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Multivariant analysis of drinking water quality parameters of lake Pichhola in Udaipur, India

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ABSTRACT : An attempt has been made to work out the physico-chemical characteristics of the Pichhola lake water. In order to ascertain the drinking water quality, various parameters like air and water temperature, pH, free CO_2, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, conductivity, total dissolved solids, hardness, total alkalinity, chloride, nitrate, phosphate and sulphate were studied. The results revealed that the values of conductivity, COD, and sulphate were found to cross the standard limits in water samples. The coefficient of correlation (r) among various physico-chemical parameters was also made.

Keywords : Lake Pichhola, Physico-chemical parameters, water quality

INTRODUCTION

Udaipur is truly famous for its beautiful lakes and watercourses. The city is popularly known by the phrase of the "City of Lakes". Lake Pichhola is one of the most beautiful and picturesque lakes of Rajasthan, India. Located in the heart of city, it is the oldest and one of the largest freshwater lakes of Udaipur. In 1362, it was built by a nomad named Pichhu during the ruling period of Maharana Lakha. It is situated towards the west of Udaipur city between the parallels 24º33'15" and 24º34'59" north latitudes and 73º39'32" and 73º41'08" east longitudes (Vikal and Tyagi, 2007). It is an important source of potable water supply for the Udaipur City. Water quality is an index of health and well being of a society. Pollution of water bodies is one of the areas of major concern to environmentalists. Industrialization, urbanization and modern agriculture practices have direct impact on the water resources. These factors influence the water resources quantitatively as well as qualitatively. The city sewage and industrial effluent drains into the lake and pollutes the water quality. Its water quality has become a matter of concern due to continuous changing environment and increasing social and industrial activity that influence the physico-chemical properties of water directly or indirectly. Because of these reasons an attempt has been made to study the physico-chemical properties in order to ascertain the potability of water of Lake Pichhola.

MATERIAL AND METHODS

At Lake Pichhola two sampling stations were selected, namely Bansi Ghat (Sampling Site I) and Maaji Ka Mandir (Sampling Site II) for the present investigation. Hydrobiological studies of both the sampling sites were carried out for one year from Jan., 2006 to Dec., 2006. On monthly basis water samples (1.5-2.0 lit.) were collected in acid washed polythene bottles during morning hours between 7.00 A.M. to 10.00A.M. at a depth of 30 cm with precautions, so as to prevent any vertical disturbance. For DO and BOD determination samples were collected in 300 ml capacity BOD glass bottles and DO was fixed at the spot. Air and water temperatures were also noted down on the spot. Water samples were brought to laboratory, Department of Botany, M.L.S. University, Udaipur and analyzed soon after on the same day and data recorded. The water samples were analyzed for air and water temperatures, pH, free carbon dioxide, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), conductivity, total dissolved solids (TDS), hardness, total alkalinity, chloride, nitrate, phosphate, and sulphates as per standard methods (Trivedi and Goel, 1986; Manivasakam, 1996 and APHA, 1998).

RESULTS AND DISCUSSION

Both air and water temperatures are important which determines the distribution of different life forms. Both air and water temperature were found to be maximum in the month of May, 06 (30.55ºC) at sampling site I and in June, 06 (30.5ºC) at sampling site II. In our study it has been found that air and water temperatures go more or less parallel proving the fact that the atmospheric temperature governs water temperature. Welch (1952), Naik and Purohit (1996), Mishra and Patel (2001), Yadav (2003) and other workers have supported above trends. The temperature is one of the vital factors which control the occurrence and abundance of phytoplankton in lentic ecosystem (Nazneen, 1980 and Veerendra *et al*., 2006).

Table 1: Physico-chemical characteristics of Lake Pichola during Jan.,2008-Dec.,2008

S. No.	Parameters	S.S	Jan. 2008	Feb. 2008	Mar. 2008	Apr. 2008	May 2008	Jun. 2008	Jul. 2008	Aug. 2008	Sep. 2008	Oct. 2008	Nov. 2008	Dec. 2008
1	Air Temperature	I	15.5	21.5	26.0	27.5	30.55	29.5	26.0	26.5	26.0	22.5	-	14.0
		II	16.0	21.0	26.0	30.0	30.1	30.5	26.5	28.0	27.5	24.0	-	15.0
2	Water Temperature	I	17.5	20.0	24.5	27.0	30.0	30.0	28.0	27.5	28.0	24.5	-	19.0
		II	18.0	23.0	25.0	28.0	31.0	31.0	28.5	28.5	28.5	25.5	-	20.0
3	pH	I	8.19	8.56	8.33	8.72	8.24	8.48	8.07	8.39	8.15	8.14	-	8.23
		II	8.16	8.48	8.33	8.78	8.52	8.59	8.39	8.72	8.19	8.18	-	8.32
4	Free CO_2	I	7.2	A	A	A	3.1	3.0	3.0	3.4	A	9.0	-	1.0
		II	9.2	A	A	A	A	2.0	2.0	A	A	6.0	-	8.0
5	Dissolved Oxygen	I	6.33	7.55	6.53	5.92	5.51	3.88	4.29	7.04	5.92	5.31	-	6.33
		II	6.33	6.73	6.73	6.94	6.94	5.0	5.51	7.55	6.94	5.92	-	6.33
6	BOD	I	10.41	0.29	6.74	5.31	3.06	3.98	3.06	1.22	3.27	1.63	-	2.45
		II	3.67	1.12	3.29	6.33	10.408	6.54	3.06	2.94	2.04	2.45	-	3.54
7	COD	I	78.03	78.72	78.4	75.2	80.16	-	-	85.12	75.28	73.6	-	71.04
		II	-	79.68	75.04	74.24	92.16	-	-	73.92	96.24	61.12	-	60.80
8	Conductivity (µS/cm)	I	590.0	632.0	596.0	666.0	550.0	745.0	622.0	571.0	731.0	605.0	-	1000.0
		II	578.0	643.0	676.0	662.0	584.0	783.0	612.0	550.0	735.0	608.0	-	1040.0
9	TDS	I	290.0	316.0	298.0	333.0	275.0	372.0	311.0	285.0	366.0	302.0	-	504.0
		II	289.0	321.0	333.0	310.0	292.0	391.0	306.0	275.0	367.0	304.0	-	520.0
10	Hardness	I	175.0	165.0	162.0	130.0	114.0	119.0	121.0	121.0	135.0	135.0	-	140.0
		II	172.0	166.0	162.0	132.0	113.0	119.0	122.0	117.0	133.0	134.5	-	143.0
11	Phenolphthalein Alkalinity	I	A	6.0	3.1	4.0	A	2.0	A	A	2.0	A	-	A
		II	A	4.0	5.0	4.0	3.0	2.0	A	4.0	2.0	A	-	A
12	Methyl Orange Alkalinity	I	149.0	152.0	151.1	143.0	114.0	137.0	135.0	135.0	147.0	140.0	-	149.0
		II	145.0	150.0	146.0	138.0	116.0	134.0	136.0	136.0	141.0	136.0	-	154.0
13	Total Alkalinity	I	149.0	158.0	158.2	147.0	114.0	139.0	135.0	135.0	149.0	140.0	-	149.0
		II	145.0	154.0	151.0	142.0	164.0	136.0	136.0	140.0	142.0	136.0	-	154.0
14	Chloride	I	39.99	26.27	37.99	46.99	45.99	47.99	45.99	35.99	44.99	44.99	-	48.98
		II	39.99	41.18	44.98	46.99	52.98	47.99	43.99	36.99	44.99	47.99	-	46.99
15	Nitrate	I	0.27	0.78	5.09	0.78	3.99	2.88	3.15	4.43	1.994	1.362	-	1.218
		II	0.13	1.55	6.31	3.21	3.10	4.21	4.87	5.19	1.706	1.606	-	1.129
16	Phosphate	I	0.015	0.024	0.028	0.038	0.033	0.035	0.021	0.015	0.038	0.035	-	0.047
		II	0.012	0.032	0.028	0.046	0.038	0.039	0.056	0.028	0.073	0.049	-	0.041
17	Sulphate	I	60.00	65.50	55.50	51.00	63.25	62.50	66.50	40.50	43.75	56.50	-	52.00
		II	64.50	65.50	55.00	51.00	74.25	61.50	66.00	38.75	42.75	55.00	-	52.00

SS = Sampling sites

It is known fact that pH plays a major role in most of the chemical and biological reactions. The pH of drinking waters should be in the range of 6.5-8.5. pH of lake water was noted to be alkaline throughout the year with maximum values in the month of April, 06, *i.e.*, 8.72 and 8.78 at sampling site I & II , respectively. Similarly, alkaline water was observed by Vijayvergiya (1988), Majumdar *et al.* (2006) and Sinha and Saxena (2007). Increase of pH has also been recorded during the summer months might be due to decrease in water level or either due to increased amounts of carbonates and or increased photosynthetic activities of producers (Abubacker *et al*., 1996). Statistical analysis suggests that it bears negative correlation with free CO_2 and nitrate and positive with air and water temperature at both the sampling sites (Table 2 &3). Similar trend was also observed by Vikal and Tyagi (2007).

Free CO_2 content in water samples was negligible in majority of the months, might be due to pollution and photosynthetic activities of algae (Sreenivasan, 1971). Likewise, no record of free CO_2 in most of the months was observed by Nandkar and Mararthe (1983) and Shankhadarwar (2002), which support our results. Highest free CO_2 values were recorded in the month of Dec., 06 at both the sites.

DO is one of the most important parameters. Its concentration in a water body gives much direct and indirect information, *e.g.*, bacterial activity, photosynthesis, availability of nutrients, stratification, etc. DO was recorded to be minimum in the month of June, 06 (3.88 & 5.0 mg/l at S.S.I and II, respectively). Maximum DO was in Feb.,06 at S.S.I (7.55 mg/l) and Aug.,06 at S.S.II (7.55 mg/l). With the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss, 1972; Morrissette and Mavinic, 1978; Sangu and Sharma, 1987 and Kataria *et al*., 1996). Martin (1970) considered a water body with BOD_5 of 8 ppm as moderately polluted. A perusal of data in table 2 shows that the values of COD were very high during the study period at both the sampling sites and exceeded the limits of 10 mg/l set by WHO as international standards of drinking water. Organic matter and anthropogenic activities were the main factors responsible for high COD (Jayaraman *et al*., 2003 and Udhayakumar *et al*., 2006). TDS shows strong positive correlation with electrical conductivity. These results coincide with the work of Shah *et al*. (2006). The permissible value of conductivity for drinking water is 300 µS/cm (USPHS) (Sreenivas *et al*., 2006). From what has been observed from this investigation, it is evident that the values were far from the standards. The results of present study illustrate an inverse relationship between free CO_2 and carbonate alkalinity, *i.e.*, in the presence of free CO_2 carbonate or phenolphthalein alkalinity will be absent and vice-versa. Total alkalinity shows strong positive correlation with hardness at S.S.I (Table 2) and with chloride at S.S.II (Table 3).

The main source of chlorides in the waters is the discharge of domestic sewage, therefore, its concentration serves as an indicator of pollution by sewage. Nitrate enters in an aquatic body from various sources like erosion of natural body or soil, as well as, artificially fertilized soil and through rainfall and sewage (Kapoor and Bamniya, 2001). Nitrate and phosphate have been found to be high in the month of Sep., 06 at both the sites. Singh *et al*. (2009) have concluded that Sagar Lake (India) has attained the higher-eutrophic state due to high nitrogen and phosphorus contents in the lake water. Sulphate ion concentration was observed to be very high in Lake Pichhola. Sulphate with sodium interferes with the normal functioning of the intestine.

Physico-chemical parameters can bring changes in limnological qualities and thus alter biotic composition (Vikal and Tyagi, 2006) while others interfere directly with the biotic community of water body. The most serious aspect of eutrophication of Lake Pichhola is water bloom formation by *Microcystis aeruginosa* during summer and rainy months. *Microcystis aeruginosa* is one of the best known indicators of sewage pollution of lakes.

The Pichhola Lake is one of the main drinking water supply reservoir for the township of Udaipur. The main cause of water pollution is development of human settlements near water bodies, creating nuisance which is the most neglected aspect of water quality problem. The high phosphate and nitrate contents and presence of bloom of *Microcystis aeruginosa* in the waters of this lake have made it completely unfit for drinking. Further, it is also an undisputed fact that the sewage and garbage from the human habitation on its banks openly flow into it, and that from the Five Star Lake Palace Hotel is also being stealthily dumped into it. Deterioration of water quality leads to reduction in its aesthetic value, potability and taste, as well as odour production resulting in death of fauna. The situation is beyond redemption, in spite of so many statements made by politicians, administrators and even academicians about the steps being taken for its amelioration.

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Table 2: Correlation Coefficient matrix among various physicochemical parameters of Lake Pichhola during Jan. 06 – Dec. 06

Parameters	Air Temp.	Water Temp.	pH	Free CO_2	DO	BOD	COD	Cond.	TDS	Hardness	Total Alk	Chloride	Nitrate	PO_4^-	Sulphate
Air Temp	+1	+0.97	+0.280	-0.670	-0.434	-0.209	+0.474	-0.528	-0.508	-0.664	-0.503	+0.1107	-0.134	+0.2387	-0.130
Water Temp		+1	+0.092	-0.528	-0.561	-0.337	+0.371	-0.339	-0.333	-0.76	-0.594	+0.273	+0.041	+0.354	-0.209
pH			+1	-0.549	+0.302	+0.006	+0.212	-0.148	-0.059	+0.15	+0.371	-0.334	-0.512	-0.284	-0.114
Free CO_2				+1	-0.083	+0.014	-0.430	+0.467	+0.529	+0.026	-0.147	+0.356	+0.253	-0.023	+0.086
DO					+1	-0.052	+0.393	-0.081	-0.009	+0.081	+0.475	-0.744	-0.065	-0.274	-0.291
BOD						+1	-0.047	-0.163	-0.199	+0.479	+0.218	+0.187	-0.391	-0.229	+0.282
COD							+1	-0.883	-0.699	+0.254	-0.335	-0.618	-0.504	-0.482	-0.062
Electrical Conductivity							+1	+0.999	-0.012	+0.335	+0.402	+0.457	+0.294	-0.188	
TDS									+1	+0.004	+0.281	+0.401	+0.457	+0.293	-0.188
Hardness										+1	+0.773	-0.538	-0.154	-0.347	+0.282
Total Alkalinity											+1	-0.393	+0.071	-0.211	-0.094
Chloride												+1	0.344	-0.284	-0.043
Nitrate													+1	+0.782	-0.554
Phosphate														+1	-0.315
Sulphate															+1

Table 3: Correlation Coefficient among various physicochemical parameters at sampling sites of Lake Pichhola during Jan, 06 - Dec, 06

Parameters	Air Temp.	Water Temp.	pH	Free CO_2	DO	BOD	COD	Cond.	TDS	Hardness	Total Alk.	Chloride	Nitrate	PO_4^-	Sulphate
Air Temp.	+1	+0.961	+0.603	-0.796	+0.051	+0.628	+0.534	-0.415	-0.416	-0.719	-0.241	+0.328	+0.336	+0.558	-0.070
Water Temp.		+1	+0.517	-0.742	-0.089	+0.445	+0.504	-0.255	-0.265	-0.845	-0.267	+0.364	+0.082	+0.633	+0.002
pH			+1	-0.657	+0.285	+0.407	+0.549	-0.260	-0.231	-0.364	+0.016	-0.021	-0.510	-0.077	-0.132
Free CO_2				+1	-0.326	+0.023	-0.651	+0.383	+0.384	+0.401	-0.062	-0.054	+0.127	-0.377	+0.116
DO					+1	-0.038	+0.444	-0.298	-0.298	+0.082	+0.439	-0.297	-0.001	-0.018	-0.459
BOD						+1	+0.647	-0.082	-0.073	-0.498	+0.360	+0.684	-0.336	+0.571	+0.447
COD							+1	-0.552	-0.552	-0.185	+0.611	+0.181	-0.428	+0.169	+0.622
Electrical Conductivity							+1	+0.998	-0.068	+0.125	+0.264	+0.596	+0.055	+0.161	
TDS									+1	-0.068	-0.125	-0.264	-0.297	-0.059	-0.161
Hardness										+1	+0.232	-0.406	-0.205	-0.667	+0.106
Total Alkalinity											+1	+0.339	-0.208	+0.260	+0.371
Chloride												+1	+0.241	+0.735	+0.390
Nitrate													+1	+0.289	-0.528
Phosphate														+1	+0.241
Sulphate															+1

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