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Limnological Studies of Upper Lake of Bhopal (India)

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ABSTRACT

Limnological study of Upper Lake includes comparison of water quality parameters of four different sites in every month at surface and bottom level of Upper Lake, Bhopal during 2008. Water sample collected were analyzed for their Limnological characters viz. Temperature, pH, conductivity, Total hardness, Total dissolved solids, Dissolved Oxygen, BOD, COD, Total alkalinity, Chloride, Sulphate, Nitrate, Nitrite, orthophosphate, data obtained from these analysis were statistically analyzed to determine the correlation between various water quality parameters.

Key words: Limnological studies, Water pollution, Upper Lake.

INTRODUCTION

Water is the important natural source, which is abundant in nature and cover about 2/3rd of earth surface. However, only 1% of the water resource is available as fresh water (i.e., surface water, rivers, Lakes, streams, and ground water) for human consumption and other activities. The water quality indicator value is based on quality and quantity of fresh water (especially ground water), wastewater treatment facilities, legalities like application of pollution regulations, India's quality indicator value stood at - 3.1 while for best ranked country**,**

In India studies of physico-chemical characteristics of water have been carried out by various workers. Agrawal[1] (1993), Das and Kalita[2] (1990), Hussainy[3] (1965), Iqbal *et al.,*[4]. (1984) and (2002)[5] Kataria *et al.,*[6] (1994), Kataria and Iqbal [7] (1995), Khan *et al.,*[8](1978), Kumar and Saha[9] (1989), Mathew[10] (Govindgarh Lake, Rewa), Magarde *et al.,*[11] (2006), Mehra[12] (Bhalaswa Lake, Delhi), Munawer[13] (1970), Pant and Sharma[14] (1985), Pathak[15] (1990), Prasad *et al.,*[16] (1985).

Study area

Bhopal city, the capital of the state of Madhya Pradesh, is endowed with several man-made Lakes created and constrcted through the centuries.

The Upper Lake, created in 11th century AD, It has special significance since it has been a

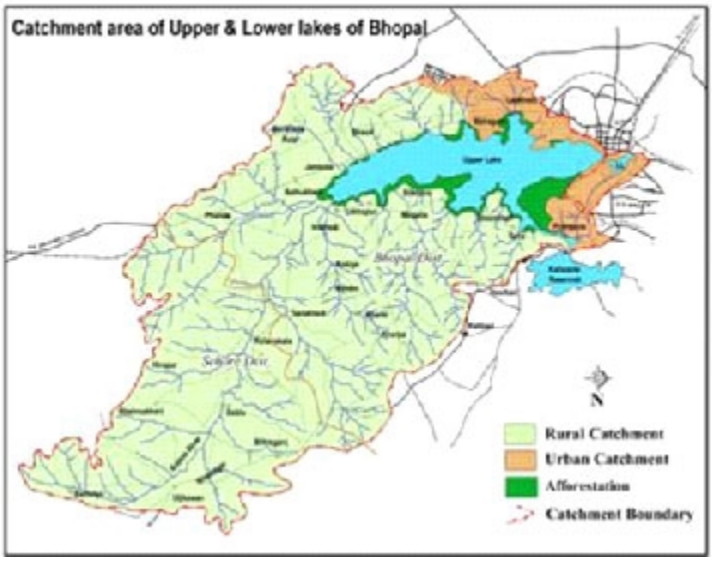

Fig. 1.

source of piped water supply to the city of Bhopal for over 75 years. Even now, the Lake accounts for some 40% of the city's water supply. Until 1947 the water quality of Upper Lake was so good that it did not require any treatment before being supplied to the public. However, tremendous population growth of the city (about 70,000 in 1951 to about 1.4 million in 2001) These Lakes are of immense importance since they are inseparably linked with the socio, economical and cultural aspects of the people of Bhopal and are referred as lifelines of the city.

Objective of the study

During present investigation water quality of Upper Lake was assessed to evaluate the degree of pollution caused due to input of toxic as well as domestic wastewater from its catchment.

The physico - chemical study includes comparison of water quality parameters in different four stations of the Upper Lake during the year 2008.

East of the Lake	Fategarh
West of the Lake	Bhainsakheri
North of the Lake	Bairagarh
South of the Lake	Bhadbhada

Method and Methodology

Water temperature

The water temperature was measured by using a probe and also using a mercury thermometer graduated up to 100 °C with an accuracy of 0.1 – 0.2 °C.

Turbidity

The turbidity was determined by Jackson turbidity tube. Results were expressed as Jackson Turbidity Unit (JTU).

Conductivity

Conductivity of the samples was measured by using conductivity meter having a conductivity cell containing platinum electrode.

TDS

TDS was determined by TDS meter, which gives reading directly in mg/L

pH

pH is the logarithm in base 10 of the reciprocal of the hydrogen ion concentration given in moles per liter.

Hydrogen ion concentration (pH) was measured by Water Analysis Kit by using hydrogen ion selective electrode.

Dissolved oxygen

Dissolved oxygen is the most significant

parameter, because it regulates the metabolic processes of the organisms. Its acts as an indicator of water quality, tropic status and magnitude of eutrophication.

The dissolved oxygen concentration depends on the physical, chemical and biological activities in the water body, and its measurement provides a good indicator of water quality. Changes in dissolved oxygen concentration can be an early indication of changing condition in the water body.

Methodology

Dissolved oxygen is measured by a number of methods including electronic oxygen meters but the most commonly used and preferred method for DO determination is the Winkler's method with azide modification. dissolved oxygen content was calculated by using the formula.

$$\text{Dissolved oxygen mg/L} = \frac{\text{mL of titrant} \times N \times E \times 1000}{\text{mL of sample}}$$

Where,
N = Normality of titrant
E = Equivalent weight of oxygen

Total alkalinity

The total alkalinity was obtained by adding carbonate and bicarbonate alkalinity.

The carbonate alkalinity was determined by titrimetric method using phenolphthalein as indicator

The bicarbonate alkalinity was determined by titrating sample with standard acid solution using methyl orange indicator.

Total hardness

Total hardness (as $CaCO_3$) was determined by EDTA tritrametric method using Erichrome Black-T indicator. Values were computed by following formula:

$$\text{Total hardness mg/L} = \frac{\text{mL of titrant} \times 1000}{\text{mL of sample}}$$

Chloride

Chloride ion is essential to the electrolytic balance of essential ions, in our bodies. Because there is a continuous intake and excretion of chloride from all animals, it is one of the more abundant anions found in wastewater and are good indicator ion for pollution sources.

Chloride concentration was determined by argentometric titration method involving formation of reddish brown complex by adding potassium Chromate which is titrated against silver nitrate solution.

Biochemical oxygen demand (BOD)

The biochemical oxygen demand (BOD) is an empirical test, in which standardized laboratory procedures are used to estimate the relative oxygen requirements of wastewater's, effluents and polluted waters.

Biochemical oxygen demand was determined by measuring the difference of the oxygen concentration (By modified Winkler's method) between the sample and after incubating it for five days at 20°C.

Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) is the amount of the oxygen consumed by organic matter from boiling acid potassium dichromate solution

Reflux condensation method was used for the determination of Chemical Oxygen Demand.

Orthophosphate

Phosphate compounds are present in fertilizers and in many detergents. Consequently they carried into both ground and surface waters with sewage, industrial waste and agricultural runoff. High concentration of phosphorous compounds may produce a secondary problem in water bodies where algal growth is normally limited by phosphorous. In such situation the presence of additional phosphorous compounds can stimulate algal productivity and enhance eutrophication.

Orthophosphate was determined spectrophotometrically using the stannous chloride method on HACH DR 4000 UV-Vis spectrophotometer.

Table 1: Water quality parameters of Upper lake during the year 2008 (Fatehgarh sampling station)

Parameters Station	Month	Depth	Water temperature (°C)	pH	Conductance	Total solids	Total alkalinity	Bicarbonate alkalinity	Carbonate alkalinity	Chloride	Nitrate	Nitrite	Total hardness	Dissolved oxygen (DO)	BOD	COD	Sulphate	Orthophosphate
(East of	Jan	S	27.3	6.5	0.2	263	142	88	54	9.98	2.04	0.751	110	5.6	0	26	14	1.98
the		B	24.6	6.3	0.4	548	146	94	52	12	2.46	0.369	120	4.4	0	28	19	2.14
Lake	Feb	S	27.6	7.2	0.1	463	118	80	38	15	2.4	0.245	98	8.8	2	20	11	1.77
(Fategarh)		B	23.9	7.1	0.2	597	124	84	40	22	2.57	0.338	108	7.2	6	24	23	2.16
	Mar	S	28.3	8.2	0.4	246	126	100	26	7.98	1.99	0.475	120	10.8	0	24	17	1.84
		B	24.3	8.1	0.1	756	132	112	20	12	2.04	0.658	128	1.2	4	30	45	2.47
	Apr	S	26.8	7.9	0.3	298	108	98	10	17	2.12	0.246	122	9.6	2	24	12	2.66
		B	23.6	7.6	0.2	365	112	86	26	27	3.16	0.398	126	4.4	4	38	16	3.14
	May	S	25.7	8.3	0.2	244	124	66	58	23	2.48	0.236	90	10.4	2	26	18	1.47
		B	23.6	8.1	0.4	239	136	48	88	34	2.99	0.321	124	1.2	10	28	29	1.49
	June	S	26.2	7.6	0.4	247	112	68	44	14	1.23	0.421	86	6	2	24	11	1.44
		B	23.1	7.4	0.5	365	124	76	48	25	2.01	0.365	122	5.6	12	38	24	1.69
	July	S	26.3	7.6	0.4	359	120	98	22	17	1.23	0.218	108	4.4	8	40	16	1.47
		B	20.4	7.1	0.2	476	124	110	14	21	1.45	0.125	124	6.4	10	42	13	1.56
	Aug	S	26.5	7.9	0.4	386	116	84	32	28	1.37	0.442	112	8.4	2	36	26	1.28
		B	22.4	7.1	0.3	469	120	68	52	35	1.43	0.362	118	4.4	6	46	12	1.74
	Sep	S	26.7	7.5	0.1	563	148	120	28	14	1.35	0.147	106	7.6	0	28	23	2.39
		B	24.2	7.3	0.3	654	164	136	28	17	2.46	0.452	120	4	2	44	28	4.78
	Oct	S	26.1	7.4	0.2	256	124	88	36	21	1.95	0.365	98	6.4	6	26	22	1.22
		B	20.7	7.2	0.3	369	136	64	72	25	2.36	0.754	102	5.6	8	28	19	1.56
	Nov	S	24.9	7.6	0.3	544	124	102	22	27	2.15	0.369	88	9.6	0	24	16	1.27
		B	19.2	7.3	0.4	368	138	84	54	30	2.63	0.478	96	7.2	2	46	11	1.84
	Dec	S	24.8	7.4	0.3	532	142	36	106	15	2.18	0.452	104	8.4	0	26	29	1.34
		B	18.2	7.1	0.3	634	146	88	58	18	2.57	0.366	120	1.2	2	28	22	1.55

S- Surface, B- Bottom.

Table 2: Water quality parameters of Upper of Bhopal during the year 2008 (Bhainsakheri sampling station)

Parameters	Month	Depth	Water temperature (°C)	pH	Conductance	Total solids	Total alkalinity	Bicarbonate alkalinity	Carbonate alkalinity	Chloride	Nitrate	Nitrite	Total hardness (DO)	Dissolved oxygen	BOD	COD	Sulphate
Station																	
(West of the lake)	Jan	S	26.3	8.6	0.2	248	48	28	20	17.9	4.12	1.118	90	10.4	0	18	2.38
		B	21.4	7.3	0.2	596	52	36	16	21.9	4.22	1.268	84	4.8	2	24	2.42
Bhainsakheri	Feb	S	27.4	8.2	0.2	244	60	44	16	24.9	4.36	1.024	68	9.6	0	16	2.14
		B	23.6	8.1	0.2	842	72	56	16	27.9	4.38	0.988	72	1.2	2	26	2.4
	Mar	S	27.3	8.3	0.4	366	44	34	10	16.9	4.98	0.184	60	8.8	0	18	2.15
		B	24.6	7.4	0.4	485	56	26	30	19.9	3.67	0.147	84	6.4	2	22	2.31
	Apr	S	28.4	7.9	0.2	127	36	16	20	21.9	3.86	0.109	64	8.8	0	24	2.59
		B	24.8	7.4	0.3	209	42	28	14	24.9	2.74	0.137	90	7.2	0	26	3.72
	May	S	27.3	9.2	0.2	244	44	26	18	13.9	3.21	0.168	68	10.4	0	24	3.17
		B	24.7	7.9	0.2	366	64	42	22	14.9	3.11	0.126	80	2.4	0.4	28	3.69
	June	S	25.1	7.3	0.3	189	28	12	16	21.9	3.87	0.122	84	6.4	2	46	2.04
		B	23.2	7.1	0.2	146	32	22	10	18.9	2.16	0.137	102	5.6	0.4	44	2.42
	July	S	24.4	7.4	0.1	158	24	10	14	15.9	2.98	0.339	96	4.4	4	28	2.24
		B	21.3	7.1	0.4	209	28	18	10	21.9	2.74	0.881	110	4.8	6	36	2.17
	Aug	S	24.8	7.4	0.2	470	32	20	12	12.9	3.21	1.028	84	6.4	4	28	2.05
		B	21.6	7.2	0.2	960	46	28	18	9.9	2.17	0.98	90	4.4	6	66	2.15
	Sep	S	25.3	7.6	0.4	312	28	16	12	24.9	2.96	0.167	68	8.8	2	48	2.04
		B	23.1	7.6	0.3	458	32	14	18	21.9	2.44	0.194	84	7.6	2.4	84	2.31
	Oct	S	24.2	7.1	0.3	249	38	14	24	20.9	3.16	0.954	66	5.6	2	22	2.15
		B	20.1	7.3	0.3	378	44	22	22	23.9	2.87	1.004	80	6.4	2.4	26	2.46
	Nov	S	23.6	7.4	0.3	246	58	38	20	14.9	3.68	0.324	68	7.2	0	28	2.4
		B	19.4	6.9	0.7	344	46	28	18	21.9	2.91	0.365	84	1.2	1.2	36	2.47
	Dec	S	21.6	7.3	0.1	298	42	26	16	23.9	2.44	0.098	60	6.4	2	24	2.8
		B	17.9	7.1	0.3	328	46	24	22	24.9	2.98	0.268	78	2.4	1.6	28	3.12

S- Surface, B- Bottom.

Table 3: Water quality parameters of Upper lake of Bhopal during the year 2008 (Bairagarh sampling station)

Parameters Station	Month	Depth	Water temperature (°C)	pH	Conductance	Total solids	Total alkalinity	Bicarbonate alkalinity	Carbonate alkalinity	Chloride	Nitrate	Nitrite	Total hardness	Dissolved oxygen (DO)	BOD	COD	Sulphate spha	Orthophospha te
			Surface and Bottom samples															
North of the lake (Bairagarh)	Jan	S	23.6	7.7	0.2	255	74	46	28	24	2.77	0.369	112	6.6	0.4	36	22	1.39
		B	19.9	7.3	0.3	364	78	44	34	30	2.89	0.486	142	2.4	1.2	38	13	1.46
	Feb	S	26.4	7.5	0.3	398	68	56	12	25	3.69	0.477	102	7.2	2	22	19	1.39
		B	19.8	7.6	0.4	247	70	52	18	22	3.68	0.652	128	4.4	4	24	22	1.42
	Mar	S	24.6	7.3	0.3	263	68	54	14	32	2.78	0.984	136	6.4	1.2	26	37	1.98
		B	21.3	7.4	0.4	255	74	52	22	22	2.96	0.482	124	2.4	2.4	14	23	1.68
	Apr	S	23.9	7.1	0.2	289	64	36	28	30	2.35	0.576	126	6	1.2	28	29	1.88
		B	19.7	7.2	0.3	367	78	48	30	32	2.48	0.445	122	4.4	4.4	36	24	2.24
	May	S	26.4	7.9	0.4	489	60	52	8	27	2.88	0.632	146	6	1.6	18	16	2.36
		B	22.3	7.6	0.4	365	84	42	42	34	2.69	0.789	138	6	2	26	17	2.18
	June	S	26.9	7.2	0.3	148	64	36	28	28	2.54	0.145	126	4.4	4	32	11	1.29
		B	19.8	7.1	0.2	635	76	44	32	39.9	2.69	0.365	128	4	4	48	28	1.44
	July	S	22.3	7.4	0.2	299	52	28	24	20	2.47	0.179	146	8	12	22	34	1.39
		B	18.7	7.1	0.2	478	68	36	32	22	2.69	0.234	138	6	16	28	39	4.56
	Aug	S	26.3	7.6	0.2	654	46	28	18	17	3.21	0.235	122	5.6	4	26	42	1.31
		B	22.6	7.5	0.2	894	86	64	22	18	2.59	0.632	126	2.4	8	34	16	1.78
	Sep	S	24.9	7.2	0.2	236	54	38	16	27	2.64	0.244	142	5.6	1.2	16	18	1.29
		B	22.1	7.1	0.3	247	60	44	16	25	3.15	0.396	144	4.2	2.8	24	21	1.44
	Oct	S	23.1	7.6	0.2	456	46	24	22	26.9	2.88	0.451	138	6	1.2	14	29	1.39
		B	19.8	7.2	0.2	236	84	42	42	34	3.28	0.244	168	5.2	2.4	28	23	1.42
	Nov	S	21.6	7.9	0.4	594	56	28	28	29	2.78	0.263	124	4.4	1.2	20	16	1.36
		B	18.9	7.4	0.3	634	58	34	24	32	2.31	0.584	144	7.2	4.4	24	19	1.58
	Dec	S	20.3	7.6	0.3	266	44	26	18	25	2.16	0.456	168	6.4	1.2	20	24	1.37
		B	17.6	7.2	0.4	354	56	28	28	28	2.66	0.255	144	5.6	8	28	22	1.98

S- Surface, B- Bottom.

Table 4: Water quality parameters of Upper lake of Bhopal during the year 2008 (Bhadbada sampling station)

(Surface and Bottom samples)

Parameters Station	Month	Depth	Water temperature (°C)	pH	Conductance	Total solids	Total alkalinity	Bicarbonate alkalinity	Carbonate alkalinity	Chloride	Nitrate	Nitrite	Total hardness	Dissolved oxygen (DO)	BOD	COD	Sulphate spha	Orthophosphate
South	Jan	S	26.4	6.3	0.4	258	120	84	36	13.9	2.66	0.635	120	6.4	0	28	16	1.94
of the		B	24.9	6.3	0.4	367	124	66	58	18.9	3.58	0.149	126	4	0	14	18	1.88
Lake	Feb	S	27.3	8.9	0.1	264	206	128	78	13	2.47	0.633	80	8.8	0	18	26	1.36
(Bhadbada)		B	23.7	8.7	0.2	122	240	124	116	16.9	3.18	0.251	110	6.4	0	20	27	2.87
	Mar	S	24.6	7.6	0.3	87	156	136	20	17.9	2.44	0.312	120	7.2	0	26	49	1.45
		B	22.8	7.5	0.4	456	184	144	40	16.9	3.76	0.333	140	6.6	4	28	18	1.69
	Apr	S	29.8	8.3	0.3	38	126	102	24	21.9	2.65	0.188	106	8.8	0	44	56	2.1
		B	26.7	8.1	0.3	269	144	116	28	33.9	3.84	0.298	120	4.4	6	26	42	2.49
	May	S	27.6	8.9	0.4	241	138	124	14	15.9	2.16	0.564	124	9.6	0	20	38	2.67
		B	23.8	7.8	0.4	156	240	168	72	23.9	2.49	0.587	136	4.4	0	24	47	3.14
	June	S	26.5	8.1	0.4	248	166	142	24	14.9	2.66	0.364	118	6	4	28	16	2.11
		B	24.7	7.7	0.4	126	142	122	20	18.9	2.87	0.289	126	2.4	10	14	24	2.56
	July	S	24.3	6.8	0.4	29	182	176	6	21.9	2.46	0.354	124	3.6	12	16	56	2.17
		B	22.8	6.4	0.5	358	124	96	28	22.9	2.75	0.326	146	4.2	16	12	14	2.74
	Aug	S	27.6	7.8	0.4	265	122	112	10	16.9	2.36	0.521	128	8.8	0	18	18	1.77
		B	24.5	7.6	0.4	344	136	104	32	21.9	2.93	0.399	130	7.2	0	20	12	1.92
	Sep	S	24.6	8.2	0.2	278	140	120	20	22.9	2.14	0.485	122	6.4	0	24	24	1.28
		B	22.1	7.7	0.3	269	128	86	42	29.9	2.64	0.314	128	7.6	2	24	26	1.47
	Oct	S	25.6	7.4	0.4	245	166	106	60	17.9	2.56	0.268	130	8	0	28	23	1.66
		B	23.1	7.1	0.4	163	148	122	26	19.9	2.39	0.355	142	4.4	0	20	27	2.14
	Nov	S	22.4	8.4	0.3	237	122	104	18	21.9	2.47	0.277	128	6.4	0	26	28	1.86
		B	19.3	7.1	0.3	348	120	84	36	26.9	2.39	0.963	130	2.4	0	20	22	2.73
	Dec	S	21.7	7.3	0.3	196	142	98	44	21.9	2.16	0.312	126	5.6	0	24	19	1.44
		B	17.6	7.1	0.6	79	156	124	32	24.9	2.94	0.359	134	3.6	0	28	26	2.09

S- Surface, B- Bottom.

Nitrate was determined spectrophometrically using the phenol disulphonic acid method on HACH DR 4000 UV-Vis spectrophotometer

Nitrite was analyzed using sulfanilamide method on HACH DR 4000 UV-VIS Spectrophotometer.

RESULT AND DISCUSSION

Station – 1 (Fategarh)

Physicochemical characteristics

The water quality of this station is comparatively better. Although, this area is also affected by various anthropogenic activities (bathing, swimming etc.) but these activities do not have much significant role in Lake Pollution. This station is also the site of Tazias immersion, but the immersion activity has only temporary effect on water quality (since no silt is added). No remarkable change was observed during the year 2008.

Station - 2 (Bhaisakheri)

This sampling station has a major inflow channels. Prominent fluctuation in different parameters has been observed during monsoon and winter seasons. The western part of the Lake has a wide spread catchment area, which accumulates the water in the Lake through Kolans River.

Physicochemical characteristics

The fluctuations in the Lake water and turbidity are due to turbulence during monsoon season. Disturbance in most of the parameters was observed during the year. In summer season, the hypolimnetic water at the sampling point indicates the higher value of Biochemical Oxygen Demand. This may be as a result of higher decomposition rate, low depth of water enriched with chemical constituents. The situation was completely reversed in the monsoon season where the external loading of suspended and dissolved solids increases the turbidity, decreases the transparency and dilutes the nutrient concentration. No remarkable changes noticed in the year 2008.

Station - 3 (Bairagarh)

This station is located near the Sehore Nalla, which has one of the major inlets that remain active through out the year.

Physicochemical characteristics

The continuous flow of domestic sewage from the northern residential area has resulted in increase in BOD, COD, NO_3, PO_4 etc. This area is also affected by the idol immersion activity through which huge quantities of nutrients and decomposable materials are dumped into the Lake. The agricultural activities in the adjoining areas are also responsible for increasing the nutrient and silt load at this station.

Station - 4 (Bhadbhada)

At this station, the water quality parameters depicted considerable fluctuations in various parameters.

Physicochemical characteristic

During the period time when spill channel was opened (during / after monsoon) high turbidity was recorded at this station. Besides this, higher concentrations of PO_4^{3-}, NO_3^- were also observed which lead to the profuse growth of algal population particularly *Microcystis aeruginosa*. The sudden increase in algal density can be related to the release of nutrients from the soil from overlying water during flushing on account of deepening and widening activity. In 2008 higher values of BOD were found as this site remains almost stagnant due to scanty rainfall which enhanced the decomposition activities.

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