

Eutrophication Status and Water Quality Index of Lakes at South Belgaum

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ABSTRACT: The water bodies are facing a severe threat of pollution all over the world. To ensure fresh water availability from the local water sources has become a big challenge. Water eutrophication in lakes is widespread all over the world and the severity is increasing, especially in the developing countries like India. The main objective is to assess the eutrophication status and Water Quality Index of various lakes situated in South Belgaum. The samples were collected from December, 2013 to May, 2014. The physicochemical characteristics of water samples like pH, turbidity, alkalinity, total hardness, total dissolved solids, nitrates, chlorides, electrical conductivity, sodium, potassium, phosphorous, dissolved oxygen, BOD etc., were analyzed in order to determine the level of contaminants present in lake water.

KEYWORDS: Carlson's Trophic State Index, Water Quality Index, Lakes.

I. INTRODUCTION

Water is a precious natural resource and is essential for a multiplicity of purposes. It constitutes about 70% to 90% of all living cells. Freshwater is utilized for drinking, several domestic and household purposes, industrial cooling, power generation, irrigation, and waste disposal. Today, in almost all spheres of human activity, a far larger amount of water is drawn out than what is actually required. Due to careless and excessive uses, a major bulk of water is drained out in an impure state as waste. At many places in India, clean water is no longer available for domestic uses. However, reckless overconsumption, misuse, pollution, eutrophication, and depletion of the underground water table are the actual causes of degeneration of freshwater.

Lakes are generally defined by stagnant water body surrounded by land. The hydrologic status of water of a lake in terms of quality, quantity and regime is a result of complex processes of physical, chemical and biological inputs. The physical features include wind, terrain relief, water current, temperature; light level etc. The chemical environment consists of water, gases like oxygen, minerals, trace metals and other complex chemicals.

Eutrophication is the Earth's most widespread water quality problem. It causes harmful algal blooms, fish kills and many related problems both in fresh waters and in coastal seas that are adjacent to areas with large human populations. Eutrophication is the process whereby water bodies become enriched by nutrients (Phosphorus and Nitrogen) from both external and internal sources. To assess the eutrophication status of lake, Carlson's Trophic State Index method is adopted in this study. The trophic status refers to the level of productivity in a lake as measured by phosphorous, algae abundance and depth of light penetration.

Water Quality Index (WQI) is a useful statistical tool for simplifying, reporting and interpreting complex information obtained from any body of water. A simple number given by any WQI explains the level of water contamination. A water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number.

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II. STUDY AREA

Belgaum is located at 15.870 N, 74.500E. The city is located at an elevation of 747.47 m above Mean Sea Level (MSL). The city is situated in the north western parts of Karnataka and lies at the border of two states, Maharashtra and Goa. Belgaum is coldest in winter and experiences continuous monsoon during June to September. The annual average rainfall is over 1200 mm. Belgaum City Corporation has been divided into two parts depending on the functioning purposes namely North Belgaum and South Belgaum. The study area is restricted to South Belgaum. The lakes are selected on the basis of the usage and inflow sources. The local people use these lakes to dump the solid waste. For the same reason the following lakes which are mentioned below are selected and seasonal analysis of these lakes were carried out from December 2013 to May 2014.

Fig 1 shows the lakes at South Belgaum and yellow mark indicates the sampling points. Fig 1(a) shows Yellur lake (b) Vadgaon lake (c) Machee lake (d) Khadarwadi lake

Yellur lake is influenced mainly by terrestrial inputs from the nearby agricultural land and anthropogenic activities from the residential areas developed around the lake.

Vadgaon lake has an area of 4.56 hectares. The lake is situated in front of lakshmi temple and the lake is used for disposal of waste generated from that temple. The lake receives agricultural runoff from adjacent fields.

Machee lake water is used for washing of cloths, animals, vehicles. The lake receives agricultural runoff from adjacent fields. The local people use the lake for the immersion of idols during festivals and also they dump the solid waste.

Khadarwadi lake has an area of 10.93 hectares. The lake water is used for washing of cloths, animals, vehicles and the local people dispose the solid waste. The lake receives agricultural runoff from adjacent fields.

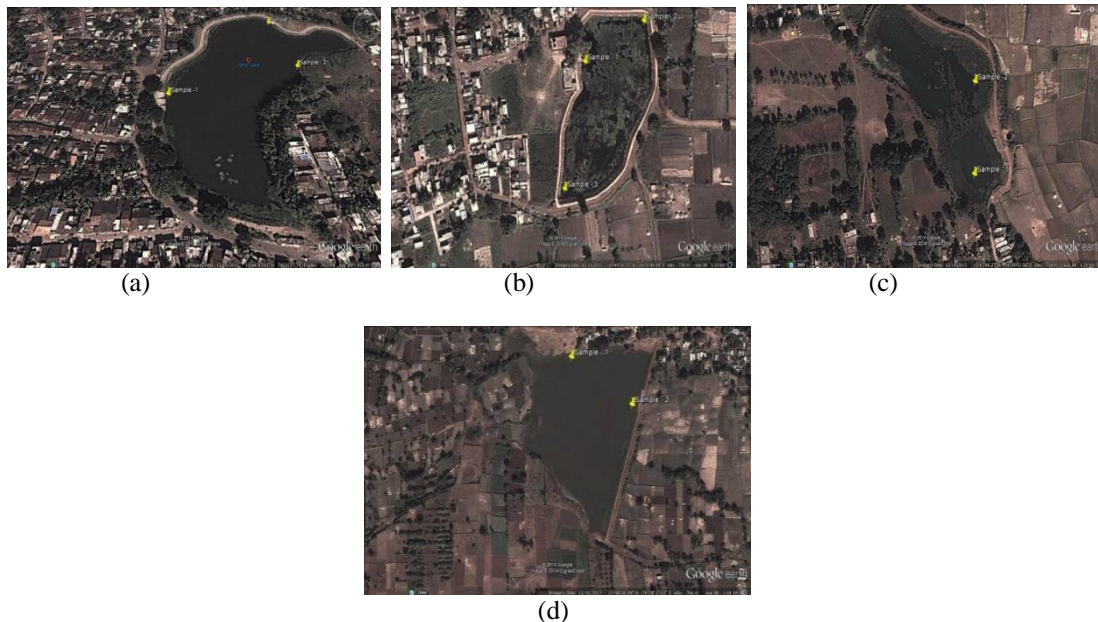


Fig 1. Lakes and its sampling points (a) Yellur lake (b) Vadgaon lake (c) Machee lake (d) Khadarwadi lake

Fig 1 shows the lakes in South Belgaum namely, Yellur lake, Vadgaon lake, Machee lake and Khadarwadi lake and the lake water samples were rich in organic matter.

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III. MATERIALS AND METHODOLOGY

Collection of samples: The sampling is fixed for six months i.e., from December 2013 to May 2014. Samples are being collected periodically at the second week of every month during morning hours between 9am to 1pm. The samples were collected in 1 litre bottles and analysed for various physicochemical parameters. The parameters such as pH, total dissolved solids, turbidity, total alkalinity, total hardness, chlorides, nitrates, phosphorous, sodium, potassium dissolved oxygen and biological oxygen demand were analysed in the laboratory as per the standard procedures of APHA.

Assessment of Trophic State Index: The trophic status refers to the level of productivity in a lake which is measured with the reference by phosphorous, nitrogen, and transparency etc., TSI values can be used to rank the lakes within a region and between the regions. Carlson's Trophic Status Index is the most important and popular TSI method selected for the present study. On the Carlson's scale if TSI is < 30 and 30 – 40 represents oligotrophy, from 40 to 50 represents mesotrophy, from 50 to 70 eutrophy and > 80 hyper eutrophy. The following equations are used to compute the Carlson's TSI.

$$TSI - P = 14.42 * \ln [TP] + 4.15 \text{ (in mg/L)}$$

$$TSI - \text{Chl-a} = 30.6 + 9.81 \ln [\text{Chl-a}] \text{ (in ug/L)}$$

$$TSI - SD = 60 - 14.41 * \ln [SD] \text{ (in meters)}$$

$$\text{Average TSI} = [TSI (P) + TSI (\text{Chl-a}) + TSI (SD)]/3$$

Where, TP is Total Phosphorus, chl-a is Chlorophyll-a, SD the Secchi Depth.

Table 1: Carlson's Trophic State Index values and classification of lakes

TSI Values	Trophic status	Attributes
< 30	Oligotrophic	Clear water, oxygen throughout the year in the hypolimnion
30 - 40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40 – 50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50 – 60	Eutrophic	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60 – 70	Eutrophic	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70 – 80	Eutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Eutrophic	Algal scum, summer fish kills, few macrophytes

Calculation of WQI: The Water Quality Index was calculated using Weighted Arithmetic Index method. In this study, for the calculation of WQI, eight parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). Further, quality rating or sub index (q_n) was calculated using the following expression.

$$q_n = 100 \times (V_n - V_{io}) / (S_n - V_{io})$$

where, q_n = Quality rating for the n^{th} water quality parameter.

V_n = Estimated value of the n^{th} parameter at a given sampling station.

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

V_{io} = Ideal value of n^{th} parameter in pure water. (i.e., 0 for all other parameters expect the parameter pH and dissolved oxygen)

Calculation of quality rating for pH and dissolved oxygen:

For pH the ideal value is 7.0 and permissible limit is 8.5. Therefore, the quality rating for pH, is calculated from the following relation:

$$q_{pH} = 100[(V_{pH} - 7.0) / (8.5 - 7.0)]$$

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For DO the ideal value is 14.6 mg/l and standard permissible value is 5 mg/l. Therefore, quality rating is calculated from the following relation:

$$q_{DO} = 100[(V_{DO} - 14.6) / (5 - 14.6)]$$

Unit weight is calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$$W_n = K / S_n$$

Where, W_n = Unit weight for the n^{th} parameters.

S_n = Standard value for n^{th} parameters.

K = Constant for proportionality.

Table 2: Water Quality Index (WQI) and status of water quality

Water Quality Index Level	Water Quality Status
0 – 25	Excellent water quality
26 – 50	Good water quality
51 – 75	Poor water quality
75-100	Very poor water quality
>100	Unsuitable for drinking

IV. RESULTS AND DISCUSSIONS

Trophic State Index is the most commonly used method for classification of lakes and is based on the productivity of the water body. Carlson's Trophic State Index (TSI) is a common method for characterizing a lake's trophic state or overall health. This method uses Secchi's disc transparency (SD), chlorophyll-a, and phosphorus (P) measurements. Trophic state is defined as the total weight of the biomass in a water body at a specific location and time.

Table 3: TSI values for Yellur lake

SI No.	Parameters	Dec	Jan	Feb	March	April	May	Average
1	TSI of P	16.59	12.80	8.68	11.88	17.87	19.99	14.635
2	TSI of SD	68.61	68.96	73.94	72.84	71.41	71.63	59.8
3	TSI of Chl-a	33.397	33.323	32.38	29.26	35.63	40.23	34.871
4	CTSI	39.53	38.361	38.23	37.99	41.63	43.95	36.43

The average CTSI has shown that Yellur lake is oligotrophic. According to the indices though Yellur lake is oligotrophic, it has a tendency of becoming anoxic during April and May recording the CTSI value of 41.63 and 43.95.

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Table 4: TSI values for Vadgaon lake

Sl No.	Parameters	Dec	Jan	Feb	March	April	May	Average
1	TSI of P	5.91	9.99	11.28	12.30	8.04	13.70	10.20
2	TSI of SD	64.73	66.43	64.53	66.20	62.51	63.39	64.64
3	TSI of Chl-a	49.052	49.21	50.58	51.145	50.14	50.99	50.186
4	CTSI	39.87	41.87	42.13	43.215	40.23	42.69	41.66

As shown in table 4, the average CTSI has shown that Vadgaon lake is mesotrophic. The lake water under this category will be moderately clear and there is increasing probability of anoxia. This may be attributed to the scanty rain fall and dwindling of water level in the lake which has enhanced the nutrients concentrations. This may be due to continuous inflow of nutrients from the neighbouring crop fields which in turn enhances the growth of phytoplankton.

Table 5: TSI values for Machee lake

Sl No.	Parameters	Dec	Jan	Feb	March	April	May	Average
1	TSI of P	11.54	10.97	10.46	8.26	11.54	13.81	11.09
2	TSI of SD	62.34	63.21	65.55	64.93	64.33	63.39	63.96
3	TSI of Chl-a	43.69	44.65	41.762	40.822	45.11	44.977	43.50
4	CTSI	39.19	39.61	39.25	38.0	40.32	40.72	39.515

The average CTSI has shown that Machee lake is oligotrophic. According to the indices though Machee lake is oligotrophic, it has a tendency of becoming anoxic during April and May recording the CTSI value of 40.32 and 40.72.

Table 6: TSI values for Khadarwadi lake

Sl No.	Parameters	Dec	Jan	Feb	March	April	May	Average
1	TSI of P	13.13	12.07	11.66	10.46	11.544	13.106	11.99
2	TSI of SD	73.56	73.94	78.34	76.87	75.12	77.34	75.86
3	TSI of Chl-a	32.78	30.50	29.45	28.77	29	37.151	31.27
4	CTSI	39.82	38.83	39.81	38.7	32.55	42.532	38.707

Table 6 showed that the average CTSI for Khadarwadi lake is 38.707 and hence the lake is oligotrophic. According to the indices though Khadarwadi lake is oligotrophic, it has a tendency of becoming anoxic during May as CTSI value for the month was 42.532.

Water Quality Index: Water quality index is defined as a rating reflecting the composite influence of a number of water quality parameters. It provides a convenient means of summarizing complete water quality data. Water quality index developed for the surface water samples indicate that there is a wide variation from lake to lake. Application of WQI in

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this study has been found useful in assessing the overall quality of water. It is also helpful for public to understand the quality of water.

The Water Quality Index for Yellur lake were evaluated using average values of all the readings for various parameters obtained during the study period are given in table 8. From the Water Quality Index results obtained for Yellur lake it is evident that the water quality is very poor.

Table 8: Water quality index for Yellur Lake

SL. No	Parameters	Observed value	Standard values (S _n)	Unit weight (W _n)	Quality rating (q _n)	W _n × q _n
1	pH	7.95	6.5 – 8.5	0.2190	63.333	13.8692
2	TDS	368.89	500	0.0037	73.778	0.2729
3	Total alkalinity	292.67	200	0.0093	146.335	1.36
4	Total hardness	171.67	300	0.0062	57.2233	0.3547
5	Chlorides	81.134	250	0.0074	32.4536	0.2401
6	Nitrate	3.738	45	0.0412	8.3066	0.3422
7	Dissolved oxygen	6.75	5	0.3723	81.77	30.44
8	BOD	3.61	3	0.62	120.34	74.610
				∑W _n = 1.2791	∑q _n = 583.539	∑W _n ×q _n = 121.48
Water quality index = $\frac{\sum W_n \times q_n}{\sum W_n} = 94.98$						

The Water Quality Index for Vadgaon lake were evaluated using the average values of all the readings for various parameter obtained during the study period are given in table 9. From the Water Quality Index results obtained for Vadgaon lake, it is evident that the water quality is very poor.

Table 9: Water quality index for Vadgaon Lake

SL. No	Parameters	Observed value	Standard values (S _n)	Unit weight (W _n)	Quality rating (q _n)	W _n × q _n
1	pH	7.891	6.5 – 8.5	0.2190	59.4	13.0086
2	TDS	507.226	500	0.0037	101.4452	0.3753
3	Total alkalinity	117.003	200	0.0093	58.5015	0.544
4	Total hardness	223.89	300	0.0062	74.63	0.4627
5	Chlorides	160.225	250	0.0074	64.09	0.4742
6	Nitrate	3.00	45	0.0412	6.667	0.2746
7	Dissolved oxygen	4.817	5	0.3723	101.90	37.937
8	BOD	3.219	3	0.62	107.3	66.526
				∑W _n = 1.2791	∑q _n = 573.933	∑W _n ×q _n = 119.602
Water quality index = $\frac{\sum W_n \times q_n}{\sum W_n} = 93.50$						

The Water Quality Index for Machee lake were evaluated using the average values of all the readings for various parameter obtained during the study period are given in table 10. From the Water Quality Index results obtained for Machee lake, it is evident that the lake water is unfit for human consumption.

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Table 10: Water quality index for Machee Lake

SL. No	Parameters	Observed value	Standard values (S _n)	Unit weight (W _n)	Quality rating (q _n)	W _n × q _n
1	pH	7.7691	6.5 – 8.5	0.2190	51.273	11.2287
2	TDS	142.5	500	0.0037	28.5	0.10545
3	Total alkalinity	70.5	200	0.0093	35.25	0.3278
4	Total hardness	74.334	300	0.0062	24.778	0.1536
5	Chlorides	42.443	250	0.0074	16.9772	0.1256
6	Nitrate	3.62	45	0.0412	8.044	0.3314
7	Dissolved oxygen	4.195	5	0.3723	108.385	40.351
8	BOD	7.541	3	0.62	251.366	155.84
				∑W _n = 1.2791	∑q _n = 524.57	∑W _n ×q _n = 208.4635
Water quality index = $\frac{\sum W_n \times q_n}{\sum W_n} = 162.97$						

The Water Quality Index for Khadarwadi lake were evaluated using the average values of all the readings for various parameter obtained during the study period are given in the table 11. From the Water Quality Index results obtained for Khadarwadi lake, it is evident that the water quality is very poor.

Table 11: Water quality index for khadarwadi Lake

SL. No	Parameters	Observed value	Standard values (S _n)	Unit weight (W _n)	Quality rating (q _n)	W _n × q _n
1	pH	8.1634	6.5 – 8.5	0.2190	77.56	16.9856
2	TDS	159.167	500	0.0037	31.8334	0.1177
3	Total alkalinity	187.334	200	0.0093	93.667	0.8711
4	Total hardness	126.33	300	0.0062	42.11	0.2610
5	Chlorides	44.925	250	0.0074	17.97	0.1329
6	Nitrate	3.551	45	0.0412	7.8911	0.3251
7	Dissolved oxygen	5.605	5	0.3723	93.6979	34.8837
8	BOD	2.167	3	0.62	72.233	44.78
				∑W _n = 1.2791	∑q _n = 436.962	∑W _n ×q _n = 98.3571
Water quality index = $\frac{\sum W_n \times q_n}{\sum W_n} = 76.895$						

V. CONCLUSION

Based on the experimental results obtained, the following conclusions have been drawn.

1. From the results obtained, it can be concluded that the lake is polluted due to continuous discharge of solid waste and from the agricultural runoff.
2. Based on the Carlson's Trophic State Index,
 - Lakes at Yellur, Machee and Khadarwadi lake are classified as oligotrophic.
 - Vadgaon lake is classified as mesotrophic.
3. Lakes of Yellur, Machee and Khadarwadi tend to get into mesotrophic state during summer giving rise to anoxic conditions at lake.
4. From the WQI values obtained during the study,

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- Machee lake has WQI value greater than 100, which means the water from lake is unsuitable for human consumption.
- The WQI values for water of Yellur, Vadgaon and Machee lakes are 94.98, 93.50 and 76.89 respectively, which means that the water is of very poor quality.

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