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Research article

DETERMINATION OF WATER QUALITY INDEX OF SOME LAKES AROUND KOLHAPUR CITY MAHARASHTRA

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ABSTRACT- The present work was undertaken to determine the Water Quality Index (WQI) of some lakes around the Kolhapur district. It was observed that the water quality of Shiroli and Vadanage is very poor for human consumption, whereas water quality of Attigre and Pethvadagaon lake is good for human use.
Key Words: - Lakes, physicochemical parameters, Water Quality Index.

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INTRODUCTION

The lakes are one of the important water resources used for irrigation, drinking, fisheries and flood control purposes [15]. However the quality of lake water is difficult to evaluate from a large number of samples, each containing concentrations for many parameters [3]. On the other hand WQI is a very useful and efficient method for assessing the suitability of water quality [2]. It is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers [31]. WQI is defined as a rating reflecting the composite influence of different water quality parameters. It is calculated from the point of view of the suitability of surface water for human consumption [6]. It provides a single number (like grade) that expresses the overall quality of water at a certain location and time based on several water quality parameters [32].

The objective of the present work is to assess the physicochemical properties with respect to water quality index (WQI) of some lakes around Kolhapur city.

MATERIALS AND METHODS

Study area: The study area includes four lakes such as Attigre lake or Shahu Lake, Pethvadagaon lake or Mahalaxmi lake, Vadanage lake or Shiv Parvati lake, and Shiroli lake which is situated around Kolhapur city along with coordinates given as below.

Sites	'N' Latitude	'E' Longitude
Attigre	16°44.322'	074°22.227'
Pethvadagaon	16°48.966'	074°18.306'
Shiroli	16°44.473'	074°35.900'
Vadanage	16°43.855'	074°12.829'

The water samples were collected from these lakes for physicochemical analysis. Samples were taken for a period of the one year after seasonal interval.Water samples were collected in a clean polyethylene container. For each sampling event, temperature was monitored and dissolved oxygen was fixed at the sampling sites while pH, TDS, alkalinity, hardness, calcium, magnesium, chloride were analyzed in the laboratory by using standard methods described by [4 and 28].

Calculation of WQI

The WQI was calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO). Eleven important water parameters were considered for calculation of water quality index and it is also calculated by using the Weighted Arithmetic Index Method [8]. The quality rating scale for each parameter qi was calculated by using the following expression.

$qn = 100\times (Vn-Vi)/ (Vs- Vi)$

When Vn = actual amount of n^{th} parameter

Vi = Ideal value of the n^{th} parameter in pure water (i.e.0 for all parameters except pH and DO which are (7.0 and 14.6 mg/l respectively) [27].

Vs = Standard value of the n^{th} parameter.

Wn = k/Sn

Wn =unit weight for the n^{th} parameter.

Sn = 'n' number of standard values.

K = constant for proportionality.

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

$WQI = \sum qn\ Wn / \sum Wn$

Table 1-Water quality classification based on WQI values [10].

Water Quality Index	Classification
0-25	Excellent Water Quality
26-50	Good Water Quality
51-75	Poor Water Quality
76-100	Very Poor Water Quality
≥ 100	Unfit for drinking

Table 2- Drinking Water Standards recommending Agencies and unit weights. (All values except pH is in mg/L.)

Parameters	Standard values (S)	Recommended agency	Units	Unit Weights (Wn)
pH	6.2-8.5	ICMR/BSI	-	0.2190
TDS	500	ICMR/BSI	mg/lit	0.0037
Dissolved oxygen	5	ICMR/BSI	mg/lit	0.3723
Alkalinity	120	ICMR	mg/lit	0.0155
Hardness	300	ICMR/BSI	mg/lit	0.0062
Calcium	75	ICMR/BSI	mg/lit	0.025
Magnesium	30	ICMR/BSI	mg/lit	0.061
Chloride	250	ICMR	mg/lit	0.0074
TSS	500	WHO	mg/lit	0.0037
Sodium	200	ICMR/BSI	mg/lit	0.004118
Nitrates	45	ICMR/BSI	mg/lit	0.0413

RESULTS AND DISSCUSSION

Physicochemical parameters

In the present investigation air temperature ranges from 26.58^{0}C to 30.98^{0}C.The highest value of air temperature (30.98^{0}C) was recorded in Attigre lake and low (26.58^{0}C) in Vadanage lake. The value of water temperature ranges from 26.03^{0}C to 28.01^{0}C. It was minimized (26.03^{0}C) in Pethvadagaon lake and maximum (28.01^{0}C) in Attigre lake. Electric conductivity is very important parameter for determining the water quality for drinking and agricultural purpose [26]. The value of electric conductivity ranges from 0.30ms/cm to 1.40ms/cm. The highest value of electric conductivity was recorded in Shiroli lake and low in Pethvadagaon lake.

PH is the intensity of acidity or alkalinity of water. All chemical and biological reactions are directly dependent upon the pH of water system [20]. In the present study, the average value of pH in the four different lake water is acceptable and it varies from 7.34 to 7.82. In the present investigation all the values of pH were found within the ICNR standards (7.8 to 8.5). If the value of pH, low it tends to make the water acidic and higher pH provide taste complaint and negative impact on skin and eyes [21]. The total dissolved solids fluctuate from 211.66mg/l to 642mg/l. The maximum value (642mg/l) of TDS was observed in Shiroli lake and minimum value (211.66mg/l) of TDS in Pethvadagaon lake.

In the present investigation, the range of free carbon dioxide was recorded from 22.58mg/l to 52.21mg/l. The highest value (52.21mg/l) of free carbon dioxide was recorded in Shiroli lake and low (22.58mg/l) in Pethvadagaon lake. Dissolved oxygen plays an important role in aquatic ecosystems. It is regulated by the rate of dissolution of photosynthesis and community respiration [1]. The DO was varied from 2.39mg/l to 9.88mg/l. The DO found to be maximized (9.88mg/l) in Pethvadagaon lake and minimum (2.39mg/l) in Shiroli lake. In the present study the alkalinity value varied from 30.41mg/l to112mg/l. Mohan and Reddy (1995) recorded total alkalinity in the range of 36 mg/lit. to 216 mg/lit. from different sampling stations of Tirupati, Andhra Pradesh and the total alkalinity between 70 mg/lit. to 113.5 mg/lit. in a highly eutrophic temple tank of Bikaner, Rajasthan also reported by [7]. The maximum value of alkalinity was recorded in Shiroli lake and minimum in Pethvadagaon lake.

Table 3-Physicochemical parameters of some lakes around Kolhapur city.

		Name of Lakes			
S. no	**Parameters/Lakes**	**Attigre**	**Pethvadagaon**	**Vadanage**	**Shiroli**
1	Air temperature (^{0}C)	30.98±5.11	29.091±1.94	26.58±4.04	28.75±1.25
2	Water temperature(^{0}C)	28.01±4.09	26.033±2.28	26.15±3.07	26.66±2.33
3	Electric conductivity (ms/cm)	0.48±0.14	0.307±0.099	0.586±0.14	1.40±0.42
4	pH	7.34±0.22	7.82±0.71	7.63±0.22	7.63±0.083
6	Total dissolved solids (mg/L)	211.66±35.47	203.33±44.81	365±73.99	642±392.45
7	Free CO2 (mg/L)	32.853±6.73	22.586±6.16	23.39±0.99	52.21±12.10
8	Dissolved oxygen (mg/L)	9.88±2.45	10.8±2.41	2.39±0.43	3.40±3.55
9	Total alkalinity (mg/L)	47.416±6.87	30.41±0.52	45.91±9.85	112±16.98
10	Hardness (mg/L)	195.06±25.91	145.86±13.26	166.46±28.14	244.3±24.81
11	Calcium (mg/L)	38.15±5.16	26.13±0.95	26.54±4.70	47.58±4.34
12	Magnesium (mg/L)	24.34±3.54	19.65±3.71	24.42±8.70	28.95±2.84
13	Chloride (mg/L)	304.24±10.93	302.24±7.651	344.13±43.83	439.96±66.76
14	Total suspended solids (mg/L)	180±35	181.66±99.28	251.66±102.75	345±34.64
15	Sodium (mg/L)	23±5.16	17.41±2.23	34.25±9.63	49.4±38.49
16	Nitrates (mg/L)	0.6398±0.34	1.65±0.51	1.21±0.54	2.03±0.99

Hardness is the property of water, which prevents lather formation with soap and increases the boiling point of water [22]. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both [24]. It is important to measure for determining the usability of water for domestic, drinking and many industrial supplies [17]. In the present study the value of hardness ranges from 145.86 mg/l to 244.3mg/l. The highest value (244.3mg/l) of hardness was observed in Shiroli lake and low value (145.86mg/l) of hardness in Pethvadagaon lake. The calcium content fluctuates between 26.13mg/l to 47.58mg/l. The maximum value (47.58mg/l) of calcium was observed in Shiroli lake and minimum value (26.13mg/l) of calcium in Pethvadagaon lake. The magnesium value in studying areas ranged from 19.65mg/l to 28.95mg/l. Maximum value (28.95mg/l) of magnesium was found in Shiroli lake and minimum value (19.65mg/l) in Pethvadagaon lake.

Table 4-Water Quality Index (WQI) of Attigre lake

S. No	Parameters	Average(Vn)	Ideal Value(Vi)	Standard Value (S)	Unit Wt. Factor (Wn)	Quality rating (Qn)	(Qn*Wn)
1	pH	7.34	7	6.2-8.5	0.2190	22.66	4.9625
2	TDS	211.66	0	500	0.0037	42.332	0.15662
3	Dissolved oxygen	9.88	14.6	5	0.3723	49.1666	18.3047
4	Alkalinity	47.416	0	120	0.0155	39.51	0.6124
5	Hardness	195.06	0	300	0.0062	65.02	0.403124
6	Calcium	38.15	0	75	0.025	50.8666	1.2716
7	Magnesium	24.34	0	30	0.061	81.1333	4.9491
8	Chloride	304.24	0	250	0.0074	121.696	0.9005
9	TSS	180	0	500	0.0037	36	0.1332
10	Sodium	23	0	200	0.004118	11.5	0.047357
11	Nitrates	0.6398	0	45	0.0413	1.4217	0.058719
					∑Wn	**∑Qn**	**∑Qn Wn**
					0.75921	521.3062	31.79982
Water Quality Index(**WQI)=∑Qn Wn/∑Wn=** 41.885							

Table 5-Water Quality Index (WQI) of Pethvadagaon lake

S. No	Parameters	Average(Va)	Ideal Value(Vi)	Standard Value (S)	Unit Wt. Factor (Wn)	Quality rating (Qn)	(Qn*Wn)
1	pH	7.82	7	6.2-8.5	0.2190	54.66	11.97054
2	TDS	203.33	0	500	0.0037	40.666	0.15046
3	Dissolved oxygen	10.8	14.6	5	0.3723	39.583	14.7367
4	Alkalinity	30.41	0	120	0.0155	25.3416	0.3927948
5	Hardness	145.86	0	300	0.0062	48.62	0.301444
6	Calcium	26.13	0	75	0.025	34.84	0.871
7	Magnesium	19.65	0	30	0.061	65.5	3.9955
8	Chloride	302.24	0	250	0.0074	120.896	0.894630
9	TSS	181.66	0	500	0.0037	36.332	0.1344284
10	Sodium	17.41	0	200	0.004118	8.705	0.0358472
11	Nitrates	1.65	0	45	0.0413	3.6666	0.1514333
					∑Wn	**∑Qn**	**∑Qn Wn**
					0.75921	478.8102	33.634778
Water Quality Index(**WQI)=∑QnWn/∑Wn=** 44.302							

In the present investigation the value of Chloride recorded maximum in Vadanage and Shiroli lake. High concentrations of chloride are indicators of large amounts of organic matter in the water eutrophic condition by [25]. High amount of chloride influences the amount of dissolved oxygen in water bodies which may adversely affect the number of aquatic organisms, those are beneficial [23]. The value of TSS ranges from 180mg/l to 345mg/l in the Attigre and Shiroli lake. Sodium salts are highly soluble in water and Impart softness in contrast to hardness [18]. Highest sodium concentration (49.4mg/l) was found in Shiroli lake while the lowest (17.41mg/l) was recorded in Pethvadagaon lake. The concentration of nitrate was found within the acceptable limit of all lakes and was highest (2.03mg/l) in Shiroli lake and lowest (0.63mg/l) in Attigre lake.

Table 6-Water Quality Index (WQI) of Vadanage lake

S. No	Parameters	Average(Vn)	Ideal Value(Vi)	Standard Value (S)	Unit Wt. Factor (Wn)	Quality rating (Qn)	(Qn*Wn)
1	pH	7.63	7	6.2-8.5	0.2190	42	9.198
2	TDS	365	0	500	0.0037	73	0.2701
3	Dissolved oxygen	2.39	14.6	5	0.3723	127.18	47.3491
4	Alkalinity	45.91	0	120	0.0155	38.258333	0.59300
5	Hardness	166.46	0	300	0.0062	55.486	0.34401
6	Calcium	26.54	0	75	0.025	35.386	0.88465
7	Magnesium	24.42	0	30	0.061	81.4	4.9654
8	Chloride	344.13	0	250	0.0074	137.65	1.01861
9	TSS	251.66	0	500	0.0037	50.332	0.1862284
10	Sodium	34.25	0	200	0.004118	17.175	0.0707267
11	Nitrates	1.21	0	45	0.0413	2.6888	0.1110511
					∑Wn	**∑Qn**	**∑Qn Wn**
					0.75921	660.55613	64.990876
Water Quality Index(**WQI)=∑QnWn/∑Wn**= 85.60							

Table 7-Water Quality Index (WQI) of Shiroli lake

S. No	Parameters	Average(Vn)	Ideal Value(Vi)	Standard Value (S)	Unit Wt. Factor (Wn)	Quality rating (Qn)	(Qn*Wn)
1	pH	7.63	7	6.2-8.5	0.2190	42	9.198
2	TDS	642	0	500	0.0037	128.4	0.47508
3	Dissolved oxygen	3.40	14.6	5	0.3723	116.66	41.5710
4	Alkalinity	112.00	0	120	0.0155	93.3333	1.4466
5	Hardness	244.3	0	300	0.0062	81.4333	0.5048867
6	Calcium	47.58	0	75	0.025	63.44	1.586
7	Magnesium	28.95	0	30	0.061	96.5	5.8865
8	Chloride	439.96	0	250	0.0074	175.98	1.302252
9	TSS	345	0	500	0.0037	69	0.2553
10	Sodium	49.4	0	200	0.004118	24.7	0.1017146
11	Nitrates	2.03	0	45	0.0413	4.5111	0.1863089
					∑Wn	**∑Qn**	**∑Qn Wn**
					0.75921	895.9577	62.513642
Water Quality Index(**WQI)=∑Qn Wn/∑Wn**= 82.34							

Table 8- Water quality classification based on WQI of the lakes.

S.No	Lakes Name	WQI	Status of water
1	Attigre or Shahu lake	41.88	Good water quality
2	Pethvadagaon or Mahalaxmi lake	44.30	Good water quality
3	Vadanage or Shiv-Parvati lake	85.60	Very poor water quality
4	Shiroli lake	82.34	Very poor water quality

Assessment of Water Quality Index

In the present study WQI calculated by applying the values of the basic elements of actual measured values, water quality standard values (S), Relative (unit) weight (Wn), Quality rating (Qn) and weighted values in the corresponded equations. The different water quality parameters used for the assessment of water quality index [16]. In this study parameters for which standards are available like pH, TDS, dissolved oxygen, alkalinity, hardness, calcium, magnesium, chloride parameters for calculation of water quality index are shown in table 2. Lake wise WQI calculations are presented in the table 4, 5, 6 and 7. In this study, the WQI value is categorized into five different types for human consumption, according to [10] such as 0-20 excellent water quality, 26-50 good water quality, 51-75 poor water quality, 76-100 very poor water quality and ≥ 100 unfit for drinking.

In the present investigation Water Quality Index of Attigre and Pethvadagaon lake shows 41.88 and 44.30 respectively, which indicates good quality of water. Kumari and Chaurasia, (2015) were founded similar type of result in Sai Rive. Arya and Zaidi (2014) were observed values of WQI in the range of 26-50 in Kanpur city. On the basis of these above result the status of the Attigre and Pethvadagaon lake are found to be suitable for human uses according to WHO guideline standards [19].

In the present study water quality index of Vadanage and Shiroli lake was observed in the range of (76-100). Gajendran and Jesumi. (2013) were found this type of result in Cauvery river basin. The values of WQI obtained in these lakes are 87.25 and 91 respectively, which indicates very poor quality of water. Similar type of observation was found by other workers, in the Qulyasan stream by Salih *et.al*., (2012) and at the Vivekanand server by Jena *et.al*., (2013). On the basis of above result the water quality of both the lake was unsuitable or unfavorable for the human uses during the period of one year [11].

CONCLUSION

In the present investigation, on the basis of Water Quality index standard the studied lakes indicated good to very poor quality of water. Hence, it is concluded that the studied water bodies are not safe for direct human consumption.

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