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Water Quality Assessment of Sasthamcotta Lake, Kollam, Kerala

Divya Raj S, K Mophin Kani

Abstract*: Sasthamcotta Lake is the largest natural fresh water lake in Kerala, known as "Queen of Lakes". This lake is located in Kollam district between 9º 0'- 9º 5' N latitude and 76º 35'- 76º 46' E longitude at an elevation of 33m above MSL. This lake has an area of 373 ha and volume of 22.4 km^3. It is one of the 26 sites in India included in the Ramsar list of wetlands of international importance. The Sasthamcotta Lake is a drinking water source for about 700000 people lived in Kollam District and is also one of the major tourist attraction places. Inland navigation and fishing are the major economical based activities takes place in this lake. This lake is facing degradation due to anthropogenic activities such as directing human waste, soil erosion due to destruction of vegetation, construction activities etc leading to the deterioration of environmental quality as well as decrease in the surface area and depth. The present study was carried out to assess the physico chemical and biological quality of water in Sasthamcotta Lake. In this study 16 water quality parameters were analyzed for water samples collected from 27 sampling points. The results showed water quality deterioration during the months of November and December 2017 whereas in January and February 2018 slight improvement in water quality. An observation of present study helps to increase the effectiveness of management strategies to bringing back the originality of the lake.

***Index Terms*: Sasthamcotta, Physic Chemical Parameters, Ramsar Lists, Degradation, Water Quality Assessment.**

I. INTRODUCTION

Water is an essential component for survival of life on earth, which contains minerals, important for humans as well as for world and aquatic life. Lakes and surface water reservoirs are the planet's most important freshwater resources and provide in numerable benefits. They are used for domestic and irrigation purposes and provide ecosystems for aquatic life especially fish, thereby functioning as a source of essential protein and for significant elements of the world's biological diversity [1].They have important social and economic benefits as a result of tourism and recreation, and are culturally and aesthetically important for people throughout the world. They also play an equally important role in flood control. However, the remarkable increase in population resulted in a considerable consumption of the water reserves worldwide. The quality of surface water is largely affected by natural processes (weathering and soil erosion) as well as anthropogenic inputs (municipal and industrial waste water discharge). The anthropogenic discharges represent a constant polluting source, whereas surface runoff is a seasonal phenomenon, Largely affected by climatic conditions [2].In this modern world it is no longer safe to use water from natural resources. The quality of surface water is unpredictable because the water continually moves and pollutants can be introduced at any time. In other words an area of the lakes or streams that is fine one day may be contaminated on next day. Water quality evaluation is considered as critical issues in recent years, especially when fresh water is becoming a scarce resource in the future [4].Water quality indicates the relation of all hydrological properties including physical, chemical and biological properties of the water body. Hence, water quality assessment involves analysis of physico chemical, biological and microbiological parameters that reflects the biotic and abiotic status of ecosystem [3, 5]. Water quality monitoring has a high priority for the determination of current conditions and long term trends for effective managements. The supply of safe water has a significant impact on the anticipation of water transmissible diseases [2]. Clean and adequate water supply is a necessity for the health of all living organisms and ecosystems, including people and their activities. Water quality monitoring has one of the highest priorities in environmental protection policy to control and minimise the incidence of pollutant – oriented problems, and to provide water of appropriate quality to serve various purposes such as drinking water supply, irrigation, recreational and industrial; and to protect the valuable freshwater resources to safeguard public health [6, 7, 8 and 9]. Sasthamcotta Lake is the largest natural fresh water lake in Kerala also called "Queen" of Lakes. The Sasthamcotta wetland is incorporated in the list of wetlands of international importance by the Ramsar convention for the conservation and sustainable utilization of wetlands [10]. A lake is a large body of water surrounded by land and inhabited by various aquatic life forms. Lake is a reflection of its watershed. Like water shed landscape, the topography, soil, geology, and vegetation determines the kinds of materials entering into the lake that in turn reflect on its water quality [11]. Sasthamcotta Lake is now facing degradation due to anthropogenic activities leading to the deterioration of environmental quality as well as a decrease in surface area and depth. Various sources of pollution are the extensive soil erosion caused mainly by agricultural activities, pollution caused by pesticides and fertilizers, human faecal contamination, animal waste and chemical contamination, encroachment on part of lake for agriculture, domestic waste from surrounding areas disposed into lakes, sand and clay mining, tourism activities, and inland navigation,

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oil and paint from boat building yards, soaking of dry leaves of coconut palm before matting, effluent from water treatment plant, fishing activities, construction activities around the lake cause debris to fall in lake, excess growth of algae and so on[12].Many research studies have been carried out regarding hydrological features of the lake [13]. But most of them are not concentrated on water quality and other environmental features. Very few studies reveal the physical, chemical and biological characteristics of the lake [13-17]. Recent research has further shown that change in climate and subsequent change in water use will further stimulate the pollution in lakes. There is therefore a growing demand for lake restoration and insight in sustainable lake management [18]. The main objective of this study is to assess the present water quality scenario of Sasthamcotta Lake.

II. MATERIALS AND METHODOLOGY

A.Study Area

The study area is Sasthamcotta Lake located in Kollam District, Kerala, a state of India on the south of the west coast. The lake is located physiographically in the midland region between 9^0 0' - 9^0 5' N latitude and 76^0 35' - 76^0 46' E longitudes at an elevation of 33m above MSL. The lake has a catchment area of 12.69 km^2, surface area of 373 hectares, average depth of 6.53 m, maximum depth of 15.2m and a storage capacity of 22.4 km^3.

Fig 1: Sasthamcotta Lake
[Source: www.visitorkerala.com>sasthamcotta-lake]

This area is selected for study because this lake is a drinking water source for over 700000 people in Kollam district. An alarming fall in water level and pollution has put the biggest fresh water lake in Kerala at risk. According to Wetland Conservation and Management Rules, 2010 by the Ministry of Environment, Forest and Climate Change, the water bodies listed under the Ramsar convention centre are not to be polluted or encroached upon. But in the case of Sasthamcotta Lake various Governmental, private bodies and people living closely to the lake have been polluting and encroaching the lake.

B. Water Sampling and Analysis

Based on habitat assessment the study area is divided into three sampling locations of approximately equal area. Water quality of lake is tightly depends upon all the activities taking place at its bank [3]. With expert's advice and Based on the activities such as pollutant intrusion, runoff entry points, onsite activities like huge gathering, agricultural, livestock and laundry activities, six different sampling points were selected within each location as shown in figure 2. Depth wise sampling is also carried out as shown in figure 3. The specific activities at selected sampling points are given in table 1. Water samples were collected during second week of each month (November 2017 to February 2018). Sampling, preservation, and assessment of the water quality were carried out as per standard methods [23].

Fig 2: Sampling Points: Surface
(Source: google2.jpg.image.784.410.jpg)

Fig 3: Sampling Points: Depth
(Source: google2.jpg.image.784.410.jpg)

The water quality parameters were selected on the basis of pollutants discharge and its effect on Lake Ecosystem and on human health. This is carried out by judgement of professional experts, agencies and government institutions that is determined in the legislative area. The selection of the variables from the 5 classes namely oxygen level, eutrophication, health aspects, physical characteristics and dissolved substances, which have the considerable impact on water quality, are recommended [22]. In this study Parameters were selected based on the site specific actions and experts advice and are given in table 2.

III. RESULTS AND DISCUSSION

The water samples were taken from 27 stations from the month of November 2017 to February 2018 and the Characteristics of physico chemical and biological parameters of studied water samples are shown in following tables 3 to 6.

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Table 1: Site Specific Activities at Sasthamcotta Lake

Sampling locations	Sampling points	Site Specific Activity
A	S1	Wastewater discharge from rubber estate
	S2	Waste discharge from ICS junction
	S3	Nutrient rich water from Karali marshes
	S4	Soil erosion and agricultural activities
	S5	Centre of the lake
	S6	Effluent from water treatment plant
B	S7	Waste from Sasthamcotta Lake jetty
	S8	Run off , mud deposition
	S9	Centre of lake
	S10	Waste deposition from construction activities
	S11	Washing, bathing, agricultural activities
	S12	Wastewater discharge from Sasthamcotta Town
C	S13	Destruction of hillocks, intense soil erosion
	S14	Centre of lake
	S15	Agrochemical discharge
	S16	Wastewater discharge from Bharanikkavu Town
	S17	The destruction of hillocks and intense soil erosion
	S18	Erosion and runoff

Table 2: Water Quality Parameters and Method of Analysis

Water Quality Parameters	Method of analysis
Temperature	APHA 2550.B
Turbidity	APHA 2130.B
pH	APHA 4500-H^+.B
Electrical Conductivity	APHA2510.B
Total Dissolved Solids	APHA 2540. D
Acidity	APHA 2320.B
Dissolved Oxygen	APHA4500 O. C
Biochemical Oxygen Demand	APHA 5210. B
Chemical Oxygen Demand	APHA 5220.B
Total Hardness	APHA 2340.C
Calcium Hardness	APHA 2340.C
Chloride	APHA 4500-Cl^-. B
Ca^{2+}	APHA 3500Ca^{2+}. B
Mg^{2+}	APHA 3500Mg^{2+}. B
Sulphates	APHA 4500 SO_4^{2-}
Total Coliforms	APHA 9230.B

Table 3(a): Characterisation of water samples (November)

	pH	EC	TDS	Temp(^{0}C)	Turbidity	Acidity	DO	BOD
Surface								
S1	3	158	79	28.3	2	48	6.48	4.06
S2	3	158.9	79.5	28.3	12	48	5.67	4.45
S3	2.8	169.6	85	28.4	4	52	5.68	4.46

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S4	3	158.6	79	28.6	10	48	5.67	4.45
S5	2.9	164.7	82.5	28.1	0.2	50	8.92	2.03
S6	3.25	156	76	28	6	46	5.68	4.06
S7	3	158.1	79	27.8	12	48	5.27	4.46
S8	2.9	162	80	28.4	8	50	6.08	4.86
S9	2.69	172	87	31.2	2	54	7.29	3.64
S10	2.8	169.9	85	29	6	52	6.08	4.86
S11	2.87	168	84	29	0.1	50	7.29	3.64
S12	2.71	170.1	85	31	9	52	6.49	4.87
S13	2.9	162.31	81.2	29.1	12	50	6.89	3.647
S14	2.56	173.8	86.5	29.8	1	54	7.7	3.646
S15	2.8	169.4	85	30	7	52	6.49	4.87
S16	2.9	162.9	81	30.1	12	48	4.865	4.455
S17	4	142	70	30.3	10	38	5.27	4.459
S18	2.8	169.8	84	30.6	15	52	5.27	4.86
Depth								
P1	3.5	152	76	24.3	14	44	5.27	4.86
P2	3.57	150	74	23.4	2	44	7.7	3.646
P3	4.5	138.1	69	24	0.5	36	6.89	3.647
P4	4.4	140	72	24.9	0..2	36	8.92	2.03
P5	4.5	138	69	23.1	2	36	8.5	2.42
P6	3.4	154.4	77.2	24	4	44	6.89	4.052
P7	3.3	154	77	24.3	10	46	6.89	4.455
P8	3.9	144	73	22.5	0.1	40	8.11	1.62
P9	3.3	154.8	77.1	24.3	4	46	6.89	3.647

Table 3(b): Characterisation of Water Samples (November)

	COD	TH	CH	Ca^{2+}	Mg^{2+}	Cl^-	Sulphates	T.Coliforms
Surface								
S1	70.4	14	6	2.4048	1.944	20	48	280
S2	72	14	8	3.2064	1.458	21	56	22400
S3	88	14	8	3.2064	1.458	25	57	1600
S4	102.4	18	8	3.2064	2.43	23	56.9	22400
S5	24	10	6	2.4048	0.972	18	50	17
S6	67.2	14	10	4.008	0.972	18	51	1600
S7	88	14	8	3.2064	1.458	19	55	22400
S8	108.8	12	8	3.2064	0.972	19	52	1600
S9	28.8	14	8	3.2064	1.458	14	50	110
S10	105.6	10	6	2.4048	0.972	16	52	920
S11	49.6	14	6	2.4048	1.944	18	56	130
S12	102.4	14	8	3.2064	1.458	23	51	920
S13	51.2	10	6	2.4048	0.972	22	51.6	350
S14	54.4	12	8	3.2064	0.972	18	53	94
S15	108.8	16	8	3.2064	1.944	21	52	920
S16	84.8	10	6	2.4048	0.972	21	57	22400
S17	72	12	6	2.4048	1.458	20	58	1600
S18	105.6	12	6	2.4048	1.458	21	51	22400
Depth								
P1	102.4	10	8	3.2064	0.486	22	54	22400
P2	51.2	10	6	2.4048	0.972	20	53	94
P3	60.8	12	8	3.2064	0.972	21	50	240
P4	25.6	10	6	2.4048	0.972	20	50	17
P5	25.6	10	6	2.4048	0.972	18	54	49

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P6	67.2	12	6	2.4048	1.458	18	52	130
P7	83.2	12	8	3.2064	0.972	20	58	240
P8	14.4	10	6	2.4048	0.972	20	56	49
P9	64	8	6	2.4048	0.486	20	52	240

Table 4 (a): Characterisation of water samples (December)

	pH	EC	TDS	Temp(^{0}C)	Turbidity	Acidity	DO	BOD
Surface								
S1	3.72	154.5	77	27.4	2	40	6.89	2.838
S2	3.72	153.9	77	27.4	6	40	4.86	3.649
S3	3.75	160	80	27.4	4	40	5.270	4.05
S4	3.81	154.1	77	27.6	10	42	4.054	3.243
S5	3.81	159	79	27.2	0.2	42	8.5	2.01
S6	3.57	150	75	27	4	44	5.68	4.06
S7	3.82	154	77.5	27	10	42	4.46	3.649
S8	3.64	156	78	26.9	12	42	4.865	4.455
S9	3.70	167.1	83	30	0.1	42	7.7	2.835
S10	3.74	164.7	82	28	10	40	5.68	4.06
S11	3.57	162	81	28.1	0.2	42	6.89	3.241
S12	3.46	166	83	29.9	6	44	5.68	4.053
S13	3.64	156.6	78	28.3	4	40	6.49	4.06
S14	3.77	169.2	84	28.8	1	40	7.29	3.236
S15	3.67	162.6	81	28.9	6	42	6.08	4.053
S16	3.65	154.9	77	29	6	42	6.08	3.65
S17	4.36	136.1	68	29.1	12	38	4.46	4.05
S18	3.72	164.7	82	29.4	12	42	4.054	3.644
Depth								
P1	3.76	147.1	73	27.4	10	40	4.46	3.649
P2	3.77	146.1	73	27	2	40	7.29	2.83
P3	4.62	132	66	26.9	1	32	6.89	3.241
P4	4.50	132.9	66	26.9	0.2	36	8.11	2.03
P5	4.61	136	68	26.3	2	32	8.11	2.84
P6	3.57	149.4	74.5	26.8	2	44	8.11	2.03
P7	3.69	149	74	27.2	4	42	7.7	3.646
P8	3.99	144	72	26.1	0.4	40	8.11	2.43
P9	3.73	138	69	26.9	2	42	6.89	4.052

Table 4(b): Characterisation of Water Samples (December)

	COD	TH	CH	Ca^{2+}	Mg^{2+}	Cl^-	Sulphates	T.Coliforms
Surface								
S1	7.264	14	6	2.45	1.94	21	46	170
S2	12.712	16	8	3.26	1.94	22	54	22400
S3	18.16	14	8	3.26	1.46	25	50	1600
S4	9.08	18	8	3.26	2.46	25	53	22400
S5	5.448	10	6	4.08	0.97	19	48	21
S6	16.344	16	10	3.26	1.46	19	45	920
S7	10.896	16	6	3.26	2.43	20	50	22400
S8	19.976	16	8	3.26	1.94	20	49	22400
S9	7.264	14	8	3.26	1.46	14	45	79
S10	16.344	10	6	2.45	0.97	18	48	920
S11	9.08	14	6	2.45	1.94	19	48.1	130
S12	14.528	16	8	3.26	1.94	24	52	920
S13	14.528	10	6	2.45	0.97	24	45	350
S14	9.08	14	10	4.08	0.97	18	45	110
S15	16.344	18	8	3.26	2.43	22	47	920

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S16	12.712	10	6	2.45	0.97	22	50	920
S17	12.712	14	6	2.45	1.94	21	54	22400
S18	10.896	14	6	2.45	1.94	22	50	22400
Depth								
P1	9.08	10	8	3.26	0.49	23	48	22400
P2	7.264	12	8	3.26	0.97	20	50	94
P3	12.712	14	8	3.26	1.46	22	47	130
P4	5.448	10	8	3.26	0.486	20	46	33
P5	7.264	10	8	3.26	0.486	18	45	34
P6	5.448	12	8	3.26	0.97	19	49	33
P7	12.712	14	8	3.26	1.46	23	47	63
P8	7.264	8	6	2.45	0.49	20	53	49
P9	12.712	8	6	2.45	0.49	24	46	170

Table 5(a): Characterisation of Water Samples (January)

	pH	EC	TDS	Temp(^{0}C)	Turbidity	Acidity	DO	BOD
Surface								
S1	4.52	131.8	65	27	1	36	7.29	2.02
S2	4.43	136	68	27.1	7	38	4.46	3.65
S3	4.55	130	65	27	5	36	6.48	3.24
S4	4.61	124.4	62	27.2	8	32	6.08	3.65
S5	4.68	124.1	62	26.8	0	32	7.7	1.22
S6	4.37	142.2	71	26.8	2	38	6.89	2.431
S7	4.62	124	62	26.9	10	32	5.27	3.25
S8	4.44	134.8	67	31	11	36	4.459	3.249
S9	4.5	132.9	66	27.6	2	36	7.29	1.23
S10	4.54	131	65	27.9	9	36	6.48	3.65
S11	4.37	142.1	71	28	2	38	7.7	2.03
S12	4.26	146	73	30	6	40	6.89	2.84
S13	4.44	134.4	67	29.3	2	38	7.29	1.62
S14	4.57	128.1	64	29.2	6	34	7.29	2.02
S15	4.47	134	67	29.1	6	36	6.89	2.03
S16	4.45	134.6	67.1	29.2	8	36	4.86	2.84
S17	5.08	110	55	29.6	10	26	6.48	3.24
S18	4.58	126.7	63	29.5	10	34	5.27	3.25
Depth								
P1	4.56	130	65	25.1	12	34	5.67	3.24
P2	4.16	148.1	74	24.2	1	40	7.7	1.22
P3	4.8	115.7	57	24.1	2	28	6.89	2.431
P4	4.53	131.2	65	25.5	1	36	7.7	1.22
P5	4.69	120.1	60	23.6	2	30	7.7	1.22
P6	4.37	142	71	25	2	38	7.7	1.22
P7	4.49	133.8	66	25	3	36	7.29	2.03
P8	4.42	140	70	23	3	38	7.7	1.22
P9	4.32	144	72	24.2	4	38	7.29	2.02

Table 5(b): Characterisation of Water Samples (January)

	COD	TH	CH	Ca^{2+}	Mg^{2+}	Cl^-	Sulphates	T.Coliforms
Surface								
S1	5.04192	18	10	4.008	1.944	23	45	170
S2	8.4	20	12	4.8096	1.944	24	54	22400
S3	8.4	16	10	4.008	1.458	26	50	1600
S4	6.72	20	12	4.8096	1.944	25	48	22400
S5	5.01492	12	6	2.4048	1.458	20	51	21
S6	6.72	18	12	4.8096	1.458	20	48	350

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S7	10.08	18	8	3.2064	2.43	22	48	22400
S8	11.76	18	8	3.2064	2.43	21	48	22400
S9	5.01492	16	10	4.008	1.458	15	45	79
S10	10.08	10	8	3.2064	0.486	21	46	1600
S11	6.72	18	10	4.008	1.944	21	46	130
S12	10.08	16	8	3.2064	1.944	26	52	920
S13	10.08	12	8	3.2064	0.972	24	44	110
S14	8.4032	16	10	4.008	1.458	20	44	79
S15	11.76	20	12	4.8096	1.944	24	46	920
S16	10.08	12	8	3.2064	0.972	25	45	22400
S17	10.08	16	8	3.2064	1.944	24	48	1600
S18	5.0419	16	8	3.2064	1.944	25	50	22400
Depth								
P1	6.72	10	8	3.2064	0.486	24	46	22400
P2	5.0419	10	6	2.4048	0.972	21	48	94
P3	11.76	12	8	3.2064	0.972	24	45	130
P4	3.36	10	6	2.4048	0.972	23	45	33
P5	3.36	12	8	3.2064	0.972	22	45	34
P6	6.72	16	8	3.2064	1.944	23	48	33
P7	10.08	18	10	4.008	1.944	25	46	63
P8	3.36	10	8	3.2064	0.486	22	51	49
P9	10.08	10	8	3.2064	0.486	26	45	170

Table 6 (a): Characterisation of Water Samples (February)

	pH	**EC**	**TDS**	**Temp(^{0}C)**	**Turbidity**	**Acidity**	**DO**	**BOD**
Surface								
S1	4.9	112.6	56	27.2	1	28	6.48	2.021
S2	4.88	113.7	56.5	27.1	7	28	4.46	3.25
S3	4.94	110.2	55	27.6	4	26	5.68	2.44
S4	5	108.9	54	27.3	8	26	5.27	2.84
S5	4.93	111.8	55.2	27	0	28	7.29	0.81
S6	4.76	116	58	27	2	32	5.27	2.44
S7	5.03	108.2	54	26.9	10	26	4.86	2.84
S8	4.85	114.9	57	33	10	30	4.459	2.839
S9	4.89	112.9	56	27.8	1	28	6.89	2.03
S10	4.91	112.2	56	28	8	28	6.08	2.03
S11	4.75	118	59	29	1	32	6.48	2.021
S12	4.68	120.7	60	31	4	34	6.48	1.62
S13	4.81	115	57.4	30	2	30	6.08	2.03
S14	4.93	111.8	55	30.3	4	28	6.89	2.03
S15	4.89	112.9	55.2	30.1	6	28	5.67	2.04
S16	4.88	113.1	56	30.4	6	28	4.46	3.25
S17	5.12	106.1	53	30	8	24	6.08	2.03
S18	4.86	114.4	57	31	10	30	4.86	2.84
Depth								
P1	4.86	114.6	57	25.6	12	30	5.27	3.25
P2	4.39	142	71	24.8	1	38	7.29	1.21
P3	4.99	110.9	55	24.4	1	26	6.48	2.021
P4	4.6	126.3	63	25.9	1	34	7.29	1.21
P5	4.72	119	59	23.8	2	32	7.29	1.21
P6	4.45	134.6	67	25	2	36	7.7	0.81
P7	4.54	131	65	25.2	2	36	6.89	2.02
P8	4.46	134	67	23.4	2	36	7.29	1.21
P9	4.81	115	57	24.4	3	30	6.08	2.03

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Table 6 (b): Characterisation of Water Samples (February)

	COD	TH	CH	Ca^{2+}	Mg^{2+}	Cl^-	Sulphates	T.Coliforms
Surface								
S1	4.8	22	12	4.8096	2.43	24	40	130
S2	6.4	24	16	6.4128	1.944	24	49	22400
S3	8	20	12	4.8096	1.944	28	48	1600
S4	6.4	26	18	7.2144	1.944	26	44	1600
S5	4.8	14	8	3.2064	1.458	22	45	17
S6	6.4	20	12	4.8096	1.944	22	43	240
S7	8	20	10	4.008	2.43	23	43	22400
S8	9.6	22	12	4.8096	2.43	22	42	1600
S9	4.8	18	12	4.8096	1.458	16	40	63
S10	8	12	8	3.2064	0.972	22	41	920
S11	6.4	20	12	4.8096	1.944	22	42	110
S12	8	20	10	4.008	2.43	28	48	350
S13	8	14	8	3.2064	1.458	25	40	110
S14	6.4	20	12	4.8096	1.944	22	41	79
S15	9.6	24	14	5.6112	2.43	25	43	350
S16	8	14	8	3.2064	1.458	25	40	920
S17	9.6	20	10	4.008	2.43	26	44	1600
S18	4.8	20	10	4.008	2.43	25	46	1600
Depth								
P1	6.4	14	8	3.2064	1.458	26	42	22400
P2	4.8	12	10	4.008	0.486	22	44	63
P3	9.6	14	6	2.4048	1.944	24	40	94
P4	3.2	12	8	3.2064	0.972	25	41	31
P5	3.2	14	8	3.2064	1.458	24	41	33
P6	6.4	18	10	4.008	1.944	24	43	27
P7	8	20	12	4.8096	1.944	26	42	46
P8	3.2	12	8	3.2064	0.972	24	46	46
P9	8	12	8	3.2064	0.972	28	40	110

pH is one of the important parameter for water quality which indicates the hydrogen ion concentration in water[25]. It is considered as an ecological factor and is the result of interaction of various substances in water and also influences numerous biological phenomenons [19]. pH is defined as the intensity of the acidic or basic character of a solution at a given temperature[3]. The pH values of the water samples taken from lake showed acidic trend. The pH values ranged from 2.56 to 4.5 in November 2017 (Acidity ranged from 54 to 36), 3.46 to 4.62 in December 2017 (Acidity ranged from 44 to 32), 4.16 to 5.08 in January 2018 (Acidity ranged from 40 to 26), and 4.39 to 5.12 in February 2018 (Acidity ranged from 38 to 24). The value of pH is slightly increased from November 2017 to February 2018. The lowest value of pH was recorded during November 2017 which falls in North East Monsoon season. The highest value recorded during February 2018 which falls in winter season. As per BIS desirable limit of pH is 6.5-8.5 in drinking water. In this study pH of all water samples was lower than that of the place of consumption. Minimum values of pH during November and December 2017 was due to dilution of water by addition of rain water, formic acid contained waste water discharge from various rubber estates and other acidic runoff. Lower values of pH during January and February 2018 may be due to the effect of soil pH, stagnation, decay of organic matters, discharge of domestic sewage and introduction of carbon dioxide into the lake due to respiration, and death of algae.

Water capability to transmit electric current is known as electrical conductivity and serves as tool to assess the purity of water [3, 26].This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentrations and temperature of measurement [27]. The highest electrical conductivity reported was 173.8 µS/cm during November 2017 and lowest was 106.1 µS/cm during February 2018. The recommended value of conductivity for potable water is 300 µS/cm (ICMR). According to WHO/BIS when conductivity is over than 600 µS/cm, it means that pollution occurs in water. According to those limits, the conductivity values determined in Sasthamcotta Lake were at normal and low levels. In the present study high electrical conductivity was observed during rainy season and then it followed decreasing trend which might be due To the entry of runoff that comes through or over soil and rocks which are capable of releasing ions, Waste water discharge from agricultural fields and presence of higher concentration of acids.Solids refer to the suspended and dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as edaphically relation that contributes to productivity within water body [28]. The total dissolved solids (TDS) in the sampled water ranged from 86.5mg/L in November 2017 to 53 mg/L in February 2018.

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The highest value of TDS during rainy period was due to the addition of organic matter and solid waste into the lake [3]. The high value of TDS during rainy season may be due to addition of domestic waste water, garbage and sewage etc. in the natural surface water body [57]. In this study TDS concentration of all water samples were below the desirable limit (500 mg/L) given by BIS.

Temperature is a measure of how much heat is present in water [29]. Temperature can vary throughout the lake, with surface water affected more by air temperature than deeper water. Water temperature is one of the most important physical characteristics of aquatic ecosystems and affects a number of water quality parameters [1]. In this study the temperature of surface water samples were ranged from 27^0C to 31.2^0C in November 2017, 26.9^0C to 30^0C in December 2017, 26.8^0C to 31^0C in January 2018 and 26.9^0C to 32^0C in February 2018 and the temperature of water samples collected from depth was ranged from 22.5^0C to 24.9 ^{0}C in November, 23.1^0C to 25.9^0C in December, 23^0C to 25.5^0C in January and 23.4^0C to 25.9^0C in February. Water temperature may depend on the seasons, geographic location and sampling time [29].Temperature of lake water was observed to be a function of depth, time of the day, and exposure to direct sunlight.

Turbidity is a measure of the intensity of light scattered by suspended particles. Clay, silt, organic matter, phytoplankton, and other microscopic organisms cause turbidity in pond water [57].Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight [20].The extent of turbidity in an aquatic system is generally taken as a measure of pollution intensity [25].In present study turbidity exhibited 15 NTU as highest value in November 2017 at sampling point S_{18} while in February 2018 it is reduced to 10 NTU. Least value of turbidity was found to be 0 NTU during January and February 2018 at sampling point S_5. The highest values were recorded during November which might be due to the entry of runoff and eroded soil particles. Highest value of turbidity other than rainy season may be due to the presence of higher number of microscopic organisms.

The higher value of dissolved oxygen indicates good aquatic life [3]. DO is indicative of the health of an aquatic system, the vital metabolism of aerobic organisms, respiration depends purely on the amount of oxygen dissolved in the water. Optimum concentration of dissolved oxygen is essential for maintaining aesthetic qualities of water as well as for supporting life [30].In the present study concentration of dissolved oxygen was found to be higher during November and December 2017 than January and February 2018. The concentration of dissolved oxygen ranged from 5.27 to 8.92 mg/L in November 2017, 4.054 to 8.5 mg/L in December 2017, 4.46 to 7.7mg/L in January 2018, and 4.459 to 7.7 mg/L in February2018. During rainy seasons, oxygen concentrations tend to be higher because the rain interacts with oxygen in the air as it falls.

The biochemical oxygen demand is the amount of dissolved oxygen required by the aerobic biological organisms to decompose organic matter present in the given water sample at certain temperature over a specific time period [25]. In this study BOD values reported were ranged from 4.87 to 1.62, 4.46 to 2.03, 3.65 to 1.22 and 3.25 to 0.81 mg/L. The maximum amounts were recorded during November and minimum values were recorded during February. Highest value of BOD was observed during November at sampling points S_{12} and S_{15}. Lowest value of BOD was reported during February at S_5 and P_6. Houses and hotels around the lake dump their food waste into the lake may be a reason for high BOD. The maximum values of BOD during November were due to input of organic waste and enhanced bacterial activity. The reason of high BOD in monsoon might be due to presence of several microbes in water bodies, which accelerate their metabolic activities with the increase in concentration of organic matter in the form of municipal and domestic waste which discharge into water bodies and so the demand of oxygen increased [31].

Chemical oxygen demand (COD) determines the oxygen required for chemical oxidation of most organic matter and oxidizable inorganic substances with the help of strong chemical oxidant. In conjunction with BOD, the COD test is helpful in indicating toxic conditions and the presence of biologically resistant organic substances [21]. COD values in Sasthamcotta Lake water was 24 to 108.8 mg/L (November 2017), 5.448 to 19.976 mg/L (December 2017), 3.36 to 11.76 mg/L (January 2018), and 3.2 to 9.6 mg/L (February 2018). The present study revealed that the COD values of the water samples in November 2017 appear to be higher than desirable limit (10 mg/L) for drinking water recommended by WHO. In December 2017 and January 2018 the COD values of some water samples exceeds the desirable limit and in February 2017 COD values of all the water samples were within desirable limit. The COD values showed a decreasing trend from November 2017 to February 2018. It might be due to the intrusion of pesticides, fertilizers, agricultural waste, hospital waste and other dumped waste along with rain water into the lake.

The total hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions [3]. Hardness of water prevents lather formation with soap and therefore hard water is not suitable for bathing and washing. Hard water have high boiling point and hence it is not suited for cooking too [16]. The total hardness and calcium hardness levels in sasthamcotta lake varied from 8 to 16 mg/L and 6 to 10 mg/L (November 2017), 8 to 18 mg/L and 6 to 10mg/L (December 2017), 10 to 20 mg/L and 6 to 12 mg/L (January 2018) and 12 to 24 mg/L and 8 to 18 mg/L (February 2018).

This study revealed that both the hardness decreased from November 2017 to February 2018. Less values of hardness is reported in November which may be due to the dilution of lake water with rain water. Both the hardness values in all water samples were below the desirable limit of 300 mg/L recommended by BIS.Calcium is an important nutrient for aquatic organism and it is commonly present in all water bodies [29]. Its concentration varies greatly in natural waters depending upon the basin [16]. Magnesium is often associated with calcium in all kind of water but its concentration remains generally lower than the calcium.

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Magnesium is essential for chlorophyll growth and acts as a limiting factor for growth of phytoplankton [3]. The amount of calcium and magnesium of sasthamcotta lake water samples ranged between 2.4048 to 4.008 mg/L and 0.486 to 2.43 mg/L (November2017), 2.45 to 4.08 mg/L and 0.486 to 2.43 mg/L (December 2017), 2.4048 to 4.8096 mg/L and 0.486 to 2.43 mg/L (January 2018) and 2.4048 to 7.2144 mg/L and 0.486 to 2.43 mg/L (February2018).According to BIS the desirable limit of Calcium and Magnesium for drinking water is 75 and 30 mg/L respectively. The present study revealed that the concentration of Calcium and Magnesium present in all water samples were within desirable limit. The lowest amount of calcium in water was due to calcium absorbed by the large number of organisms for shell construction, bone building and plant precipitation of lime [3]. The lowest value of Magnesium was due to the magnesium essentiality for chlorophyll bearing plant for photosynthesis [32].

Chloride is one of the major inorganic anions in water [16]. From the present study chloride content in water samples were ranged between 14 to 23 mg/L (November2017), 14 to 25 mg/L (December 2017), 15 to 26 mg/L (January 2018), and 16 to 28 mg/L (February2018). Lowest value of chloride was observed in November 2017, it might be due to the dilution of lake water by rain. Highest value was observed in February 2018, it might be due to the evaporation of fresh water from lake.

In all natural water sulphates are found. Water with about 500 mg/L sulphate has a bitter taste and those with 1000 mg/L or more may cause intestinal disorders [16]. The sulphate content in the lake varied from 48 to 58 mg/L (November2017), 45 to 54 mg/L (December 2017), 44 to 54 mg/L (January 2018), and 40 to 49 mg/L (February2018).In this study sulphate concentration decreased from November 2017 to December 2018. The highest value of sulphate was recorded in November 2017. It may be due to the decay of plants. Sulphate values in all water samples were below the desirable limit of 200 mg/L recommended by BIS for drinking water.

The coliform bacteria include the genera *Escherichia*, *Citrobacter*, *Enterobacter*, *Klebsilla* etc. Coliform bacteria may not cause disease, but they are used as one of the indicators of pathogenic contamination that can cause different diseases like dysentery, intestinal infections, typhoid fever, hepatitis, cholera, and other illness [19]. According BIS for drinking water quality, the drinking water should be devoid of coliforms. In this study the total coliforms ranged from 17 to 22400 count / 100mL (November 2017), 21 to 22400 count / 100mL (December), 21 to 22400 count / 100mL (January 2018) and 17 to 22400 count / 100mL (February). The high total coliform counts indicate that the lake is exposed to human faecal contamination, animal waste and chemical waste because of human settlements near the lake.

IV. CONCLUSION

The results obtained from the present study shall be useful in future management of the Sasthamcotta Lake. COD, BOD, pH, and turbidity of the water samples were exceeding the desirable limit. But this study observed that, there are fluctuations during months. The other physico chemical parameters such as EC, TDS, DO, calcium, magnesium, total hardness, calcium hardness, chlorides and sulphates were within desirable limits during entire study period. All the sampling points were bacteriologically contaminated. So quality of lake was poor and is not suitable for drinking, washing, bathing and other recreational purposes. Studies carried out in present investigation revealed that one of the most important causes of water pollution is unplanned town development without adequate attention to suitable management of waste material. The present study recommended that measures for the prevention of this contamination should be taken. Microbial contamination was detected in all samples, which is a serious threat to human health. So this problem should be considered seriously. Government and other responsible authorities of Sasthamcotta should take measures to protect Sasthamcotta Lake and to provide safe drinking water. A comprehensive public awareness programme is to be conducted to improve the aesthetic environment near the lake.

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