

Evaluation of Physico-Chemical Parameters in Water Samples Collected from Bhopal Lakes, Madhya Pradesh, India

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Abstract— The present study was carried out to determine various physico-chemical parameters and water quality of the lakes of Bhopal, district of Madhya Pradesh to examine the quality of water for public consumption, recreation and other purposes. This study deals with the influence of environmental factors as well as domestic activities in the water quality in the related area. In Physico-chemical analysis, various quality parameter are measured including pH, Specific conductivity (SP), total dissolved solids (TDS), and total hardness, compared with WHO standards of water quality.

Keywords—Analysis, Bhopal, Physico-Chemical, Specific conductivity, pH

I. INTRODUCTION

Water is an essential component of the environment and it sustains life on the earth. During last decade, this is observed that lake water get polluted drastically because of increased human activities mainly sewage. Consequently number of cases of water borne diseases has been seen which a cause of health hazards. The quality of water is of vital concern for the mankind since it is directly linked with human welfare. The supply of quality water remains a major challenge for humanity in the twenty-first century (Schwarzenbach et al. 2010). The whole human kind needs water for sustaining life; the provision of a safe drinking water supply is a high priority issue for safeguarding the health and well-being of humans (Van Leeuwen, 2000; WHO 2011) and is an important development issue at national, regional and local level (WHO, 2011).

Physico-chemical properties of the water gets varied season wise and in addition, anthropogenic activities such as agriculture, urbanization, domestic sewage, etc in the catchment area result in the deterioration of water quality. Temperature, turbidity, nutrients, hardness, alkalinity and dissolved oxygen are some of the important factors that play a vital role for the growth of living organisms in the water body. Water quality indicates the relation of all

hydrological properties including physical, chemical and biological properties of the water body. The present study deals with the assessment of physico-chemical characteristics of water and on the basis of the various parameters, in the Upper Lake, Lower Lake, and Shahpura Lake, Bhopal, Madhya Pradesh, India.

II. STUDY AREA

Bhopal is known as the City of Lakes for its various natural as well as artificial lakes. Bhopal has an average elevation of 500 metres (1401 ft). Bhopal is located in the central part of India, and is just north of the upper limit of the Vindhya mountain ranges. Located on the Malwa plateau, it is higher than the north Indian plains and the land rises towards the Vindhya Range to the south. The lakes selected for the present study are the twin lakes i.e. Upper lake & Lower Lake and Shahpura Lake of Bhopal. Three samples from each lake were collected, details of which are given below-

Details of Sampling Stations in Upper Lake

(i) Medical College station (UL/1): situated on northeastern part of the lake adjoining medical college. A major inlet joins the lake at this station that brings domestic sewage from the adjoining residential area.

(ii) Khanugaon station(UL/2) :the most polluted zones of the lake, subjected to various anthropogenic activities like bathing, swimming, washing as it is very close to residential area. The station is present in the littoral zone of the lake.

(iii) kamla park station (UL/3): This station is situated on northwestern part of the lake adjoining temples and city area

Details of Sampling Stations In Lower Lake

(i) Khatlapura station (LL/1): This is one of the most polluted stations of Lower Lake. Situated near the densely populated Jehangirabad area and two major sewage inlets join the Lower lake at this station.

(ii) Karishma park station (LL/2): non-point pollution sources (small drains) join the lake near this site.

(iii) Bhoipura station (LL/3): This sampling station is situated near the Khatlapura temple, which is a major idol immersion site. Apart from this, direct human intervention is also witnessed at this station.

Details of Sampling Stations in Shahpura Lake

(i) Manisha market inlet station (SL/1)-sewage and the discharge from Hospital is dumped areas in the lake through this inlet.

(ii) PCB station (SL/2)-this lake sample was collected nearby EPCO, PCB bhopal.

(iii) Kolar line station (SL/3)- this area is usually prone to garbage dumping

III. METHOD

The samples were collected from depth of 5-10 cm below the surface water in sterilized polythene bottles of one liter capacity. Monitoring was performed during December 2016 to January 2017. For unstable parameters such as temperature, electrical conductivity (EC), pH, and dissolved oxygen (DO) were measured at the sampling site. In acid washed plastic bottles. Temperature was measured directly on field by thermometer; pH measurement was carried out by a pH meter (Elico LI 120). Separate samples were collected for dissolved oxygen (DO) in 250 ml bottles and dissolved oxygen was fixed in the field by adding alkali reagent. The samples analyses were carried out immediately after return to the laboratory. Physico-chemical parameters like total alkalinity, dissolved oxygen, total hardness, salinity, chloride, electric conductivity were determined by

standard method (APHA, 1998). The parameters were compared according to the standard methods-

1. pH- It is one of the most important parameter in water chemistry and is defined as $-\log [H^+]$, and measured as intensity of acidity or alkalinity on a scale ranging from 0-14. If free H^+ are more it is expressed acidic (i.e. $pH < 7$), while more OH^- ions is expressed as alkaline (i.e. $pH > 7$).

pH was positively correlated with electrical conductance and total alkalinity (Gupta 2009). The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition (Karanth 1987).

$$pH = -\log ([H^+])$$

2. Electrical Conductivity

Conductivity (specific conductance) is the numerical expression of the water's ability to conduct an electric current. It is measured in micro Siemens per cm and depends on the total concentration, mobility, valence and the temperature of the solution of ions. Conductance is defined as the reciprocal of the resistance involved and expressed as mho or Siemen (s)

Navneet Kumar et al (2010) suggested that the underground drinking water quality of study area can be checked effectively by controlling conductivity of water and Apparatus required: Conductivity meter

Procedure: The electrode of the conductivity meter is dipped into the sample, and the readings are noted for stable value shown as mS/cm.

3. Total Dissolved Solids (TDS)

Dissolved solids are solids that are in dissolved state in solution. Waters with high dissolved solids generally are of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer.

Principle: The difference in the weight of total solids and the total suspended solids expressed in the same units gives the total dissolved solids.

Procedure: The difference in the weights of Total Solids (W_1) and Total Suspended Solids (W_2) expressed in the same units gives Total Dissolved Solids (TDS).

Calculation:

Total Dissolved Solids (mg/L) = $(W_1 - W_2) \times 1000 /$
Sample volume (ml)

W_1 = Weight of total solids + dish

W_2 = Weight of total suspended solids

4. Total Hardness

In alkaline conditions EDTA (Ethylene-diamine tetra acetic acid) and its sodium salts react with cations forming a soluble chelated complex when added to a solution. If a small amount of dye such as Eriochrome black-T is added to an aqueous solution containing calcium and magnesium ions at alkaline pH of 10.0 ± 0.1 , it forms wine red colour. When EDTA is added as a titrant, all the calcium and magnesium ions in the solution get complexed resulting in a sharp colour change from wine red to blue, marking the end point of the titration. Hardness of water prevents lather formation with soap rendering the water unsuitable for bathing and washing. It forms scales in boilers, making it unsuitable for industrial usage. At higher pH > 12.0, Mg^{++} ion precipitates with only Ca^{++} in solution. At this pH, murexide indicator forms a pink color with Ca^{++} ion. When EDTA is added Ca^{++} gets complexed resulting in a change from pink to purple indicating end point of the reaction.

Procedure: 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.

Calculation:

Total hardness (mg/L) = $(T) (1000) / V$

Where, T = Volume of titrant

V = Volume of sample

5. Calcium Hardness

When EDTA (Ethylene-diamine tetra acetic acid) is added to the water containing calcium and magnesium, it combines first with calcium. Calcium can be determined directly with EDTA when pH is made sufficiently high such that the magnesium is largely precipitated as hydroxyl compound (by adding NaOH and iso-propyl alcohol). When murexide indicator is added to the solution containing calcium, all the calcium gets complexed by the EDTA at pH 12-13. The end point is indicated from a colour change from pink to purple.

Procedure: A known volume (50ml) of the sample is pipetted into a clean conical flask, to which 1ml of sodium hydroxide and 1ml of iso-propyl alcohol is added. A pinch of murexide indicator is added to this mixture and titrated against EDTA until the pink color turns purple.

Calculation:

Calcium hardness (mg/L as $CaCO_3$) = $T \times 1000 \times$
 $1.05 / \text{Sample}(\text{ml})$

6. Magnesium Hardness:

Magnesium is a relatively abundant element in the earth's crust, ranking eighth in abundance among the elements. It is found in all natural waters and its source lies in rocks, generally present in lower concentration than calcium. It is also an important element contributing to hardness and a necessary constituent of chlorophyll. Its concentration greater than 125 mg/L can influence cathartic and diuretic actions.

Principle: Magnesium hardness can be calculated from the determined total hardness and calcium hardness.

Calculation- Magnesium(mg/L) = $(T - C) \times 0.243$

where, T = Total hardness mg/L (as $CaCO_3$),

C = Calcium hardness mg/L (as $CaCO_3$)

7. Chlorides:

In alkaline or neutral solution, potassium chromate indicates the endpoint of the silver nitrate titration of chlorides. Silver chloride is quantitatively precipitated before the red silver chromate is formed.

Procedure: 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 (Ag_2CrO_4) starts precipitating.

Calculation:

Chlorides (Cl) = $(A - B) (N) (35.45) / \text{sample}(\text{ml})$

Where,

A - Vol of silver nitrate consumed by the sample, B - Vol of silver nitrate consumed by the blank

N - Normality of silver nitrate

8. Dissolved Oxygen:

Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata Vikal, 2009). In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss 1972, Morrisette 1978, Sangu 1987, Kataria, 1996). During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO₂ and giving off oxygen. This possibly accounts for the greater qualities of O₂ recorded during summer (Krishnamurthy R, 1990). DO in sample is measured titrimetrically by Winkler's method after 5 days incubation at 293 K. The difference in initial and final DO gives the amount of oxygen consumed by the bacteria during this period. This procedure needs special BOD bottles which seal the inside environment from atmospheric oxygen.

Principle: Oxygen present in the sample oxidizes the dispersed divalent manganous hydroxide to the higher valency to precipitate as a brown hydrated oxide after addition of potassium iodide and sodium hydroxide. Upon acidification, manganese reverts to its divalent state and liberates iodine from potassium iodide, equivalent to the original dissolved oxygen content of the sample. The liberated iodine is titrated against N/80 sodium thiosulphate using fresh iodine as an indicator.

Procedure: The samples are collected in BOD bottles, to which 2ml of manganous sulphate and 2ml of potassium iodide are added and sealed. This is mixed well and the precipitate allowed to settle down. At this stage 2ml of conc. sulphuric acid is added, and mixed well until all the precipitate dissolves. 203ml of the sample is measured into the conical flask and titrated against 0.025N sodium thiosulphate using starch as an indicator. The end point is the change of colour from blue to colourless.

Calculations:

203ml because $(200) (300) / (200-4) = 203\text{ml}$.

1ml of 0.025N Sodium thiosulphate = 0.2mg of Oxygen

$\text{DO}(\text{mg/L}) = (0.2) (1000 \text{ ml of Sodium thiosulphate}) / 200$

9. Biological Oxygen Demand (BOD):

It is the amount of oxygen required by microorganisms for stabilizing biologically decomposable organic matter (carbonaceous) in water under aerobic conditions. The test is used to determine the pollution load of wastewater, the

degree of pollution and the efficiency of wastewater treatment methods.

Principle: The method consists of filling the samples in airtight bottles of specified size and incubating them at specified temperature (20 °C) for 5 days. The difference in the dissolved oxygen measured initially and after incubation gives the BOD of the sample.

Procedure: The sample having a pH of 7 is determined for first day DO. Various dilutions (at least 3) are prepared to obtain about 50% depletion of D.O. using sample and dilution water. The samples are incubated at 20 °C for 5 days and the 5th day D.O is noted using the oximeter. A reagent blank is also prepared in a similar manner.

Calculation: $\text{BOD}(\text{mg/L}) = (D_1 - D_2) - (B_1 - B_2) \times f/p$

10. Chemical Oxygen Demand (COD):

It is the measure of oxygen equivalent to the organic content of the sample that is susceptible to oxidation by a strong chemical oxidant. The intrinsic limitation of the test lies in its ability to differentiate between the biologically oxidisable and inert material. It is measured by the open reflux method.

Principle: The organic matter in the sample gets oxidized completely by strong oxidizing agents such as potassium dichromate in the presence of conc. sulphuric acid to produce carbon-di-oxide and water. The excess potassium dichromate remaining after the reaction is titrated with Ferrous Ammonium Sulphate (FAS) using ferroin indicator to determine the COD. The dichromate consumed gives the oxygen required for the oxidation of the organic matter.

Procedure: 15ml of conc. sulphuric acid with 0.3g of mercuric sulphate and a pinch of silver sulphate along with 5ml of 0.025M potassium dichromate is taken into a Nessler's tube. 10ml of sample (thoroughly shaken) is pipetted out into this mixture and kept for about 90 minutes on the hot plate for digestion. 40ml of distilled water is added to the cooled mixture (to make up to 50ml) and titrated against 0.25M FAS using ferroin indicator, till the colour turns from blue green to wine red indicating the end point. A reagent blank is also carried out using 10ml of distilled water.

Calculation:

$$\text{COD} \left(\frac{\text{mg}}{\text{L}} \right) = \frac{\text{Vol. FAS for sample} \times \text{Normality of FAS} \times 8000}{\text{Vol. of sample}}$$

11) Free Carbon-Di-Oxide Carbon dioxide is the end product of organic carbon degradation in almost all aquatic environments and its variation is often a measure of net ecosystem metabolism (Smith 1997, 1993, Hopkinson 1985). The important source of free carbon-di-oxide in surface water bodies is mainly from respiration and decomposition by aquatic organisms. It reacts with water partly to form calcium bicarbonate and in the absence of bicarbonates gets converted to carbonates releasing carbon-di-oxide.

Principle: Free carbon-di-oxide reacts with sodium carbonate or sodium hydroxide to form sodium bicarbonate. The completion of the reaction is indicated by the development of pink colour, characteristic of phenolphthalein indicator at an equivalent pH of 8.3

Procedure: A known volume (50ml) of the sample is measured into a conical flask. 2-3 drops of phenolphthalein indicator is added and titrated against 0.22N sodium hydroxide till the pink colour persists indicating the end point.

Calculation:

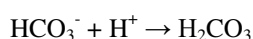
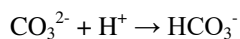
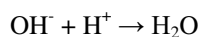
$$\text{Free CO}_2 \text{ (mg/L)} = \frac{V_t (1000)}{V_s}$$

Where, V_t - volume of titrant (ml)

V_s - volume of the sample taken (ml)

12) Alkalinity is defined as a measure of the buffering capacity of water to neutralize strong acid. This capacity is attributed to bases that are present in natural waters including OH^- , HCO_3^- , and CO_3^{2-} . More alkalinity in your water sample means more buffering capacity of your water sample.

The following reactions are occurring during titration;



If carbonate (CO_3^{2-}) is present in your sample, CO_3^{2-} will consume one H^+ when the solution is titrated to pH 8.3, and it will consume another H^+ during further titration from pH 8.3 to pH 4.5. If the volume of acid required to get pH 8.3 is equal to the volume of acid used from pH 8.3 to pH 4.5, your sample contained only CO_3^{2-} (no OH^-) as the major alkalinity component. If the pH of your sample is below 8.3, and a certain amount of acid

is required to reach pH 4.5, your sample contained only HCO_3^- (no OH^- and CO_3^{2-}). If your sample requires a certain amount of acid to reach pH 8.3, but no acid is required from pH 8.3 to pH 4.5, your sample contained only OH^- .

Calculation

Total Alkalinity = Amount of acid used to reach pH 4.5 (ml) * Normality of acid (eq/L) * 50,000 (mg CaCO_3 /eq) / sample volume (ml)

IV. RESULTS AND DISCUSSION

1. pH- during the study the value fluctuated between 6.5 to 8.9. minimum values being 5.4(LL/2), 6.5(UL/1, LL/1, LL/3), 7.5(UL/3), 8.2(SL/2), 8.5(SL/1) and the maximum value recorded was 8.9(SL/3).

2. ELECTRICAL Conductivity- during the study the value fluctuated between 0.22 to 0.60 $\mu\text{mhos/cm}$ minimum values being 0.22(UL/2, UL/3), 0.23(UL/1), 0.38(LL/3), 0.39(LL/1), 0.44(LL/2) and the maximum value recorded was 0.54(SL/3), 0.58(SL/3) and 0.60(SL/1).

3. TDS(mg/L) - during the study the value fluctuated between 134.2 to 366(mg/l) minimum values being 134.2(UL/3, UL/3), 140.3(UL/1), 231.8(LL/3) and the maximum value recorded was 305(SL/3), 329.5(SL/2), 366(SL/1).

4. DO (mg/L)- during the study the value fluctuated between 5.4 to 9.6 minimum values being 5.4(SL/2), 5.8(SL/3), 6(SL/1), 6.2(LL/3), 6.8(LL/2), 7.4(LL/1) and the maximum value recorded was 7.6(UL/3), 8.0(UL/2) and 9.6(UL/1).

5. Carbonate(mg/L)- during the study the value fluctuated between 0 to 6 minimum values being 0(UL/1, LL/1, LL/2, LL/3, SL/1, SL/2, SL/3) and the maximum value recorded was 2(UL/3) and 4(UL/2).

6. Free CO_2 (mg/L)- during the study the value fluctuated between 0 to 10.8 minimum values being (UL/2, UL/3), 4(UL/1), 6(LL/2), 8(LL/1, LL/3, SL/1) and the maximum value recorded was 10.8(SL/2), and 12.0(SL/3).

7. Chloride (mg/L)- during the study the value fluctuated between 29.97 to 149.8 minimum values being 29.97(LL/3), 32.96(LL/2,SL/3), 49.95(SL/1), 119.8(UL/3), 139.8(UL/2) 33.96(LL/1) and the maximum value recorded was 149.8(UL/1) .

8. Total Alkalinity(mg/L)- during the study the value fluctuated between 104 to 240 minimum values being 104(UL/3), 130(LL/1), 156(UL/2), 170(LL/1), 178(LL/2), 175(LL/3) and the maximum value recorded was 220(SL/2) and 240(SL/3)

9. Total Hardness(mg/L)- during the study the value fluctuated between 68 to 254 minimum values being 68(UL/1), 100(UL/3), 104(UL/2), 146(LL/2), 158(LL/3) and the maximum value recorded was 168(LL/1),176(SL/1),190(SL/2) and 254(SL/3)

10. Calcium Hardness(mg/L)- during the study the value fluctuated between 63 to 195.3 minimum values being 63(UL/3), 71.4(UL/2), 92.4(UL/1), 113.4(SL/1), 119.7(LL/3) and the maximum value recorded was 136.5(LL/2),147(LL/1),168(SL/2) and 195.3(SL/3).

11. Magnesium Hardness(mg/L)- during the study the value fluctuated between 5.3 to 86.0 minimum values being 5.3(SL/3), 9.5(LL/2), 21(LL/1), 32.6(UL/2), 37(UL/3), 38.3(LL/3) and the maximum value recorded was 43.6(UL/1),62.6(SL/1) and 86(SL/2).

12. COD(mg/L)- during the study the value fluctuated between 120 to 268 minimum values being 120(UL/2),130 (UL/3), 168(UL/1), 200(SL/2), 240(LL/2)and the maximum value recorded was 260(LL/3), 268(SL/3) and 280(SL/1).

13. BOD(mg/L)- during the study the value fluctuated between 4 to 19.5 minimum values being 4(UL/1), 6(UL/2), 12(UL/3,SL/2), 14(LL/2),16(LL/3) and the maximum value recorded was 19.2(SL/3) and 19.5(SL/1).

V. CONCLUSION

The present study was conducted to analyze the physico-chemical parameters and to evaluate the extent of pollution in Upper Lake, Lower lake and Shahpura lake of bhopal. It has been found that in some of the samples have total dissolved solids, pH, alkalinity, total hardness, magnesium, calcium and dissolved oxygen values exceeding the permissible limits as prescribed by Indian standards. The parameters such as electrical conductivity, chloride and biological oxygen demand values are within permissible limits.

The completed study indicates that the water quality is poor in shahpura lake due to high alkalinity and extremely low DO and is not totally safe for human consumption due to presence of high level of pollutants. The water must not be not used for public consumption and recreation due to lack of water purification. This study showed that if the water quality of Upper lake and Lower Lake remain as it is than it will destroyed the ecosystem of the lake. The government body such as pollution control board PCB bhopal, NABARD, EPCO, Bhopal should take the action against releasing of domestic waste directly into the lake or installed a water purification system.

This study gave us an insight that upper lake can be treated and the used for consumption whereas Lower lake and Shahpura lake are beyond treatment and effective measures must be taken as the conditions of these once flourished lakes are alarming.

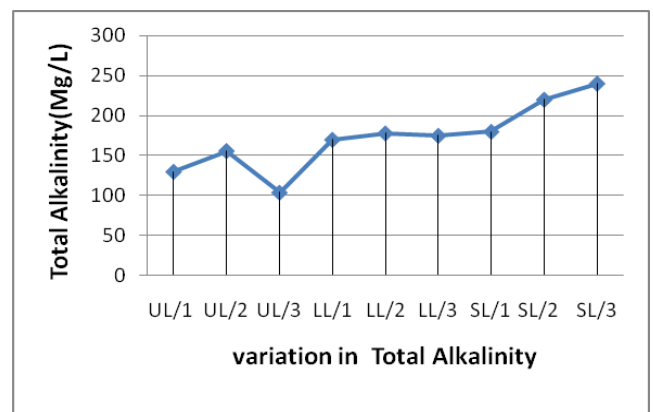
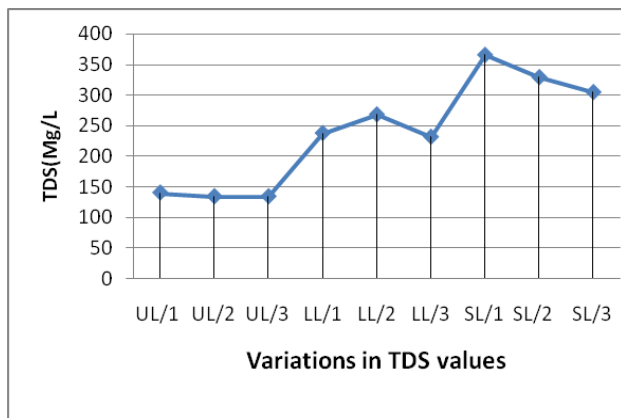
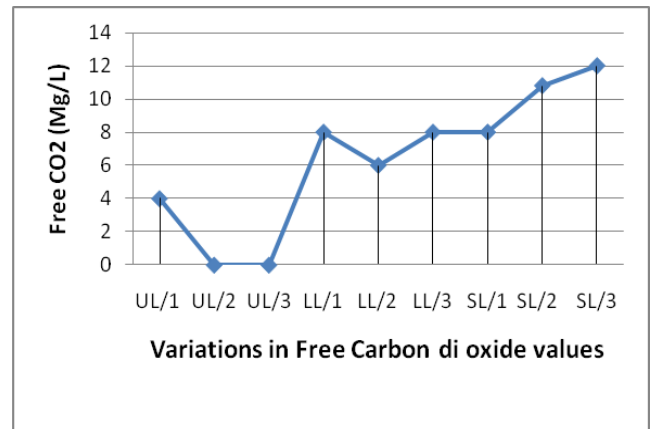
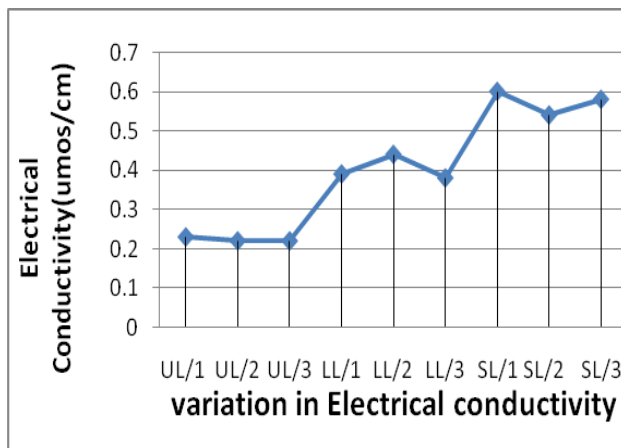
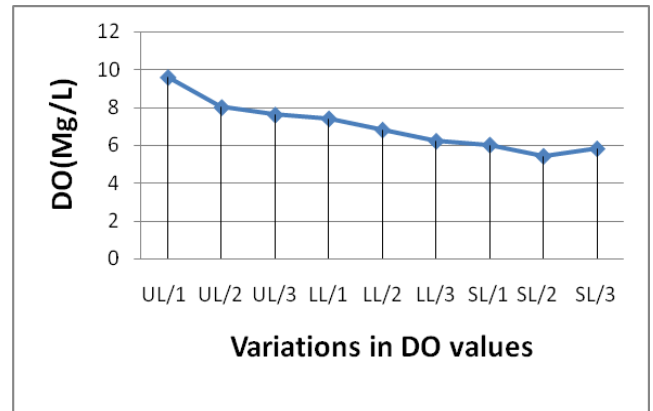
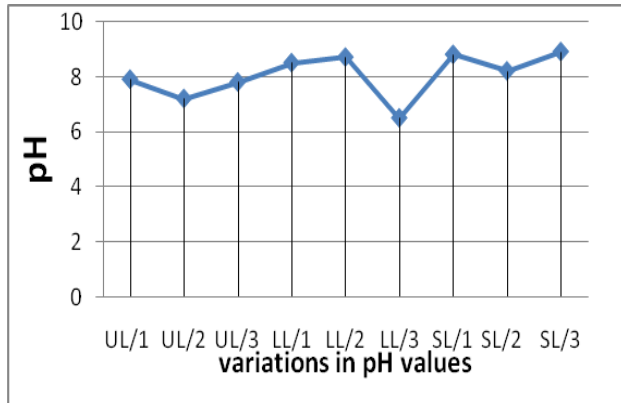
Table 1: General Information about the samples collected from Upper Lake, Lower lake and Shahpura lake

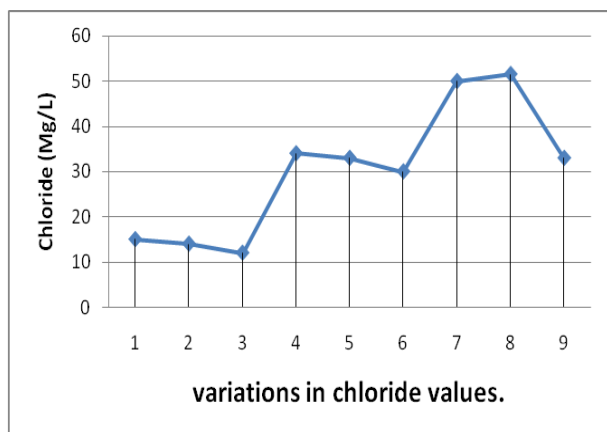
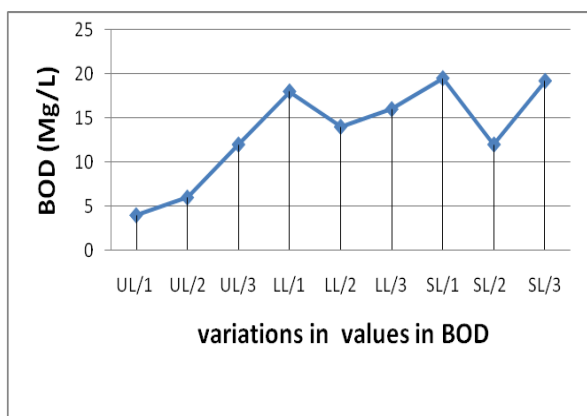
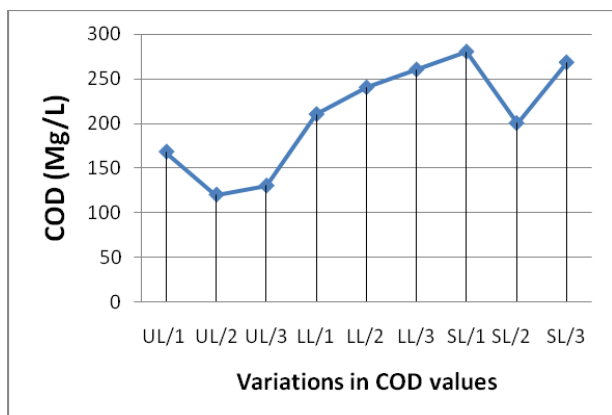
S.NO	Sample Station	Time (Pm)	Climate	Temp (°C)	Depth	Colour
1	(UL/1)	4:21	Bright Sunlight	21	Surface	Greenish Black
2	(UL/2)	4:35	Bright Sunlight	21	Surface	Black
3	(UL/3)	4:50	Bright Sunlight	21	Surface	Olive Green
4	(LL/1)	3:45	Bright Sunlight	24	Surface	Olive Green
5	(LL/2)	4:00	Bright Sunlight	24	Surface	Olive Green
6	(LL/3)	4:10	Bright Sunlight	24	Surface	Black
7	(SL/1)	5:25	Bright Sunlight	18	Surface	Black
8	(SL/2)	5:35	Bright Sunlight	18	Surface	Muddy Green
9	(SL/3)	5:55	Bright Sunlight	17	Surface	Olive Green

Table 2: Values of variations in different physico-chemical parameters in Upper Lake, Lower Lake and Shahpura Lake lake samples collected in the present study

Guideline value	Upper lake samples			lower lake samples			Shahpura Lake Samples			Max and Min value		Permissible limits		Method used
	UL/1	UL/2	UL/3	LL/1	LL/2	LL/3	SL/1	SL/2	SL/3	Min Value	Max Value	WHO(1973)	Isi 10500-91	
pH	6.5	5.5	7.5	6.5	7.7	6.5	8.5	8.2	8.9	6.5	8.9	7-8.5	6.5-8.5	Recorded by pH meter
Electrical Conductivity (Umas/Cm)	0.23	0.22	0.22	0.39	0.44	0.38	0.6	0.54	0.58	0.22	0.6	1400	-	Electric Conductometer
TDS (Mg/L)	140.3	134.2	134.2	237.9	268.4	231.8	366	329.4	305	134.2	366	1000	500	Gravimetric
DO (Mg/L)	9.6	8	7.6	7.4	6.8	6.2	6	5.4	5.8	5.4	9.6	-	5	Titrometric
Free CO ₂ (Mg/L)	4	0	0	8	6	8	8	10.8	12	0	10.8	-	-	Titrometric
Chloride (Mg/L)	14.98	13.98	11.98	33.98	32.96	29.97	49.95	51.49	32.96	11.98	51.49	250	250	Mohrs method
Total Alkalinity (Mg/L)	130	156	104	170	178	175	180	220	240	104	240	120	200	Neutralizing with Std. HCl
Total Hardness (Mg/L)	68	104	100	168	146	158	176	190	254	68	254	500	300	EDTA method
COD (Mg/L)	168	120	130	210	240	260	280	200	268	120	268	20	20	Titrometric
BOD (Mg/L)	4	6	12	18	14	16	19.5	12	19.2	4	19.5	2	2	Titrometric

VI. GRAPHS





VI. ACKNOWLEDGEMENT

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