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Systematic Investigation of Hydro-Chemical Characteristics of Six Different Lakes in and around Kolhapur city, Maharashtra, India

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Abstract:

A systematic investigation of hydro chemical characteristics was carried out for six different lakes of Kolhapur city. The release of untreated domestic sewage and other anthropogenic activities are leading to gross lake water pollution of major lakes in the city. The present study aims to ascertain the drinking water quality and various physico-chemical parameters like pH, Total Dissolved Solids, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Phosphate, Nitrate, Hardness, Total Dissolved Solids, Calcium and Magnesium. There were variations in pH (7.0-8.2 mg/lit), Total Dissolved Solids (204.1-264.7 mg/lit), Dissolved Oxygen (2.6-6.0 mg/lit), Biochemical Oxygen Demand (8.04-26.0 mg/lit), Chemical Oxygen Demand (14.0-50.83 mg/lit), Phosphate (0.1-1.96 mg/lit), Nitrate (0.72-4.05 mg/lit), Hardness (143.0-338.0 mg/lit), Calcium (69.66-333.0 mg/lit) and Magnesium (4.2-71.66 mg/lit). The results of the study showed that water quality of lakes near densely populated area is highly depleted as compared to the lakes that are away from the city.

Key words: Lakes, water quality, physicochemical analysis, seasonal variation.

Introduction:

Water is one of the most important component for human survival (Versari *et al*. 2002). Pure water having low suspended solids, biological growth and obnoxious gases, is considered suitable for potable purpose. The quality of water changes day by day and from source to source, which determines its use. Any change in the natural quality of water may disturb the equilibrium of the system and would become unfit for designated use. A lake is a watershed area in which its quality depends upon every component of that ecosystem (Indra 2006, Krishnan *et al*. 2007). Topography of the surrounding area, soil, geology and vegetation determine the kind of materials entering into lake which indicates the water quality (Dong *et al*. 2010). Lakes are subject to various natural processes taking place in the environment, such as hydrologic cycle. With enormous developmental activities, human beings are responsible for the severe deterioration of several lakes. Most urban and rural lakes have vanished under this pressure with worldwide environmental concerns (Iscen *et al*. 2008; Prasanna *et al*. 2010). Storm water runoff and discharge of sewage into the lakes are few of the common causes where various nutrients enter the aquatic, ecosystems resulting in their death (Jana and Das 1995). The untreated wastewater entering through point and non-point pollution sources contains effluents rich in phosphate, caustic soda, detergent etc. responsible for the huge amount of aquatic macrophytes. These nutrients support the fast growth of the aquatic plants, mainly *Eichhornia crassipes, Hydrilla, Ceratophyllum* etc., this leading to eutrophication (Tamot and Sharma 2006).

Eutrophication is considered a major environmental problem in most parts of the world (Oczkowski and Nixon 2008). Though nutrient enrichment is beneficial for algal growth, it leads to deterioration of water quality and degradation of entire ecosystems (Yu *et al.* 2010). In recent

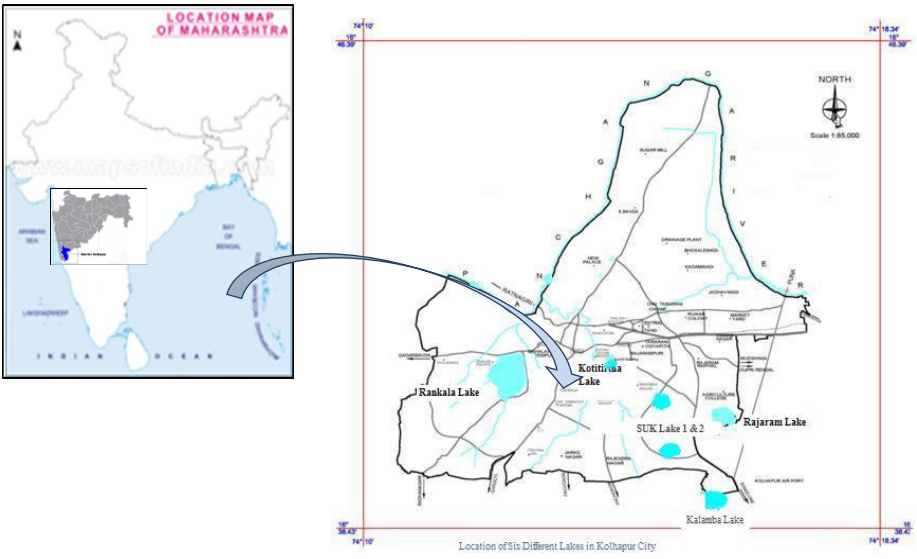
decades, population growth, agricultural practices and sewage runoff from urban areas have increased nutrient input many folds to the level of their natural occurrence, resulting in accelerated eutrophication (Choudhary *et al.* 2010; Zan *et al.* 2010). Periodic monitoring and assessment of water quality helps to develop management strategies to control surface water pollution (Shuchun *et al.* 2010). In the present study effort is made to characterize six lakes in and around Kolhapur city of Maharashtra, India, in terms of different parameters.

Study area:

Kolhapur city (Latitude 16° 36' N, Longitude 74°21' E), Maharashtra, is situated in the Western part of India. It was known as 'City of Lakes' in the past due to the presence of 24 lakes in and around. However, in recent decades, the lake ecosystems in the city have changed drastically and come into exacerbated trend because of disturbances in the catchment areas. The major problem of these lakes is nutrient enrichment from catchment area in the form of domestic wastewaters coming from residential areas and run off from agricultural fields. Today, due to vast urbanization and industrialization only eight lakes remained in good condition, the rest of the lakes being converted into open land. These lakes serve as important multi-usage components, such as source of drinking water, irrigation, fishery, agriculture, socio-economic development and recreation. Despite of all these facts, anthropogenic activities are depleting quality and aesthetic value of these water bodies. During the present study, an attempt was made to evaluate the water quality status of different lakes in Kolhapur city. The study was conducted for six lakes in Kolhapur city including Kalamba, Rankala, Kotitirth, Rajaram, Shivaji University Lake 1 and Shivaji University Lake 2.

Table No. 1. Geocoordinates of lakes in Kolhapur city.

Sr. No.	Name of the lake	Coordinates	Year of construction	Area	Mean sea level (M)	Depth meter
1	Kalamba	Lat 16⁰ 39' 18.18" N Long 74⁰ 12' 39.42" E	1881	63.13 hect.	597.71	14
2	Rankala	Lat 16⁰ 41' 17.21" N Long 74⁰ 12' 39.60" E	1887	107 hect.	552.90	30
3	Kotitirth	Lat 16⁰ 41' 39.74" N Long 74⁰ 14' 12.24" E	------	57740 sq. M	564.79	60
4	Rajaram	Lat 16⁰ 40' 48.58" N Long 74⁰ 15' 54.77" E	1928	21.6 sq. m	575.46	11
5	Shivaji University lake1 (Bhashabhavan)	Lat 16⁰ 40' 24.25" N Long 74⁰ 15' 11.37" E	2007	1.8 Ha	588.87	11.16
6	Shivaji University lake 2 (Music Department).	Lat 16⁰ 41' 00" N Long 74⁰ 15' 11.52"E	2007	0.244 km²	585.52	6.55



Methodology

Six different lakes in and around Kolhapur city were selected for the study. Water samples were collected in clean polythene cans and plastic bottles. All water samples were stored in insulated cooler containing ice and taken on the same day to laboratory and stored at 4°C until processing and analysis. The samples were collected monthly to detect noticeable changes in the quality of the lake water. Water samples were collected between September, 2011 and February, 2012.

Temperature (T) of water was measured in situ during sample collection by using mercury centigrade thermometer (Ree 1953). PH was determined by pH meter (Bates 1978). Calcium (Ca) and Magnesium (Mg) concentrations were determined by the Versenate titrimetric method (Katz and Navone 1964). Nitrate nitrogen (NO3-N) was determined by Phenate method (Solorzano 1969) using spectrophotometer. Phosphate phosphorous (PO4) was determined by Molybdate method (Edwards *et al*. 1965). Dissolved Oxygen content (DO) and Biochemical Oxygen Demand (BOD5) were determined using Winkler's method (Mancy and Jaffe 1966). Chemical Oxygen Demand (COD) was estimated by Dichromate method (Pitwell 1983).

Results and Discussions:

The values of the various physico-chemical parameters of the lake water samples of Kolhapur city are presented in Table 2. PH plays an important role in balancing the aquatic ecosystem. It determines the suitability of water for various purposes, including toxicity to animals and plants. Acidic pH affects the aquatic ecosystem (Patil *et. al*. 2011). Variations of pH are often observed in the lakes due to several factors such as interactions with suspended matter, influence of freshwater

inputs, pollution, photosynthesis etc. (Yadava et *al*. 1987).

Sr. No.	Lakes / Parameters		Kalamba	Rankala	Kotitirth	Rajaram	Bhasha Bhavan	Music Department
1.	pH	Average	7.68 ± 0.19	7.25 ±0.06	7.57 ±0.13	7.52 ±0.28	7.48 ±0.56	7.885 ±0.39
		Minimum	7.4	7.2	7.4	7	6.45	7.51
		Maximum	7.9	7.35	7.72	7.75	7.95	8.4
2.	TDS	Average	204.1±0.6	227.5±2.35	264.75±1.31	233.1±11.86	233.6±7.46	220.9±1.57
		Minimum	125	212	207	232	224	220
		Maximum	450	249	264	259	242	289
3.	DO	Average	5.85± 1.54	3.1 ±0.76	4.026±0.35	4.533±0.186	4.333±0.27	4.201±0.52
		Minimum	5.5	1.8	3.57	4.3	4.0	3.6
		Maximum	6.3	4.1	4.55	4.8	4.4	5.06
4.	BOD	Average	8.36±0.87	26±1.44	20.24±1.28	11.89±1.38	8.04±1.45	9.96±1.15
		Minimum	7.3	13	8.8	6.23	6.15	5.4
		Maximum	9.4	29	12.17	10.9	7.9	6.9
5.	COD	Average	16±1.8	50.8±0.97	41.04±0.92	21.6±2.09	17.90±1.32	15.4±0.12
		Minimum	17	35.2	30.5	21.73	20.73	21.76
		Maximum	35.2	52.2	47.8	27.48	24.6	30.2
6.	Phosphate	Average	0.1±0.06	1.96±0.10	1.64±0.07	1.57±0.11	1.353±0.32	1.781±0.50
		Minimum	0.09	1.7	1.55	1.43	0.7	1.48
		Maximum	0.1	2.1	1.76	1.73	1.77	2.8
7.	Nitrate	Average	1.21 ±0.08	3.1±0.08	4.051±0.56	1.77±0.09	0.72±0.11	0.84±0.23
		Minimum	1.11	1.8	3.2	0.6	0.6	0.6
		Maximum	1.3	2.3	4.6	0.8	0.88	1.31
8.	Hardness	Average	143±2.18	213±1.46	338±1.08	158.5±0.33	168.4±0.30	200±0.73
		Minimum	139.7	200	244	102.33	105	135
		Maximum	151	220	399.5	224.6	248.5	265
9.	Calcium	Average	78.9±0.67	152±6.03	333±0.07	115.99±0.52	122.08±0.28	157.25±0.95
		Minimum	47	141	140	70.66	76	95
		Maximum	91	157	395	170	190	215
10.	Magnesium	Average	64.1 ±0.97	60.66±4.96	42.68±0.36	46.64±0.77	44.41±0.62	32.83±0.74
		Minimum	51	48.1	37	31.6	29	39.5
		Maximum	65.2	64	47	58	48.5	47

Table No. 2 Analysis of physico- chemical parameters from lake water in Kolhapur city.

All parameters except pH are expressed in mg/l.

The average pH of the six lakes ranged from 7.25-7.8, which shows the alkaline nature of water. Clay, silt, organic matter, plankton and other microscopic organisms cause turbidity in natural water (Kishor and Joshi 2005). The average Total Dissolved Solids (TDS) of all the lakes were in range of 204.1-264.75 mg / lit. The Kalamba Lake shows lowest TDS

while Kotitirth lake shows the highest TDS. The maximum permissible limit of TDS for potable water is 500 mg/ lit (BIS). All the lakes showed TDS values within the limit. High level of TDS in water used for drinking purposes leads to many diseases, which are not water-borne, but due to excess salts**,** TDS levels were higher at the point of discharge of sewage. In addition, Total Solids were found highest during the summer and lowest in winter, which are in agreement with studies carried out by Ugale and Hiware (2005).

Dissolved Oxygen (DO) is an important characteristic used to check the quality of water. Its concentration in a water body gives direct and indirect information about bacterial activity, photosynthesis, availability of nutrients, stratification, etc. Low DO concentration (< 3 mg/lit) in fresh water aquatic system indicates higher pollution causing negative effects on aquatic ecosystem (Jadhav *et al*. 2012). In the present study, the average concentration of dissolved oxygen in all the study sites varied in between 2.6-6.0 mg/lit. Higher dissolved oxygen was recorded during rainy season. DO was recorded minimum for the lake Rankala 1.8-3.8 mg/lit due to mixing of urban sewage and maximum for Kalamba lake 6.9-8.4 mg/lit. 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 and Kataria *et al*. 1996). Higher rate of decomposition of organic matter and limited flow of water leads to consumption of O2 from water (Jameel 1998). Average values of DO of all sites were seen slightly above the limits of BIS (4 mg/lit)

Biological Oxygen Demand (BOD) is one of the pollution indicator parameter. A higher BOD value indicates the presence of organic material in water (ICMR 1975). This parameter gives a complete picture of the nature and extent of pollution and water quality (Kumar and Sharma 2002). The BOD indicates high concentration of biodegradable matter and high oxygen consumption by heterotrophic organism (Patil *et al.*

2011). It was observed that the Rankala lake showed maximum BOD (29.0±1.943 mg/lit) during summer while the minimum (5.4±0.122) was noticed for Shivaji University lake II in winter. The BOD showed fluctuation in lake water due to seasonal effect as well as topography of the lake. During summer, due to depletion of water level and increased microbial activity, there were shown increased BOD levels. The Rankala and Kotitirth lakes are located in densely populated areas, which explains the high load of organic pollution as compared to other lakes which are located away from the city. The observation shows that the BOD values of all the lakes are above the limits of BIS (3.0 mg/lit).

Chemical Oxygen Demand (COD) is an important parameter for establishing the quality of water. It determines the amount of oxygen required for chemical oxidation of organic and inorganic matter (Maithy 2004). Organic matter and anthropogenic activities are the main factors responsible for higher COD (Jayaraman et *al.* 2003; Udhayakumar *et al.* 2006). During the analysis, it was observed that the COD level was higher at Kotitirth (41.04± 0.92 mg/lit), Rankala (50.8±0.97 mg/lit) and Rajaram lakes (21.6±2.09mg/lit) lake while it was minimum at Kalamba (16±1.8mg/lit), Shivaji University lake I (15.4±0.12 mg/lit) and Shivaji University lake II (15.4±0.12 mg/lit). The COD load in the catchment area of Rankala and Kotitirtha lakes was high due to mixing of sewage while Kalamba lake shows less COD. The COD varies from lake to lake as well, as it shows fluctuations due to seasonal changes.

Phosphate is one of the important factor for the growth of planktons and an important nutrient for maintaining fertility of water body. The observation shows that the Rankala (1.96±0.10 mg/lit) and Kotitirth (1.64±0.07 mg/lit) lakes showed higher phosphate levels than other lakes. The higher concentration of phosphate may be due to presence of detergents in sewage waste dumped in the pond and washing of clothes, cleaning utensils in the pond (Parikh 2012).

Nitrate enters in an aquatic body from various sources, like erosion of natural water body or soil, as well as by means of artificially fertilized soil and through rainfall and sewage (Kapoor and Bamniya 2001). The present study reveals that the Rankala (3.1±0.08mg/lit) and Kotitirth (4.051±0.56mg/lit) lakes show higher nitrate levels than the other lakes. This may be due to the higher phytoplankton production, decaying macrophytes and concentration of nutrients owing to the evaporation of lake water with subsequent increase in nitrate (Sulekh 2012). Nitrates (NO3) and Phosphates (PO4) are the nutrients responsible for eutrophication in any water body. Their impact is extremely varied and potentially destructive (Nauman 1932). Nitrates and phosphates in a water body can contribute to high BOD levels. These are plant nutrients and can cause plant life and algae to grow quickly. These contribute to the organic waste in the water, which is then decomposed by bacteria. This results in the high BOD level leading to eutrophication.

The Total Hardness is the total soluble magnesium and calcium salts present in the water expressed as its CaCO3 equivalent. It also includes sulphates, chlorides of calcium and magnesium. In most natural waters the predominant ions are those of bicarbonates associated mainly with calcium, to a lesser degree with Magnesium, and still less with sodium and potassium (Rafiullah 2012*)*. The total hardness of all the lakes was found within the range of 102.3 to 399.0 mg/lit. The minimum Hardness was observed for Kalamba lake while the maximum - for Kotitirth lake. The hardness of water increases in the polluted waters by the deposition of calcium and magnesium salts **(**Bhatt 1999). Hardness below 300 mg/l is considered potable while beyond this limit it can cause gastro-intestinal irritation (ICMR 1975). All the lakes except Kotitirtha lake (338 $\pm$ 1.08mg/lit) shows hardness above the BIS standards. Mixing of sewage, detergents and large scale

human use causes increased hardness of water (Mohanta and Patra 2000).

Calcium is found abundantly in all natural water. The major calcium source is rock leaching. Calcium hardness was found ranging in between 69.66-333.7 mg/l for Kalamba and Kotitirth lake respectively. The higher concentration of Calcium may be due to sewage coming from the surrounding residential areas of Kotitirth lake. It also reveals that the Kalamba lake is also getting some sewage sources.

The concentration of Magnesium remains generally lower than the calcium. It is mostly associated with calcium in all kinds of water. Magnesium acts as a limiting factor for the growth of phytoplankton and essential for chlorophyll growth (Dagaonkar 1992). Therefore, depletion of magnesium reduces the number of phytoplankton's population. The present investigation shows the magnesium content up to 64.1mg/lit in Kalamba lake, lower concentration in 32.83 mg/lit. in Shivaji University lake II.

Conclusion:

The investigation shows that the lakes which are near to the city i.e. Rankala and Kotitirtha are more polluted as compared to the lakes which are located away from the city i.e. Kalamba, Rajaram, Shivaji University Lake I and Shivaji University Lake II. The study also confirms that the main cause of water pollution is human centered activities near water bodies. Deterioration of water quality leads to reduction in its aesthetic value, potability and taste, as well as odour resulting in death of fauna. The concerned authorities will get a guideline from this study, which will be useful for planning control measures to improve health of the lakes.

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