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WATER QUALITY ASSESSMENT OF KAYAMKULAM LAKE, KERALA, INDIA

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ABSTRACT

The present investigation was carried out in Kayamkulam Lake near National Thermal Power Corporation (NTPC) industrial area, Alappuzha district, Kerala, India, with regard to various Physico -chemical parameters like surface water Temperature, pH, Total Alkalinity (TA), CO_2, Dissolved oxygen(DO), Chloride, Total Hardness (TH), Calcium, Phosphate, Sulphate, Nitrate Biochemical Oxygen Demand(BOD), Chemical Oxygen Demand (COD), Silicate and heavy metals viz., Iron, Lead, Zinc, Cadmium and Copper. Monthly variations in physico- chemical parameters were recorded. Surface water Temperature varied from 29.6 to 37°C, the pH values decreased up to 6.3 and it reached below the permissible limit at site II. The Total Alkalinity of lake water ranged from 20 to160 mg/l and it reached beyond the permissible limit of 120 mg/l. The DO falls up much lower than the desirable limit at site II. The average value of BOD reached beyond the permissible limit at site II . The chloride concentration varied from 47 to1127 mg/l and concentration reaches beyond the permissible limit. The TH of the lake water ranged from 26 to1112 mg/l. Sulphate concentration of the lake water lie within the permissible limit. Heavy metal analysis revealed that sites II and III are much polluted than site I .Results of the study showed that the lake water is not suitable for irrigation and domestic purpose without proper treatment. The results are discussed in the text.

KEY WORDS: Water quality, NTPC, Physico chemical parameters

INTRODUCTION

All aquatic organisms require a healthy environment with sufficient nutrients for their growth and existence. With the advent of industrialization, population growth and urbanization demands for higher quantity of water with good quality have increased. It increases the pressure on natural ecosystems. The natural aquatic bodies have been used as places for dumping of wastes which caused serious changes in physico-chemical properties of these aquatic bodies and resulted in environmental pollution. Therefore the characterization of water quality is very essential before using any water for day-to-day life. A systematic water quality monitoring plan will deliver basic scientific information about ecologically related toxicological threshold values to protect specific our natural aquatic ecosystems.

Several works have documented the water quality profile of major water bodies of India. (Sundary *et al.,* 2006; Mandal *et al.,* 2009; Prasanna and Ranjan, 2010; Perumal *et al.,* 2016; Sanjaya Kumar *et al.,* 2019; Himani *et al.,* 2020). However very little information is available in relation to Physico-chemical characteristics of Kayamkulam lake (Mary John, 1958; Prabha Devi *et al*., 1996; Remya Krishnan and Jaya., 2014; Dhanya *et al.,* 2017). So the present study was undertaken to characterize the water quality of Kayamkulam lake with respect to different hydrographical parameters.

MATERIALS AND METHODS

The investigation was carried out by selecting three sites from Kayamkulam Lake. The lake stretches

about 24 km along Kollam and Alappuzha districts. Pamba and Achankovil rivers flow into the Lake. The first sampling site (**SI**) is at Karthikappally. Second sampling site (**S II**) is at the effluent discharge point from NTPC and it is 4.5 Km away from the first site. Third sampling site (**S III**) is at Kanakakunnu and there is domestic waste discharge in this area. This site is located approximately 5 Km away from the second site.

The water samples were collected at an interval of one month for a period of two years from October 2015 to September 2017 between 9.30 to 10.30 am. Surface water temperature was measured at the sampling site itself using Mercuric thermometer. Samples for dissolved oxygen and BOD were fixed at the sampling site immediately after collection following Winkler method. Remaining parameters were analyzed in the laboratory within 8 hours by following standard methods (APHA, 2005).

RESULTS AND DISCUSSION

Table 1. Range, Average and Standard deviation of hydrographic parameters at three sites of Kayamkulam Lake during the period from October 2015 to September 2017.

The Physico-chemical parameters of the three selected sites of Kayamkulam Lake showed variations. The results obtained from the analysis of water quality parameters are shown in Table 1. The surface water temperature of the Kayamkulam Lake ranged from 27 to 31 ºC. The highest temperature (31°C) was recorded at site II in March 2016 and this may due to the increased solar radiation, low rainfall and stagnant condition as observed by Anilakumary (2016). The lowest Surface water temperature of 27 ºC was recorded at site I in July 2016. Monthly variations of water temperature showed a decline as the southwest and north east monsoon period progressed. Water with temperature above 30ºC is unfit for public use (Zajic, 1971). In the present study the average values were less than 30°C at all the three sites. The pH of lake water at sites I and III are remained alkaline throughout the study. But at site II the pH values decreased up to 6.3 during June 2016 and it is below the permissible limit (WHO, 1993). The lower pH values recorded during rainy months can be attributed to the influx of river water and acidic effluent discharged from NTPC. The maximum value of 7.6 was noted during the months of February and April 2017 at Site I.

Phenolphthalein alkalinity (PA) was completely absent in all the three sites of Kayamkulam lake. The total alkalinity showed considerable variations between months and stations. The Total Alkalinity (TA) of lake water ranged from 20 to160 mg/l. The highest value (160 mg/l) was observed at site III in April 2017 and is beyond the permissible limit of 120 mg/l. At all the three sites the higher values were recorded in months of February, March and April. Alkalinity above 100 mg/l is considered highly productive and less than 50 mg/l as oligotrophic as

Sl		SITE I			SITE II			SITE III		
No	Parameters*	Range	Average	SD	Range	Average	SD	Range	Average	SD
1.	Surface water temperature (°C)	27-28.6	27.6	0.441	27.4-31	29.02	1.03	27.4-29.6	28.39	0.53
2.	pH	7.1-7.6	7.3	0.140	6.3-7.3	6.8	0.29	6.8-7.5	7.1	0.187
3.	Total Alkalinity	41-140	90.08	32.70	20-110	73.2	21.85	44-160	106.7	30.73
4.	Phenolphthalein alkalinity	0-0	0	0	0-0	0	0	0-0	0	0
5.	Free CO_2	3.6-10.6	6.4	2.16	1.2-5.7	3.2	1.10	4.5-13.5	9.5	2.04
6.	Dissolved Oxygen	4-7.1	5.5	0.84	1.8-3.4	2.5	0.46	2.1-6.3	4.4	1.49
7.	Chloride	47-673	190.8	195.6	47-970	222.2	232.8	53-1127	274.9	280
8.	Total Hardness	26-350	136.9	95.46	47-1112	268.7	276	30-415	164.04	114.1
9.	Calcium	10.6-120	60.10	34.61	18.2-196	74.2	45.6	13.4-135	70.65	33.18
10.	Phosphate	0.11-1.72	0.79	0.49	1.3- 4.1	2.42	0.67	0.9-3.6	2.04	0.62
11.	Sulphate	26-63	43.8	10.06	77-93	84.3	4.77	83-103	93.9	5.41
12.	Nitrate	0.16-0.85	0.49	0.233	0.4-3.9	2.1	0.98	0.26-1.5	0.66	0.413
13.	BOD	1.9-3.3	2.56	0.354	4.3-8.5	6.11	1.28	2.1-5.2	3.75	0.917
14.	COD	39-63	51.3	6.44	163-256	207.2	28.2	54-79	65.08	6.93
15.	Silicates	3.6-12.2	7.6	2.76	8.1-23.5	15.8	4.79	5.1-13.4	10.6	2.74
16.	Iron	0.08-0.28	0.17	0.047	0.1-0.39	0.26	0.085	0.1-0.36	0.23	0.086

*All parameters except Temperature and pH are expressed in mg/l

per the study reports from Valanthakad backwater (Meera and Nandan, 2010). Here the TA falls up to 20 mg/l at site II in August 2017. The free CO_2 of the lake water ranged from 1.2- 13.5 mg/l. At all the three stations the maximum values were observed during non monsoon months and minimum values were observed during the period of June to September. The higher values during pre -monsoon may be due to high temperature which favours decomposition of organic matter and there by release CO_2. The warm temperature also increases the metabolism of all organisms and their respiration rate is high during pre- monsoon months as observed by Vishnu (2005).

Dissolved Oxygen (DO) of the lake water ranged from 1.8 to 7.1 mg/l. The maximum DO of 7.1 mg/l was recorded at site I in July 2016 and it fall up to 1.8 mg/l at site II in March 2016. The higher values from June to September were due to heavy rain fall and the resultant mixing of fresh water from Pamba and Achankovil River. At site II the DO concentrations during non monsoon months fall beyond the permissible limit (WHO, 1993). This can be attributed to the presence of industrial effluent from NTPC. Biochemical Oxygen Demand (BOD) ranged from 1.9 to 3.3 mg/l with an average value of 2.56 mg/l at site I, 4.3 to 8.5 mg/l with an average value of 6.11 mg/l at site II and at site III it ranged from 2.1 to 5.2 mg/l with an average value of 3.75 mg/l. The BOD values of site II were higher than the remaining stations. At site II all the observed BOD values of second year of study were beyond the permissible limit of 5 mg/l (WHO, 1993). The Chemical Oxygen Demand (COD) values varied from 39 to 63 mg/l with an average value of 51.3 mg/l, 163 to 256 mg/l with an average value of 207.2 mg/l and from 54 to 79 mg/l with an average value of 65.08 mg/l at sites I, II and III respectively. According to BIS (1991) the maximum permissible limit of COD for the discharge of effluent into the surface water is 250 mg/l. The site II of the kayal is characterized by higher COD than the other sites with maximum concentration of 256 mg/l in May 2017. This may be due to the discharge of industrial effluent from the NTPC. The lower value of 39 mg/l was recorded from site I in November, 2015.

The estimated average values of phosphate were 0.79, 2.42 and 0.62 in the lake water at sitess I, II and III respectively. According to WHO (1993) the maximum permissible limit of phosphate in drinking water is 0.1 mg/l. The phosphate concentration was much higher and exceeded the maximum permissible limit at all the three sites. The sulphate concentration ranged from 26 to 63 mg/l with an average of 51.3 mg/l at site - I, 163 to 256 mg/l with an average of 207.2 mg/l at site - II and 54 to 79 mg/l with an average of 65.08 mg/l at site - III. The values of all the samples were found within the maximum permissible limit of 400 mg/l (BIS, 1991). The average values of nitrate were 0.49, 2.1 and 0.66 mg/l at sites - I, II and III respectively. The nitrate values of the samples were found to be within the permissible limit of 50 mg/l given by WHO (1993).

Chloride concentration ranged from 47 to 673 mg/l with an average of 190.8 mg/l at site I, from 30 to 415 mg/l with an average of 222.2 mg/l at site II and from 53 to 1112 mg/l with an average of 268.7 mg/l at site III. At site III the chloride concentration reached beyond the permissible limit of 250 mg/l (WHO, 1993) during dry months indicating pollution load of the Lake. The Total Hardness (TH) of the lake water ranged from 26 to1112 mg/l. The highest value of 1112 mg/l was observed in April 2017 at site II and the lowest of 26 mg/l was noted in August 2016 at site I. TH of water increases due to industrial discharge of effluent and also due to run off fertilizers from agricultural lands. TH decreases with the onset of monsoon. TH of the lake water is comparatively higher during the second year of study and it reached beyond the permissible limit of 300 mg/l (WHO, 1993) at site II and III during summer months. The average values of silicate were 7.6 mg/l in at site I, 15.8 mg/l at site II and 10.6 mg/l at site III. Silicate concentration was higher at site II compared to other stations. The lower concentration of 3.6 mg/l was noted at site - I in March 2017. The Calcium concentration ranged from 10.6 to 196 mg/l. The highest value of 196 mg/l was observed from site - II in May 2016 and the lowest of 10.6 was from site I in August 2017. At all the three sites the maximum values were recorded during non - monsoon months. These higher values may be due to the fall of water level, increased rate of evaporation and higher rate of decomposition of organic matter. Remya and Jaya (2014) also reported higher concentration of calcium from Kayamkulam lake.

The chronic exposure to heavy metals at low levels causes adverse effects on environment (Showkat *et al*., 2019). Heavy metals were analysed only once in each season and the average values are summarized in Table-2. The iron content in lake water at sites- I, II and III were 0.18, 0.39 and 0.14

respectively. Its concentration at all the three sites exceeded the permissible limit of 0.1 mg/l (WHO, 1993). The lead content at sites II and III were 0.4 and 0.1 mg/l respectively. It was below detectable limit at site I. At site II its concentration exceeded the maximum permissible limit of 0.1 mg/l given by WHO (1993).

The cadmium content was below detectable limit at sites - I and III. At site II, its concentration (0.6 mg/l) exceeded the permissible limit of 0.01 mg/l (WHO, 1993). The concentration of Zinc was 0.1 mg/l at site I 0.8 at site II and 0.4 at site III. All these values are within the permissible limit (5.0 mg/l). The copper content at site I was below detectable limit, but it was detected at sites II (1.3 mg/l) and III (0.1 mg/l).

Table 2. Heavy metals (mg/l) concentration at three sites of Kayamkulam Lake

Heavy metals	Site I	Site II	Site III
Iron	0.18	0.39	0.14
Lead	BDL	0.4	0.1
Cadmium	BDL	0.6	BDL
Zinc	0.1	0.8	0.4
Copper	BDL	1.3	0.1

BDL = Below detectable level

Water quality index (WQI): Ten parameters viz., pH, total alkalinity, total hardness, DO, BOD, COD, chloride, iron, phosphate and nitrate were used for the calculation of WQI. The calculated values are given in Table 3. In the present study application of WQI gives a comparative account of water quality of three selected sites of Kayamkulam Lake. The WQI values were 140.58, 180.42 and 155.15 for sites - I, II and III respectively. All these values indicated that the lake water is not suitable for domestic and drinking purpose and proper treatment should be taken before use. The index value was maximum at second site. The higher WQI values in the lake water can be attributed to the continuous discharge of industrial effluent from NTPC.

Table 3. The calculated sub index ($q_n w_n$) values of different parameters and water quality index of lake.

Parameters	Sub index ($q_n w_n$) values		
	Site I	Site II	Site III
pH	12.38	13.68	12.1
TA	0.46	0.58	0.49
TH	0.15	0.19	0.17
DO	12.12	12.31	11.9
BOD	25.6	31.24	28.63
COD	10.55	16.03	15.9
Iron	21.07	28.06	24.03
Phosphate	58.1	77.56	61.3
Nitrate	0.13	0.29	0.21
Chloride	0.024	0.48	0.42
Water quality index	140.58	180.42	155.15

All the three sites of Kayamkulam Lake exhibited high phosphate, nitrate, total hardness, calcium, silicate, BOD and COD which are sourced to industrial wastes being discharged into the lake water. Heavy metal analysis revealed that the second and third sites are highly polluted than the first site. The values of TA, TH, Chloride phosphate and COD exceeded the permissible limit especially at site II and also DO was much lower than the desirable limit at site II. Hence the lake water at all the three sites are unsuitable for domestic purpose and proper treatment should be taken before use.

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