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Qualitative Evaluation of SasthamkottaLake

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Abstract: Sasthamkotta Lake, the largest fresh water lake in Kerala, a state of India on the south of the West Coast has been a designated wetland of international importance under the Ramsar Convention since November 2002 and one among the nineteen wetlands identified for conservation and management by the ministry of environment and forests under the national wetland conservation program. It meets the drinking water needs of half a million people of Kollam district in Kerala and also provides fishing resources. The lake is facing degradation due to anthropogenic activities such as directing human waste, soil erosion due to destruction of vegetation, changes in land use pattern etc. thus leading to the deterioration of environmental quality as well as a decrease in the surface area and depth. The present study is to assess the quality of the water in Sasthamkotta Lake by developing a WQI and to predict the future pollution level and its impact.

Keywords: Assessment of eutrophic condition, Characterizations of physicochemical and biological parameters, Freshwater Lake, Statistical analysis, Water Quality Index

I. INTRODUCTION

Water is an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and the free gift of nature. However, the chemical composition of surface and subsurface water is one of the prime factors on which the suitability for domestic, industrial or agriculture purpose depends. Natural, readily available water such as shallow groundwater, surface water, water from the boreholes and springs are the main sources for drinking water production [1]. Though surface water contributes only 0.3% of the total water resources on earth, it is one of the major and preferred sources of drinking water in rural as well as urban areas, particularly in the developing countries like India. But in the era of economic growth, surface water is getting polluted due to urbanization and industrialization.

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose [2]. Based on the separate parameters we could be confused about the assessment of the temporal and spatial changing trend of WQ; the zoning and classification of WQ; the comparison of WQ in the rivers; and the interpretation of water quality to the community[3]. Above disadvantages can be overcome by using Water Quality Index[4].WQI is an aggregation parameter calculated on many WQ parameters according to a defined method. A water quality index provides a single number that expresses the overall water quality at a certain location and time based on several water quality parameters[5]. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. However, a water index based on some very important parameters can provide a simple indicator of water quality. Briefly we can say, WQI numerically summarizes the information from multiple water quality parameters into a single value [6].

The State's largest freshwater lake and one of the 26 Ramsar sites in the country, Sasthamcotta Lake in the Kollam district is fast becoming grassland (The Hindu, April 9, 2013). Even as it is feared that Sasthamcotta Lake is shrinking to death, a recent study by the Kerala Sasthra Sahithya Parishad (KSSP) brings the relief that the State's largest freshwater lake is not in danger of extinction. The study submitted to the State government shows that water level of the lake fell to alarming levels in 2004 and 2009.

Many research studies had been done regarding hydrological features of the lake. But most of them are not concentrated on water quality and other environmental features [7]. Very few studies reveal the physical, chemical and biological characteristics of the lake. No studies have been undertaken to estimate the eutrophic conditions of the lake. After detailed review of literature it has been understood that tools like GPS and computation of WQI can be effectively utilized for assessing the pollution level

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of the lake. So the present study was envisaged to have a detailed assessment of water quality of the Sasthamkotta Lake.

The objective of the study is to assess the quality of the water in Sasthamkotta Lake by developing a water quality index after analyzing the physical, chemical and biological parameters and finally to predict the future pollution level and its impacts.

II. MATERIALS AND METHODS

A. Study area selection

The Sasthamkotta 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 longitude at an elevation of 33 m above mean sea level. The Lake has a catchment area of 934.56 hectares, an average depth of 6.7 m and a maximum depth of 13.9 m.

B. Sampling and data collection

The samples were taken from 8 stations (Figure 1) during the months from October 2012 to July 2013.The collections were made during day time. Maximum care was taken for the collection of samples, their preservation and storage as per the APHA standards[8]. Latitude and Longitude of the sampling stations are also marked by using GPS. The previous water quality data of Sasthamkotta Lake were obtained from the Kerala Water Authority, Q.C Division.

C. Measurement and analysis of water quality parameters

Water quality was analyzed for physical, chemical and biological parameters such as DO, BOD, COD, Turbidity, Total Solids, Electrical conductivity, Acidity, Alkanity, Sulphate, Total Hardness, Calcium, Magnesium, Chloride, Fluoride, Iron, pH, Total coliform and Fecal coliform for more accurate value of Water Quality Index. These parameters were measured as per standard method APHA[8].

D. Water Quality Index

Calculation of water quality index by using the improved method for aggregation of the water quality subindices (S) by Swami and Tyagi (2007). Water quality parameters such as temperature, turbidity, total solids, total hardness, nitrate, phosphate, fluoride, iron, pH, DO, BOD and total coliform were selected for preparing water quality index.

Calculation of water quality index by using the improved method for aggregation of the water quality

$WQI = (1-N + \sum_{i=1}^{N} S_i^{-1/k})^{-k}$

Where N = no. parameters

S= Subindices

k=positive constant(0.4)

E.Statistical analysis of data

Water quality data were statistically analyzed by using R software. To find out the most significant parameters among the quality variables, Pearson's correlation studies were conducted between water quality index and parameters. Those parameters having coefficient of correlation nearer to one are more significant and the P-value should be less than 0.05.

F.Assessment of Eutrophic condition of the Lake

Eutrophic condition of the lake was analyzed by using Carlson trophic state index value. This index was developed for use with lakes that have few rooted aquatic plants and little non-algal turbidity. Use of the index with lakes that do not have these characteristics is not appropriate [9].

The formula for calculating the Carlson Trophic State Index values for total phosphorus is given below.

TSI = 14.42 ln Total phosphorous (µg/L) + 4.15

Where TSI is the Carlson trophic state index

Ranges of trophic state index values are often grouped into trophic state classifications (Table 11).

III. RESULTS AND DISCUSSION

A. General

After conducting detailed survey, identified the main contamination stations (Figure 1) and latitude and longitude of the stations also marked (Table 1). The samples were taken from the stations from the months of October 2012 to July 2013 and the

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characterizations of the samples in pre monsoon, monsoon and post monsoon seasons are shown in Table 2, 3 and 4.

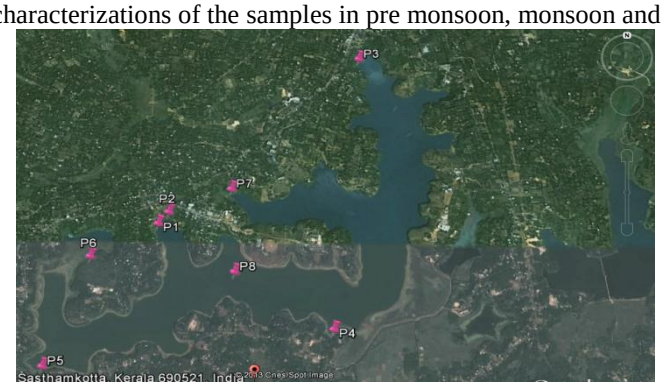

Fig. 1 Sampling points

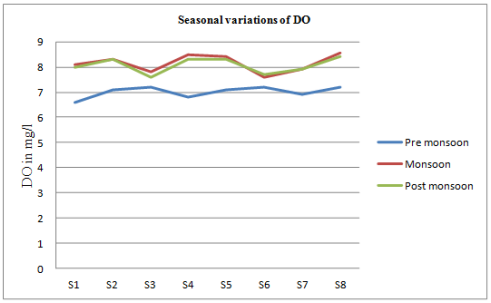

Fig. 2 Mean seasonal variations of DO

B. Water Quality Analysis

Seasonal analysis of water quality was done by using the average value of the parameters obtained from all the stations (Table 2, 3 and4).

Variations in the concentration of dissolved oxygen at pre monsoon, monsoon and post monsoon seasons from the eight sampling stations were, presented in Table 2, 3, 4 respectively and the graphical representation showed in Fig. 2**.** The average value of dissolved oxygen at pre monsoon season ranged from a minimum of 6.6 mg/L in S_1 to a maximum of 7.2 mg/L in S_8.At monsoon season it ranges from 7.6 mg/L in S_6 to 8.54 mg/L in S_8 and post monsoon season it ranges from 7.6 mg/L in S_3 to 8.4 mg/L S_8.Seasonal mean showed that dissolved oxygen is sufficient (*> 5.0* mg/l) at all stations and highest during monsoon and post monsoon seasons than pre monsoon.

The observed variations of BOD at pre monsoon, monsoon and post monsoon seasons were illustrated in Table 2, 3, 4 respectively and the graphical representation in Fig. 3.The minimum BOD of 4 mg/L at pre monsoon season was recorded from S_2 and S_8 and highest BOD of 15 mg/L in S_7 at post monsoon season. The maximum BOD was observed S_7 at post monsoon season because of the direct discharge of waste water from Sasthamkotta and nearby areas.

Table 1 List of sampling stations

Sampling Stations	Coordinates	Remarks
S1	9^0 2’ 30.28” N 76^0 37’ 20.56” E	Effluent from water treatment plant
S2	9^0 2’ 33.77” N 76^0 37’ 23.43” E	Soil erosion and agricultural activities
S3	9^0 3’ 22.73” N 76^0 38’ 16.83” E	Wastewater discharge from Bharanikkavu town
S4	$9^0$1’58.76”N 76^0 38’ 8.70” E	The destruction of the hillocks, intense soil erosion and deposition of mud in the lake
S5	9^0 1’ 48.18” N 76^0 36’ 48.30” E	Nutrient rich water flow from the Karali marshlands
S6	9^0 2’ 20.35” N 76^0 37’ 02.25” E	Wastewater discharge from rubber estate
S7	9^0 2’ 40.87” N 76^0 37’ 40.65” E	Wastewater discharge from Sasthamkotta town
S8	9^0 2’ 15.68” N 76^0 37’ 41.78” E	Centre of the lake

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Table 2 Characterization of water sample (Pre monsoon season)

Parameters	Units	Sampling Stations							
		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
DO	mg/L	6.6	7.1	7.2	6.8	7.1	7.2	6.9	7.2
BOD	mg/L	5	4	7	5	10	5	7	4
COD	mg/L	190	30	30	110	120	197	140	30
Turbidity	NTU	7.2	5.8	7.2	7.1	7.3	5.8	6.9	5
Temperature	^{0}C	30.1	30	29.9	29.8	29.9	29.8	30.1	29.9
Total Solids	mg/L	43.2	42.1	42.5	43.1	44.2	42.1	43.5	38
pH		6.79	6.82	6.71	6.9	6.9	6.82	6.71	6.9
Iron	mg/L	0.46	0.41	0.37	0.45	0.32	0.41	0.38	0.03
Fluoride	mg/L	0.41	0.37	0.36	0.47	0.31	0.37	0.40	0.2
Potassium	mg/L	1	1.2	1	1.3	1.3	1.2	1.3	1
Total coliform	No.of coliforms/100ml	1100	800	1000	1100	1100	467	1100	467
E coli	No.of coliforms/100ml	120	120	120	67	120	120	120	30

Table3Characterization of water sample (Monsoon season)

Parameters	Units	Sampling Stations							
		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
DO	mg/L	8.1	8.3	7.8	8.5	8.4	7.6	7.9	8.54
BOD	mg/L	9	9	10	5	12	7	12	6
COD	mg/L	190	30	30	110	120	197	140	30
Turbidity	NTU	14	10	16	8	10	14	18	8
Temperature	^{0}C	27	26.9	26.9	27	26.8	27	27.1	26.8
Total Solids	mg/L	46	42	52	44	46	44	60	42
pH		7.2	7.3	7.1	6.9	7.4	7.2	7.2	7.1
Iron	mg/L	0.45	0.40	0.42	0.47	0.41	0.38	0.40	0.1
Fluoride	mg/L	0.42	0.37	0.38	0.44	0.30	0.39	0.42	0.2
Potassium	mg/L	1.2	1.4	1.2	1.3	1.3	1.1	1.4	1.2
Total coliform	No. of coliforms/100ml	1100	1100	1100	1100	1100	1100	1100	1100
E coli	No. of coliforms/100ml	140	160	260	260	140	260	260	140

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Table 4 Characterization of water sample (Post monsoon season)

Parameters	Units	Sampling Stations							
		S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
DO	mg/L	8.0	8.3	7.6	8.3	8.3	7.7	7.9	8.4
BOD	mg/L	10	9	12	4	12	8	15	5
COD	mg/L	160	195	197	110	80	190	160	30
Turbidity	NTU	12	9.6	20	6.8	9.2	12	18	6.7
Temperature	^{0}C	27.4	27.5	27.4	27.2	27.3	27.1	27.4	27.2
Total Solids	mg/L	45.5	43	62	42.1	45.1	44	58	40
pH		7.2	7.1	6.9	7.2	7.6	7.1	7.2	7.1
Iron	mg/L	0.44	0.37	0.42	0.46	0.32	0.36	0.42	0.1
Fluoride	mg/L	0.38	0.36	0.42	0.36	0.20	0.4	0.42	0.2
Potassium	mg/L	1.2	1.3	1.2	1.2	1	1.3	1.3	1
Total coliform	No.of coliforms/100ml	1100	1100	1100	1100	1100	1100	1100	1000
E coli	No.of coliforms/100ml	160	120	260	260	160	260	260	120

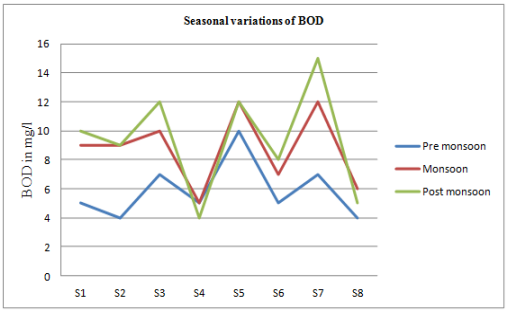

Fig. 3 Mean seasonal variations of BOD

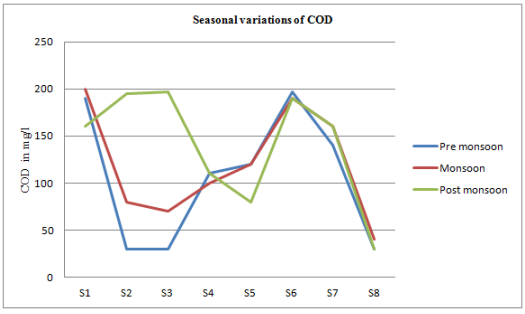

Fig. 4 Mean seasonal variations of COD

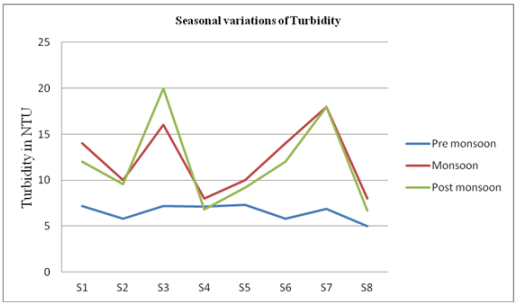

Fig. 5 Mean seasonal variations of turbidity

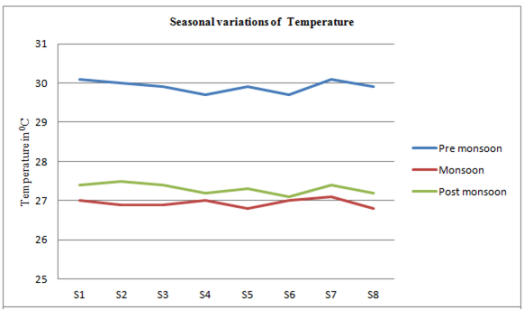

Fig. 6 Mean seasonal variations of temperature

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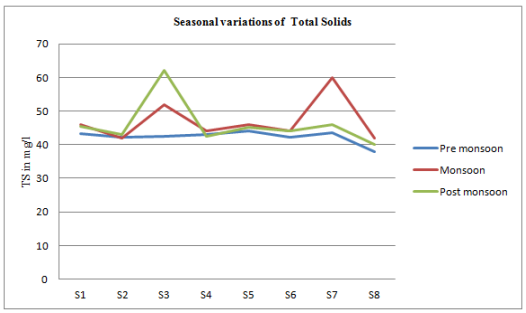

Fig. 7 Mean seasonal variations of T.S

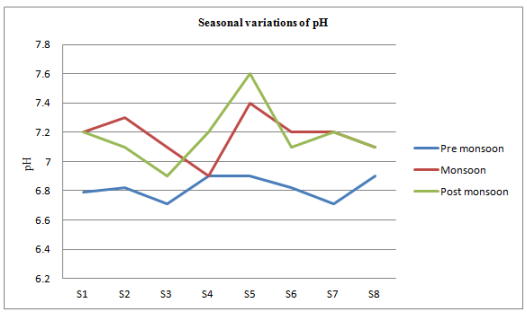

Fig. 8 mean seasonal variations of pH

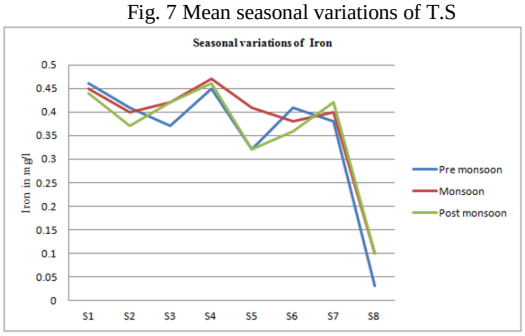

Fig. 9 Mean seasonal variations of Iron

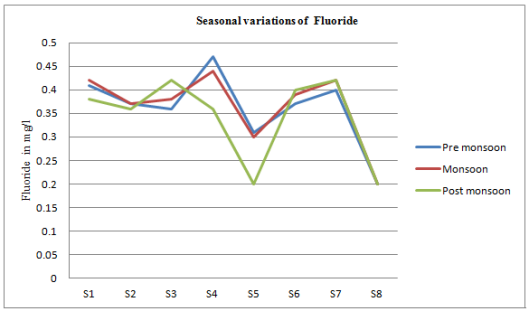

Fig. 10 Mean seasonal variations of Fluoride

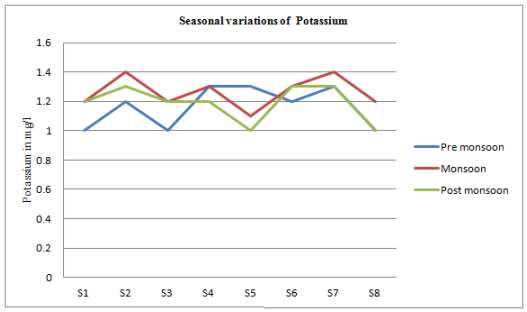

Fig. 11 Mean seasonal variations of potassium

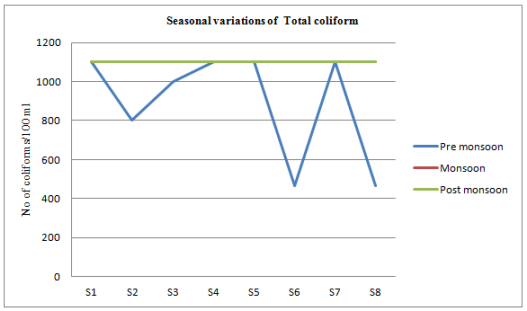

Fig. 12 mean seasonal variations of Total Coliforms

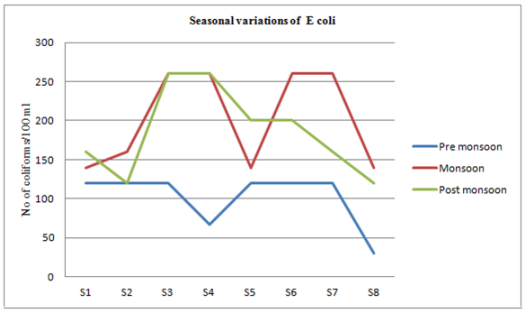

Fig. 13 Mean seasonal variations of E coli

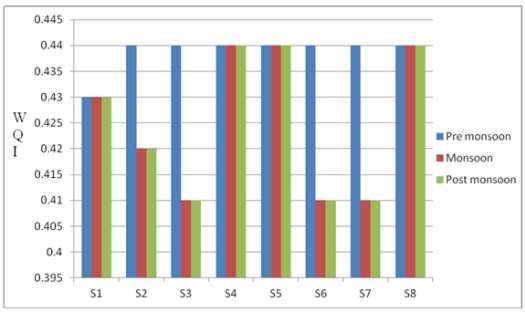

Fig. 14 Seasonal variation of WQI

The observed variations of mean chemical oxygen demand values were illustrated in Table 2, 3, 4 and Fig. 4. At pre monsoon season the COD ranges from a minimum of 30 mg/L in S_2, S_3 and S_8 to a maximum of 197 mg/L in S_6.

At monsoon season it ranges from 30 mg/L in S_2, S_3 and S_8 to 197 mg/L in S_6 and at post monsoon season 30 mg/L in S_8 to 197 mg/L in S_3. In S3 and S_6, COD value is very high because of the waste agricultural chemicals discharged into the lake from rubber plantations at Rajagiri, Bharanikkavu and the adjoining areas. All other stations COD value is

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high because of the waste agricultural chemicals discharged into the lake from rubber plantations at Sasthamkotta and nearby areas and the direct discharge of drainage water from Sasthamkotta, Bharanikkavu and nearby areas.

The observed variations in turbidity values were illustrated in Table 2, 3, 4 and Fig. 5.The turbidity values ranged between 5 NTU in S_8 to 7.3 NTU in S_5 at the pre monsoon, 8 NTU in S_4 and S_8 to 18 NTU in S_7 at monsoon and at post monsoon season it was 6.7 NTU in S_8 to 20 NTU in S_3. The seasonal mean values of turbidity showed that minimum was observed during pre monsoon and maximum during monsoon and post monsoon season. In station S_7 turbidity value is very high in the monsoon and post monsoon season because of the direct discharge of drainage water from Sasthamkotta and nearby areas.

Surface water temperature measured and the seasonal analysis during the period of study was given in Table 2, 3, 4 and Fig. 6**.** The average temperature ranges from 29.8^{0}C in S_4 and S_6 to 30.1^{0}C in S_1 and S_7 at pre monsoon season. At monsoon season it ranged from 26.8^{0}C S_5 and S_8 to 27.1^{0}C in S_7 and at post monsoon season it from 27.6^{0}C in S_6 to 27.5^{0}C in S_2.Highest water temperature was observed at pre monsoon season in S_1 and S_7, while the lowest temperature was at monsoon season in S_5 and S_8.

The seasonal variations of total solids of the lake water are shown in Table 2, 3, 4and figure 7. At pre monsoon season TS values ranged from a minimum of 38 mg/L in S_8 to a maximum of 44.2 mg/L in S_5 and at monsoon season a minimum of 42 mg/L in S_2 and S_8 to a maximum of 60 mg/L in S_7.At post monsoon season it ranged from 40 mg/L in S_8 to 62 mg/L in S_3.Total solid values at pre monsoon are slightly lower than monsoon and post monsoon seasons.The highest value was recorded during post monsoon season at S_3 and the lowest was at S_8 during pre monsoon season.

The seasonal variations of pH of the lake water are shown in Table 2, 3, 4 and figure 8.The desirable limit is 6.5 to 8.5(IS 10500:2004).All the seasons pH is within the range. At pre monsoon season pH ranges from 6.71 to 6.9, at monsoon it from 6.9 to 7.4 and at post monsoon it from 6.9 to 7.6. In pre monsoon season pH is slightly acidic, i.e., below 7.

Seasonal variations of iron of the lake water are shown in Table 2, 3, 4and figure 9.The desirable limit is 0.3 mg/l (as per IS 10500:2004).At pre monsoon iron ranged from 0.03 mg/L in S_8 to 0.46 mg/L in S_1,at monsoon it ranged from 0.1 mg/L in S_8 to 0.47 mg/L in S_4 and at post monsoon it ranged between 0.1 mg/L in S_8 to 0.46 mg/L in S_4.All the seasons presence of iron is beyond the range except sampling station 8, which is the centre portion of the lake.

Seasonal variations of fluoride of the lake water are shown in Table 2, 3, 4 and figure 10.Fluoride ranged between 0.2 mg/L in S_8 to 0.47 mg/L in S_4 at pre monsoon season, at monsoon it ranged from 0.2 mg/L in S_8 to 0.44 mg/L in S_4 and at post monsoon it ranged from 0.2 mg/L in S_8 to 0.42 mg/L in S_3 and S_7. All season presence of fluoride are within the range.

Seasonal variations of potassium of the lake water are shown in Table 2, 3, 4 and figure 11.The desirable limit is 1 mg/L (as per IS 10500:2004).At pre monsoon season potassium ranged from a minimum of 1 mg/L in S_1,S_3 and S_8 to a maximum of 1.3 mg/L in S_4,S_5 and S_7,at monsoon it ranged from 1.1 mg/L in S_6 to 1.4 mg/L in S_2 and S_7 and monsoon season it ranged from 1 mg/L in S_5 and S_8 to 1.3 mg/L in S_2,S_6 and S_7. In all seasons presence of potassium are slightly above the desirable limit.

Seasonal variations of number of coliforms in the lake water are shown in Table 2, 3, 4 and figure 12. At pre monsoon season number of colifrms ranged between 467 / 100 ml in S_6 and S_8 to 1100 / 100 ml in S_1,S_4,S_5 and S_7 and at monsoon and post monsoon seasons number of coliforms in all stations were 1100 / 100ml. All seasons presence of coliforms are beyond the limit. At monsoon and post monsoon season numbers of coliforms are higher than pre monsoon season.

Seasonal variations of number of E coli in the lake water are shown in Table 2, 3, 4 and figure 13.At pre monsoon season the number of E coli ranged between 30/100 ml in S_8 to 120/100 ml in S_1,S_2,S_3,S_5,S_6 and S_7,at monsoon season it ranged from 140 / 100ml in S_1,S_5 and S_8 to 260 / 100 ml in S_3,S_4,S_6 and S_7 and at post monsoon season it from120 /100 ml in S_2 and S_8 to 260 / 100 ml in S_3,S_4 and S_6.In all seasons presence of E coli are beyond the limit. At monsoon and post monsoon season number of E coli are higher than pre monsoon season because of the direct discharge of waste water from Sasthamkotta, Bharanikkavu and nearby areas.

C. Water Quality Index

The water quality index also calculated by using the improved method by Swami and Tyagi, comparing the seasonal variations of WQI (Table 5, 6,7and figure 14) .In pre monsoon season almost all the samples have the same WQI, i.e., 0.44; it belongs to the fair condition. In monsoon and post monsoon season the least WQI is from stations S_3, S_6 and S_7.Stations S_3 and S_7 are the direct drainage water discharge from Bharanikkavu and Sasthamkotta towns respectively. S_6 is the waste water discharge from rubber estates.

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Table 5 WQI of pre monsoon season

Sample No.	WQI	Remarks
S1	0.43	Fair
S2	0.44	Fair
S3	0.44	Fair
S4	0.44	Fair
S5	0.44	Fair
S6	0.44	Fair
S7	0.44	Fair
S8	0.44	Fair

Table 6 WQI of monsoon season

Sample No.	WQI	Remarks
S1	0.43	Fair
S2	0.42	Fair
S3	0.41	Fair
S4	0.44	Fair
S5	0.44	Fair
S6	0.41	Fair
S7	0.41	Fair
S8	0.44	Fair

Table 7 WQI of post monsoon season

Sample No.	WQI	Remarks
S1	0.43	Fair
S2	0.42	Fair
S3	0.41	Fair
S4	0.44	Fair
S5	0.44	Fair
S6	0.41	Fair
S7	0.41	Fair
S8	0.44	Fair

Table 8 Comparison of water quality

Characteristics	Units	2006	2013
pH		6.99	7.2
Phosphate	mg/L	0.03	1.3
DO	mg/L	8.56	7.5
BOD	mg/L	4.5	7
COD	mg/L	9	120
Total coliforms	No.of coliforms / 100 ml	12	1100+

Table 9 Characterization of eutrophication enhancing parameters

Characteristics	Unit	Quantity
Total nitrogen		1400
Phosphorus		1300
DO	mg/L	6.4-8.0
Nitrate		400
COD	mg/L	197

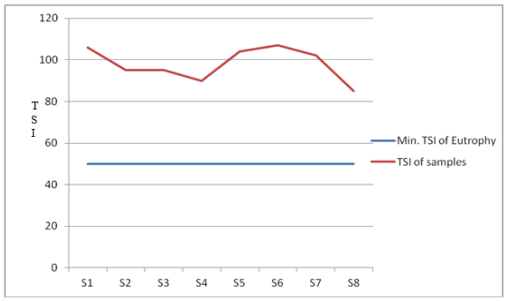

Fig. 15 Comparison of TSI of the lake

D. Assessment of Eutrophic Condition of the Lake

Comparison of the present water quality data with 2006 (data obtained from the Kerala Water Authority) was done (Table 8). In 2006, the average pH value was 6.9, but the present value is 7.2, slightly alkaline in nature. Now BOD is also increasing. In 2006 COD was 9 mg/L but now the COD is 120 mg/L, a very high increase because of anthropogenic activities. DO value is also decreasing compared with 2006.

Table 10 Trophic classification of lakes
(Source: Nutrient Criteria Technical Guidance Manual Lakes and Reservoirs, USEPA, 2000)

Trophic class	P	Unit
Oligotrophic	0-12	µg/l
Mesotrophic	12-24	µg/l
Eutrophic	24-96	µg/l
Hypereutrophic	96-384+	µg/l

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Table 11 Trophic State Index classification
(Source: Nutrient Criteria Technical Guidance Manual Lakes and Reservoirs, USEPA, 2000)

TSI range	Classification
<40	Oligotrophy (low productivity)
40-50	Mesotrophy (moderate productivity)
50>	Eutrophy (high productivity)

This Lake managed to remain a freshwater body for long owing to the virtual absence of nutrients in it. It was the lack of nutrients that prevented the growth of algae in the lake. In 2006, the value of nutrient contents, i.e., total nitrogen and phosphorus were negligible, but now the value is high (Table 9) and it leads to the hypereutrophic condition (Table 10).Also the eutrophication condition of the lake was analyzed by using Carlson trophic state index (Table 11 and figure 15).From these analysis it is clear that the lake is in eutrophic condition. The algal growth in the lake has already lent a green hue to the lake in some pockets, and this is causing unusual sedimentation in the Sasthamcotta water treatment plant and in the overhead water tanks fed by the treatment plant.

IV. CONCLUSIONS

The present paper analyzes the water quality data collected from the Sasthamkotta Lake. Important issues include decreasing water quality, alternations in biological productivity (tropic state), increase in nutrient concentrations, contaminant migration into the lake etc.

The DO values were found to range from 6.6 to 8.54 mg/L in all seasons. In comparison with the previous data, the DO of the lake is decreasing dangerously due to anthropogenic activities.The BOD range from 4 to 15 mg/L in all seasons. BOD is slightly increasing compared with the previous values.The COD ranges from 30 to 197 mg/L. Compared to the previous data, COD is increasing rapidly. This may be due to the waste agricultural chemicals discharged into the lake from the adjoining rubber plantations.The turbidity ranges from 5 to 18 NTU. This is high in monsoon and post monsoon seasons compared with pre monsoon season because of the direct discharge of drainage water from Sasthamkotta, Bharanikkavu and nearby areas.In pre monsoon season pH is slightly acidic, i.e., below 7.In all season pH is within the limit.

Coliforms ranges from 400 to 1100/100ml.Number of coliforms is increasing very rapidly compared with the previous values. Ecoli ranges from 30 to 260/100ml.This is also found to be increasing very rapidly compared with the previous values.

The quantities of phosphate and nitrate are increasing and higher than the prescribed limits.DO values of the lake are decreasing. They indicate that the lake is in hypereutrophic condition.In all the season water quality index remains in the category“fair”.

As per the analysis of the results it can be seen that in the post monsoon season the physical, chemical and biological parameters are higher than pre monsoon season. Presence of coliforms and Ecoli are beyond the limit. So it can be concluded that during monsoon season contaminant migration into the lake is happening abundantly and thus result in the poor quality of water. Also based on total nitrogen and phosphorus, the lake belongs to hypereutrophic class. If eutrphication and contamination proceed at this rate, within next 5 to 10 years our own Sasthamkotta Lake, the largest fresh water lake in Kerala, categorized as a designated wetland of international importance under the Ramsar Convention, will end up in a miserable condition. Hence the issues revealed in this study will have to be addressed seriously by all concerned.

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Salin Peter, working as Engineer in Kerala Water Authority (is the largest water supply cum sewage services company in the state of Kerala, India. It is a government owned organization and hence a monopoly in most parts of the state).He has completed Bachelors degree in Engineering from College of Engineering Kothamangalam, Mahathma Gandhi University, Kerala in 1997 and completed post graduate degree in Environmental Engineering from College of Engineering Trivandrum, Kerala University, India in 2013.The author has sixteen years of experience in different field of engineering mainly in drinking water treatment and water supply. His research area is water quality analysis and environmental impacts.

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