi (1983) in Kashmir Himalayan Lake. These findings are higher than those of Shukla and Thakur (2017) who retrieved the Chloride values from Shahpura Lake in the range of 39.18 to 51.3mg/l in rainy season and 48.98 to 50.18 mg/l in winter season.

The major cause of high free CO_2 content in stagnant water is due to its diffusion from atmosphere, respiration by animals along with plants and bacterial decomposition of organic matter (Misra *et al*., 1993). The ideal level of CO_2 in fishponds is less than 10 mg/l (Ekubo and Abowei, 2011). We observed that maximum free CO2 was 9mg/l ± 1.56 from Upper

Lake, 8.8mg/l ± 1.37 from Lower Lake, 7.9mg/l±1.29 from Sarangpani Lake, 6.3mg/l ± 1.62 from Shahpura Lake and 3.6mg/l ± 1.41 from Kolar Lake (Table-1). The free CO_2 values were in acceptable range which was closer to range observed by Singh and Shrivastava (2016) as 4-18.2mg/l from Upper Lake.

Alkalinity in natural water is due to the presence of salts of weak acids. According to Santhosh and Singh (2007) the ideal value of alkalinity for fish culture is 50 to 300 mg/l. In our study, we observed maximum alkalinity 352mg/l ± 12.25 from Lower Lake, 129mg/l ± 6.48 from Kolar Lake, 114mg/l ± 8.12 from Shahpura Lake and 102mg/l ± 12.09 from Sarangpani Lake (Table-1). Minimum alkalinity was 91.2mg/l ± 6.24 from Upper Lake. These results are in line with the findings of Parashar (2006) who mentioned 88 to 90 mg/l pre monsoon alkalinity and 76 to 80 mg/l post monsoon alkalinity.

Overall, the physico-chemical parameters of water studied from different water bodies showed minor variations (Fig. 1 to 10) and were within the desirable limit for the survival of fishes indicating healthy status of lakes of Bhopal region.

Table-1: Physico-chemical analysis of water from samples collected from five Stations studied.

Sr.No.	Sample Site Parameters	Upper Lake (UL)	Lower Lake (LL)	Sarangpani Lake (Sr)	Shahapura Lake (Sh)	Kolar Lake (KL)
1.	Temperature	27±4.32	28±3.49	31±4.02	26±4.10	31±4.02
2.	Colour	--	Light Yellow	Light Yellow	--	--
3.	Odour	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
4.	Conductivity (µs/cm)	313 ±0.12	3050.52	253 ±0.23	644 ±0.30	228 ±0.41
5.	pH	7.3±0.30	8.1±0.15	6.78±0.13	7.7±0.28	8.1±0.15
6.	Total Dissolves solids (TDS) (ppm)	145±2.42	178±2.16	398±1.37	386±4.32	209±1.28
7.	Turbidity (ntu)	4.1±1.42	4.7±1.21	4.9±2.12	3.9±2.01	2.7±3.16
8.	Dissolved Oxygen (DO) (mg/l)	6.1 ±2.01	4.5 ±1.06	4.9 ±2.14	6.5 ±1.21	6.8 ±1.42
9.	Hardness(mg/l)	112.6±11.41	214 ±8.29	286 ±18.26	161.6 10.23	126 ±13.58
10.	Chloride(mg/l)	86 ±8.05	177 ±3.52	56 ±3.28	67 ±5.29	27±2.19
11.	Free CO_2 (mg/l)	9 ±1.56	8.8 ±1.37	7.9 ±1.29	6.3 ±1.62	3.6 ±1.41
12.	Total Alkalinity (mg/l)	91.2 ±6.24	452 ±12.25	102 ±12.09	114 ±8.12	129 ±6.48

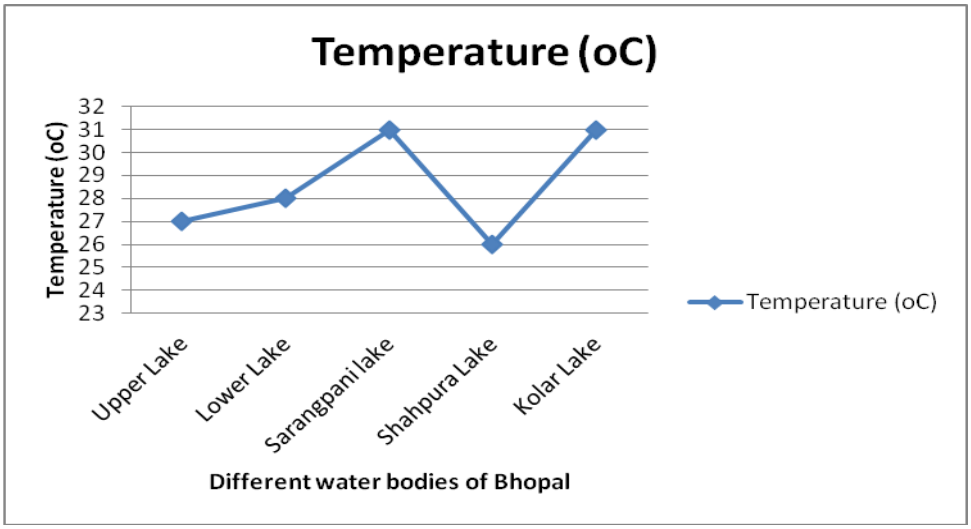

Fig.1: Comparative Temperature profile of the water bodies of Bhopal.

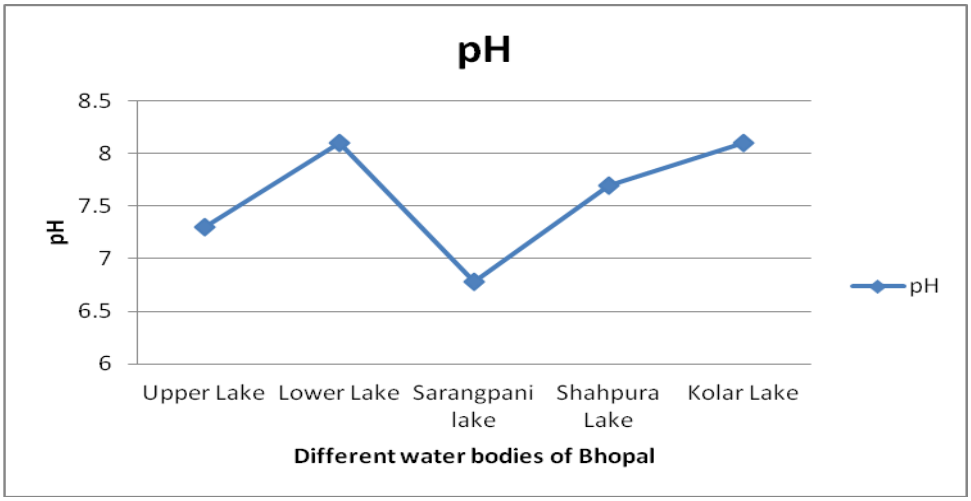

Fig.3: Comparative pH profile of the water bodies of Bhopal.

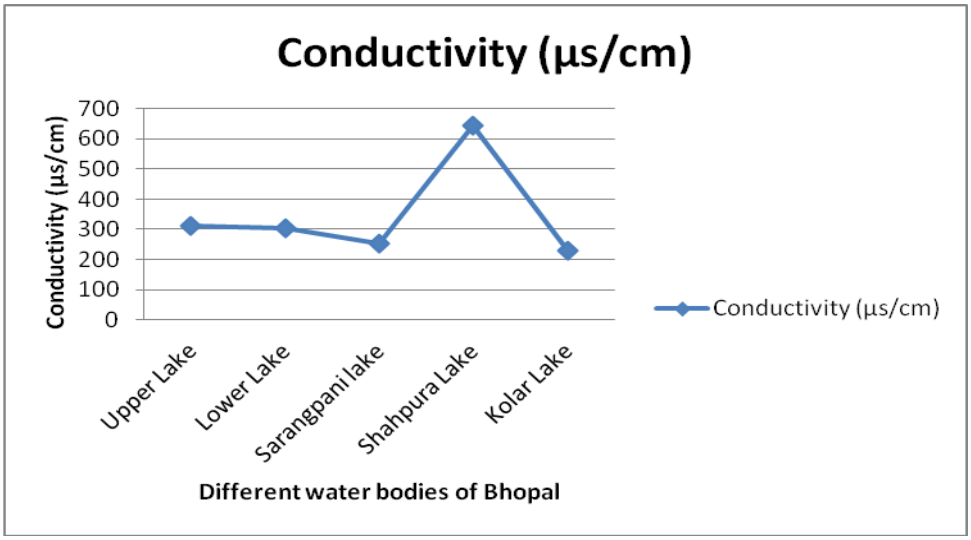

Fig. 2: Comparative conductivity profile of the water bodies of Bhopal.

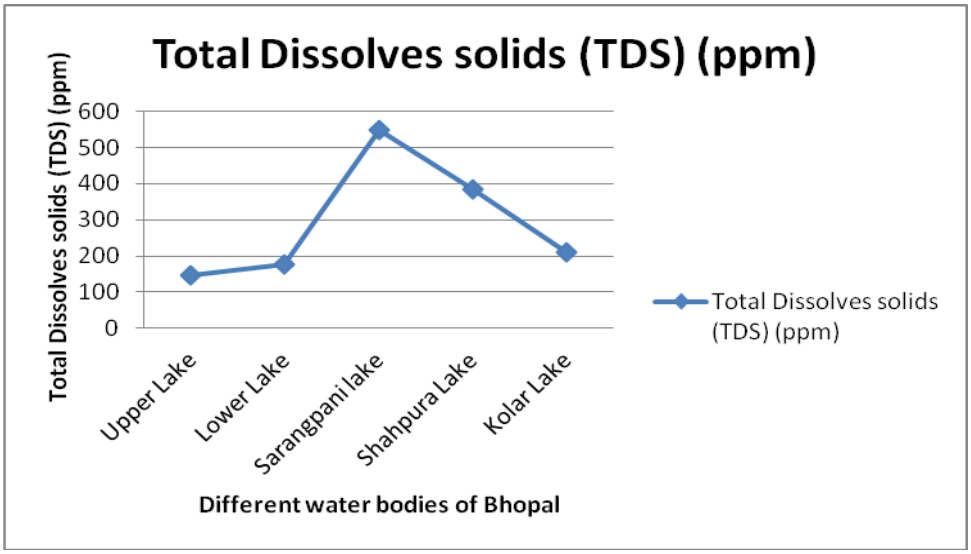

Fig. 4: Comparative TDS profile of the water bodies of Bhopal.

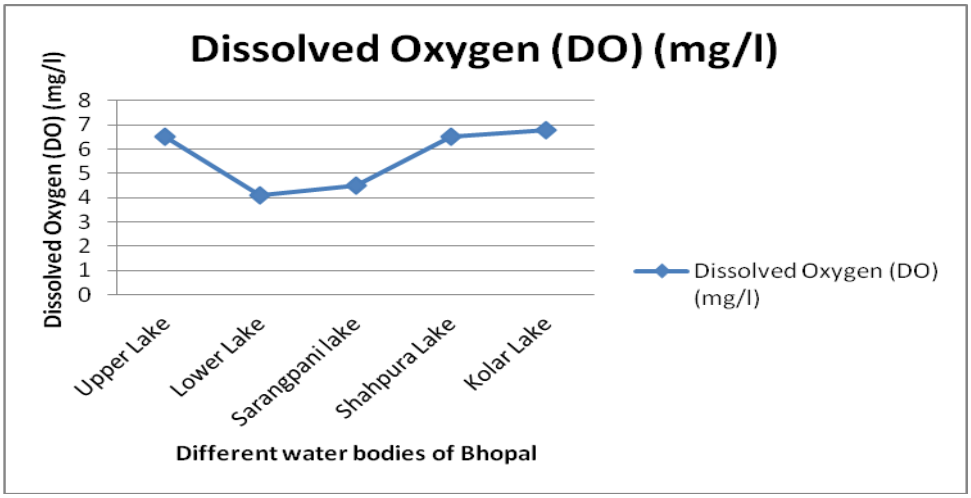

Fig. 5: Comparative dissolved oxygen profile of the water bodies of Bhopal.

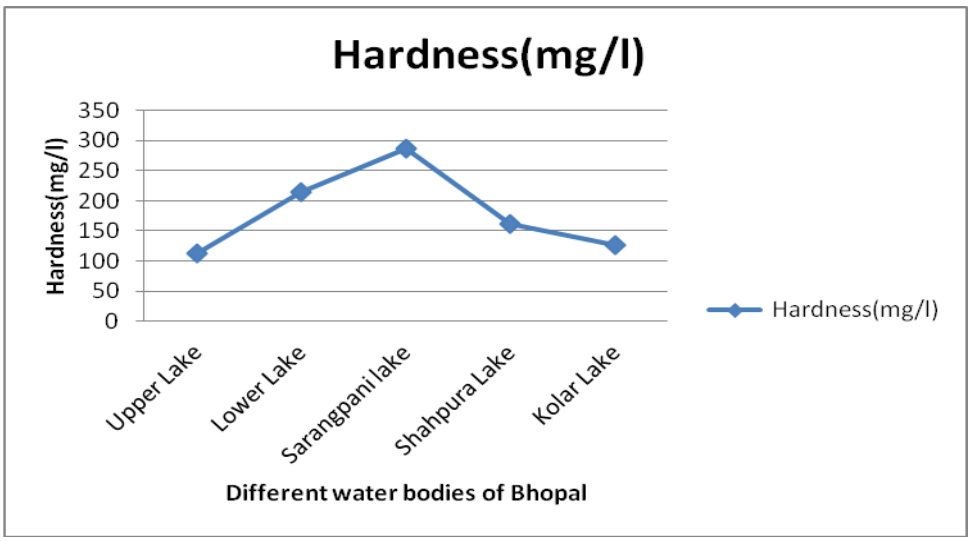

Fig. 6: Comparative hardness profile of the water bodies of Bhopal.

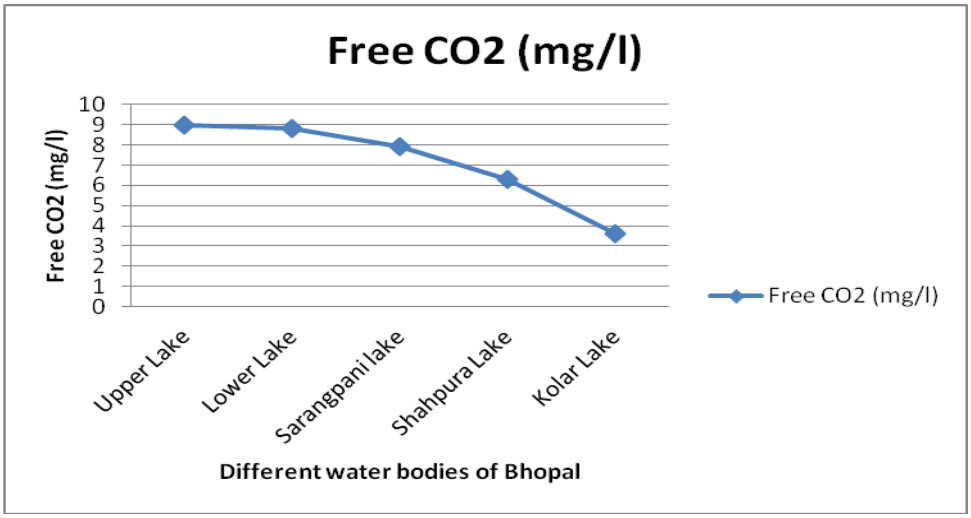

Fig. 7: Comparative free CO_2 profile of the water bodies of Bhopal.

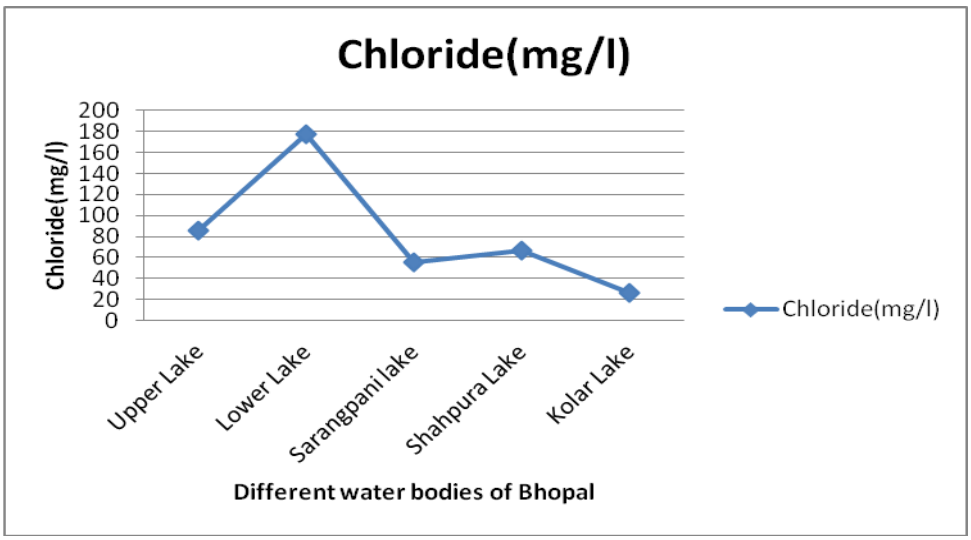

Fig. 8: Comparative chloride profile of the water bodies of Bhopal.

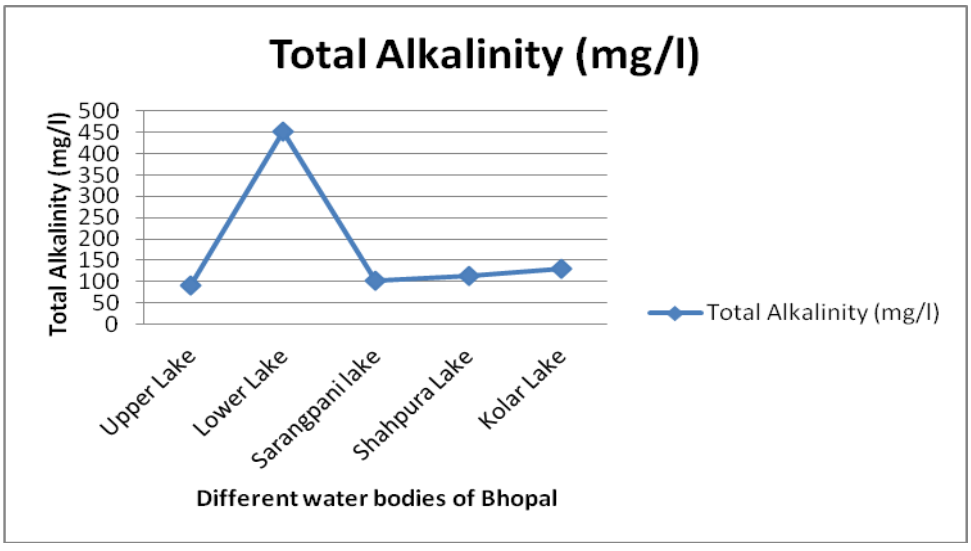

Fig. 9: Comparative total alkalinity profile of the water bodies of Bhopal.

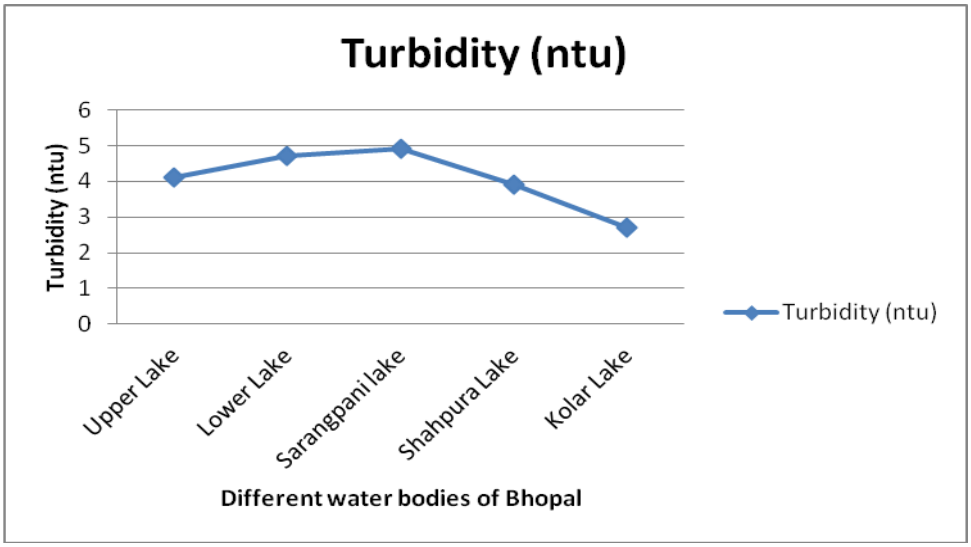

Fig. 10: Comparative turbidity profile of the water bodies of Bhopal.

4. CONCLUSION

In the present study, all the water parameters studied were within the level. The Sarangpani Lake and Shahpura Lake were observed to be more polluted as the parameters like alkalinity and pH were slightly higher than the other lakes. Overall, the water bodies of Bhopal found to be in favorable condition. To maintain the healthy status of water bodies there should be continuous assessment of the pollution level of the lakes.

5. ACKNOWLEDGMENT

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