

**“Water quality assessment and the development of green water
treatment technologies for the lake of Sasthamcotta”**

First year Report

Submitted to

Kerala State Council for Science and Technology Environment



Submitted By

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Sasthamcotta fresh water lake is the largest of its kind in Kerala, serving as a portable water source for half a million people of the Kollam district of Kerala. It has been pronounced as a 'Ramsar Site' since 2002 owing to its wetland importance. But this aquatic body is under threat mainly due to anthropogenic activities. The Department of Chemistry of KSMD College, Sasthamcotta has taken up the initiative of the assessment of the water quality of this lake through the prestigious SARD project funded by KSCSTE for 3 years from Sep 2017. First year of the study has been undertaken with the following objectives.

- 1) To assess the seasonal variation of the Physico-Chemical characteristics of the water of the Sasthamcotta lake during pre-monsoon and post-monsoon periods.
- 2) To evaluate the effect of nonpoint source pollution in the two seasons. In this study, we have selected five potent sites in the lake during the pre and post monsoon periods of the April 2018 and July 2018 respectively. The Physico-Chemical parameters of the water samples before and after monsoon have been evaluated and compared.

The purchase of the instrument sanctioned to us (AAS) has been accomplished during this time period. Thermo scientific iCE 3000 series Atomic Absorption Spectrometer has been procured and installed successfully in our laboratory. It is in good working condition and used by other research students and teachers from other institutes also.



Fig.1: Atomic Absorption Spectrometer

MATERIALS AND METHOD

THE SITE SELECTED FOR INVESTIGATION

The site selected for the study is a fresh water lake of international importance as it is one among the three Ramsar sites in Kerala. A recent picture of this site is given in Fig.2.



(a)



(b)

Fig.2: Photographs of Sasthamcotta Fresh water Lake during a) Pre monsoon and b) Post monsoon

COLLECTION OF WATER SAMPLES

Water samples were collected from six sites within Sasthamcotta lake under aseptic conditions and were kept at 4°C and taken to the Instrumentation Lab, Department of Chemistry, K.S.M.D.B.College, Sasthamcotta, Kerala, India in a standard transport box for samples of analysis. All the samples were kept at very low temperatures.

To assess the impact of season on the extent of pollution, sample collections were made from six specific locations, on the fourth day of April which is in the pre monsoon period and on the 4th day of June 2018 which is in the post monsoon period. All these samples were chemically analysed. The positions of the sites selected for the study are given in Table .1.

Table.1: The geographical details of the sites within Sasthamcotta Lake selected for water collection

Site No.	Name of Location	Latitude (N)	Longitude (E)
1	Vallakadavu	9 ⁰ 2 ¹ 25 ^{II}	76 ⁰ 37 ¹ 43 ^{II}
2	Centre of Lake	9 ⁰ 2 ¹ 19 ^{II}	76 ⁰ 37 ¹ 40 ^{II}
3	Opposite of Vallakadavu	9 ⁰ 2 ¹ 11 ^{II}	76 ⁰ 37 ¹ 41 ^{II}
4	Opposite of Filter House	9 ⁰ 2 ¹ 60 ^{II}	76 ⁰ 37 ¹ 31 ^{II}
5	Filter House	9 ⁰ 2 ¹ 30 ^{II}	76 ⁰ 37 ¹ 24 ^{II}
6	Near MTMM Hospital	9 ⁰ 3 ¹ 17 ^{II}	76 ⁰ 38 ¹ 37 ^{II}

REAGENTS

The chemicals Sodium hydroxide, K₂Cr₂O₇, Ferrous ammonium sulphate, mercuric chloride, silver nitrate, hydrochloric acid, silver sulphate, Eriochrome black-T, methyl orange, phenolphthalein etc., sulphuric acid and commercial sample of Ferroin indicator used in the present study were of analytical grade purity. Solvents employed were either of 99% purity or purified by known laboratory procedures.

ANALYTICAL METHODS

Physicochemical Methods:

The physicochemical parameters of the water samples were determined by standard procedures as given below. All the experiments were carried out in triplicate at the Department of Chemistry, Devaswom Board College, Sasthamcotta, Kerala, India.

pH

The pH of a solution is the concentration of hydrogen ions, expressed as a negative logarithm. It reflects the acidity or alkalinity of a solution, in this case water. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly alkaline solutions. It is important to consider the effects of pH on other potential toxicants; e.g. the bioavailability of heavy metals. The measurements were carried out at the Physical

Chemistry Lab, Department of Chemistry, K. S. M. D. B. College, Sasthamcotta using a systronics digital pH meter at $25 \pm 1^\circ\text{C}$.

Conductivity

Electrical conductivity is the measure of the ability of water to conduct an electric current and depends upon the number of ions or charged particles in the water, and is measured by passing a current between two electrodes (a known distance apart) that are placed into a sample of water. The unit of measurement for electrical conductivity is expressed in either ohm^{-1} (mho/cm) or milli ohm^{-1} centimeter (mmho/cm). Electrical conductivity determinations are useful in aquatic studies because they provide a direct measurement of dissolved ionic matter in the water. Low values are characteristic of high-quality, low-nutrient waters. High values of conductance can be indicative of salinity problems but also are observed in eutrophic waterways where plant nutrients (fertiliser) are in greater abundance. Very high values are good indicators of possible polluted sites. However, electrical conductivity readings do not provide information on the specific ionic composition and concentrations in the water. The conductance was measured by a dip type conductivity cell at $25 \pm 1^\circ\text{C}$.

Total suspended solids (TSS)

Total suspended solids (TSS) are defined as the portion of total solids in a water sample retained by a glass fiber (GF/C) filter of pore size $>2 \mu\text{m}$. About 200 mL of water was filtered through a G 4 crucible the retained material is dried at 105°C . TSS is determined as the weight of the retained material.

Total dissolved solids (TDS)

An evaporating dish is dried and cooled for 1 h and weighed. Stir sample with a magnetic stirrer and while stirring pipette a measured volume on to the filter using a wide bore pipette. After washing with distilled water, transfer total filtrate with washings to the weighed evaporating dish and evaporate to dryness in an oven at $104 \pm 10^\circ\text{C}$. Cooled in a desiccator and weighed. The dissolved solids can be calculated as:

$$\text{dissolved solids} / L \equiv \frac{(A - B) \times 1000}{\text{mL of sample}} \text{ mg}, \text{ where } A = \text{weight of dried residue + dish, mg and}$$

$B = \text{weight of empty dish, mg.}$

Heavy metal concentration by Atomic Absorption Spectroscopy

Atomic absorption spectrometry (AAS) is an analytical technique that measures the concentrations of elements. Atomic absorption is so sensitive that it can measure down to parts per billion of a gram ($\mu\text{g dm}^{-3}$) in a sample. The technique makes use of the wavelengths of light specifically absorbed by an element. They correspond to the energies needed to promote electrons from one energy level to another, higher, energy level. Atomic absorption spectrometry has many uses in different areas of chemistry. Clinical analysis, Analyzing metals in biological fluids such as blood and urine, Environmental analysis. Monitoring our environment – eg finding out the levels of various elements in rivers, seawater, drinking water, air, petrol and drinks such as wine, beer and fruit drinks. Pharmaceuticals-In some pharmaceutical manufacturing processes, minute quantities of a catalyst used in the process (usually a metal) are sometimes present in the final product. By using AAS the amount of catalyst present can be determined. Industry- Many raw materials are examined and AAS is widely used to check that the major elements are present and that toxic impurities are lower than specified – eg in concrete, where calcium is a major constituent, the lead level should be low because it is toxic. Mining-By using AAS (purchase in the present scheme) the amount of metals such as gold in rocks can be determined to see whether it is worth mining the rocks to extract the gold.

Chemical Method

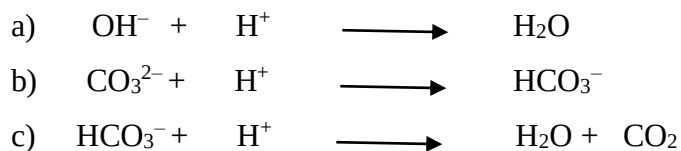
Alkalinity:

The alkalinity of the water is a measure of its capacity to neutralize acids. The alkalinity of natural waters is due primarily to the salts of weak acids. Bicarbonates represent the major form of alkalinity. Alkalinity of a sample of water is due to the presence of OH^- (hydroxide ion), HCO_3^- (bicarbonate ion) and CO_3^{2-} (carbonate ion) or the mixture of two ions present in water. The possibility of OH^- and HCO_3^- ions together is not possible because they on combination form CO_3^{2-} ions.



The alkalinity due to different ions can be estimated separately by titration against

standard acid solution, using selective indicators like phenolphthalein and methyl orange.



The neutralization reaction upto phenolphthalein end point shows the completion of reactions (a) and (b) only. The volume of acid used thus corresponds to complete neutralization of OH^- plus half neutralization of CO_3^{2-} . The titration of water sample using methyl orange indicator marks the completion of the reactions (a), (b) and (c). The amount of acid used after phenolphthalein end point corresponds to one half of normal carbonate and all the bicarbonates. Total amount of acid used represent the total alkalinity due to all ions present in water sample. Alkalinity is measured by titrating against an acid and is significant in man uses and also in the treatment of waste water. A brief description of the procedural details are given as: About 20 mL of the water sample is pipette into a 100 mL conical flask and titrated against (N/20) H_2SO_4 after the addition of 2 drops of phenolphthalein indicator till the color of the solution changes from pink to colorless. Corresponding burette reading indicates the phenolphthalein end point (V_1). Again pipette out 20 mL of the water sample in a conical flask and 2 drops of methyl orange indicator is added. The color of the solution becomes yellow. Continue the titration against the (N/20) H_2SO_4 solution till the color changes to red. This burette reading corresponds to the methyl orange end point (V_2).

$$20 \times S_1 = V_1 \times \text{Normality of } \text{H}_2\text{SO}_4 \text{ solution}$$

where S_1 is the phenolphthalein alkalinity in water sample

$$\text{So, } S_1 = (\text{Tit. Vol of } \text{H}_2\text{SO}_4 \times \text{Normality of } \text{H}_2\text{SO}_4) / 20.$$

Strength in terms of CaCO_3 equivalent, $P = S_1 \times \text{Eq. Wt of } \text{CaCO}_3$

$$= S_1 \times 50 \times 1000 \text{ mg/L}$$

$20 \times S_2 = \text{Tit. Vol of } \text{H}_2\text{SO}_4 \times \text{Normality of } \text{H}_2\text{SO}_4$. Where, S_2 is the methyl orange alkalinity in water sample

$$S_2 = (\text{Tit. vol of H}_2\text{SO}_4 \times \text{Normality of H}_2\text{SO}_4 / 20)$$

$$\text{Strength in terms of CaCO}_3 \text{ equivalent} = S_2 \times \text{Eq. Wt. of CaCO}_3$$

$$= S_2 \times 50 \times 1000 \text{ mg/L}$$

In the present case, Phenolphthalein alkalinity (P) = 0; that means the volume of acid used till the completion of reaction (i) and (ii) is 0. This can only happen when both OH^- and CO_3^{2-} ions are not present in water. Alkalinity is present due to HCO_3^- ion only which can be determined using methyl orange indicator and called methyl orange alkalinity (M).

Acidity

Acidity of water sample is its quantitative capacity to react with a strong base to a designated pH. The mineral acidity of the sample can be measured by titration to a pH of about 3.5, which is the methyl orange end point known as methyl orange acidity. Titration of the sample to phenolphthalein end point of pH 8.3 measures total acidity which is mineral acidity plus acidity due to weak acids. To determine, 25 mL water sample is taken in a conical flask and 2-3 drops of methyl orange indicator is added. Titrate is continued till the endpoint against about 0.02N NaOH solution. Note the volume as V_1 and calculate the methyl orange acidity as:

$$\text{Methyl orange acidity} = \frac{V_1 \times N \times 50 \times 1000}{\text{Volume of Sample}}$$

To this about 2-3 drops of phenolphthalein indicator is added and the titration is continued till the end point (V_2 mL). The total acidity can be calculated as:

$$\text{Total acidity/ Phenolphthalein acidity} = \frac{V_2 \times N \times 50 \times 1000}{\text{Volume of Sample}}$$

Chemical oxygen demand (COD)

Chemical Oxygen Demand or COD is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water. It is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to

anaerobic conditions, which is deleterious to higher aquatic life forms. The COD test is often used as an alternate to BOD due to shorter length of testing time.

A common method for the determination of Chemical Oxygen Demand involves using a strong oxidizing chemical, potassium dichromate $\text{Cr}_2\text{O}_7^{2-}$, to oxidize the organic matter in solution to carbon dioxide and water under acidic conditions. Often, the test also involves a silver compound to encourage oxidation of certain organic compounds and mercury to reduce the interference from oxidation of chloride ions. The sample is then digested under reflux for approximately 2 hours at 150°C . The amount of oxygen required is calculated from the quantity of chemical oxidant consumed. A very brief description of the procedure employed in this study is given as: About 50 mL of effluent water sample is added into a 500 mL refluxing flask followed by 1g HgSO_4 , few glass beads, and 5 mL sulphuric acid reagent (prepared by the addition of 5.5g A R grade Ag_2SO_4 per kg of conc. H_2SO_4 and keeping for two days to dissolve) and cooled. To this added 25 mL of 0.0417M $\text{K}_2\text{Cr}_2\text{O}_7$ solution and mixed. After connecting the flask to the condenser, add an additional 70 mL of sulphuric acid reagent through open end of condenser, with swirling and mixing. Refluxed for 2 hours, cooled and washed down the condenser with distilled water to double the volume of contents and cooled. Titration of the remaining potassium dichromate is carried out after addition of two drops of Ferroin indicator, and against FAS, until a colour change from bluish green to reddish brown. Also reflux and titrate a distilled water blank with reagents. From the titre values, obtained for unreacted dichromate. The experimental set up for the determination of COD is in Fig.3.

$$\text{COD} = \frac{(V_2 - V_1) \times N_{\text{FAS}} \times 8000}{V_o} \quad \text{Where } V_2 = \text{Volume of FAS titrated for sample (mL),}$$

$V_1 = \text{Volume of FAS titrated for blank (mL)}$ and $V_o = \text{Volume of sample taken.}$

The
of

experimental set up used for the determination
COD is given in Fig.3.



experimental set up used for the
determination of COD

Estimation of Chloride

An argentometric method was employed for the determination of natural or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as an indicator. Silver chloride is quantitatively precipitated before red silver chromate is formed. The quantity can be estimated as:

$$\text{Chloride mg/L} = (A-B) \times N \times 35.45 \times 1000 \text{ ml sample}$$

Where, A = ml AgNO₃ required for sample, B= ml AgNO₃ required for blank, N= Normality of AgNO₃ used.

Pipette out 25 ml water sample into a conical flask. To this, 1 mL K₂CrO₄ indicator solution (5% solution) is added and titrated with standardized AgNO₃ titrant to a pinkish yellow end point. The titration is repeated with distilled water blank. A blank of 0.2 to 0.3 mL is usual.

Estimation of Total hardness

Total hardness is a measure of polyvalent cations (Cations with a charge greater than +1) dissolved in water. It generally represents the consternation Ca²⁺ and Mg²⁺ because these are the most common polyvalent cations. Other ions such as Fe²⁺ and Mn²⁺ may also contribute to the hardness of water, but are generally present in much lower concentrations especially in surface water. Hardness mitigates metal toxicity as Mg²⁺ and Ca²⁺ result in the absorption of Pb, As and Cd into the blood stream of fish through their gills. Water with total hardness in the range 0 to 60 mg/L are termed soft whereas from 60 to 120 mg/L are moderately hard; from 120 to 180 mg/L hard and above 180 mg/L very hard.

RESULTS

The specification of Bureau of Indian Standards for drinking water is given in Table 2. The pH value is significant as many chemical reactions inside aquatic organisms (cellular metabolism) that are necessary for survival and growth of organisms require a narrow pH range. At the extreme ends of the pH scale, (2 or 13) physical damage to gills, exoskeleton, fins, occurs. Changes in pH may alter the concentrations of other substances in water to a more toxic form. Examples: a decrease in pH (below 6) may increase the amount of mercury soluble in water.

Table.2. Taken from Water Portal, India: Drinking Water Specification –Indian Standard IS 10500; 2004.

**INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER
IS: 10500**

S.NO.	Parameter	Requirement desirable Limit	Remarks
1.	Colour	5	May be extended up to 50 if toxic substances are suspected
2.	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3.	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4.	Total Hardness	300	May be extended up to 600
5.	Calcium as Ca	75	May be extended up to 200
6.	Magnesium as Mg	30	May be extended up to 100
7.	Copper as Cu	0.05	May be relaxed up to 1.5
8.	Iron	0.3	May be extended up to 1
9.	Manganese	0.1	May be extended up to 0.5
10.	Chlorides	250	May be extended up to 1000
11.	Sulphates	150	May be extended up to 400
12.	Nitrates	45	No relaxation
13.	Fluoride	0.6 to 1.2	If the limit is below 0.6 water should be rejected, Max. Limit is extended to 1.5
14.	Phenols	0.001	May be relaxed up to 0.002
15.	Mercury	0.001	No relaxation
16.	Cadmium	0.01	No relaxation
17.	Selenium	0.01	No relaxation
18.	Arsenic	0.05	No relaxation
19.	Cyanide	0.05	No relaxation
20.	Lead	0.1	No relaxation
21.	Zinc	5.0	May be extended up to 10.0
22.	Anionic detergents (MBAS)	0.2	May be relaxed up to 1
23.	Chromium as Cr ^{VI}	0.05	No relaxation
24.	Poly nuclear aromatic Hydrocarbons	--	--
25.	Mineral Oil	0.01	May be relaxed up to 0.03
26.	Residual free Chlorine	0.2	Applicable only when water is chlorinated
27.	Pesticides	Absent	--
28.	Radio active	--	--

An increase in pH (above 8.5) enhances the conversion of nontoxic ammonia (ammonium ion) to a toxic form of ammonia (un-ionized ammonia). In the case of the 5 water samples collected in

the pre monsoon and also for the 6 samples collected in the post monsoon period have pH within the permissible level of BIS which is in the range 6.5 to 8.5. The result is given in Fig. 3.1. The highest value was noted at the centre of the lake in the pre monsoon period. The pH values of all the post monsoon samples were found to be lower than that of pre monsoon. All the samples invariably showed a pH indicative of weakly acidic water indicating the presence of dissolved carbon dioxide. The seasonal change in the pH value is given in Fig.4.

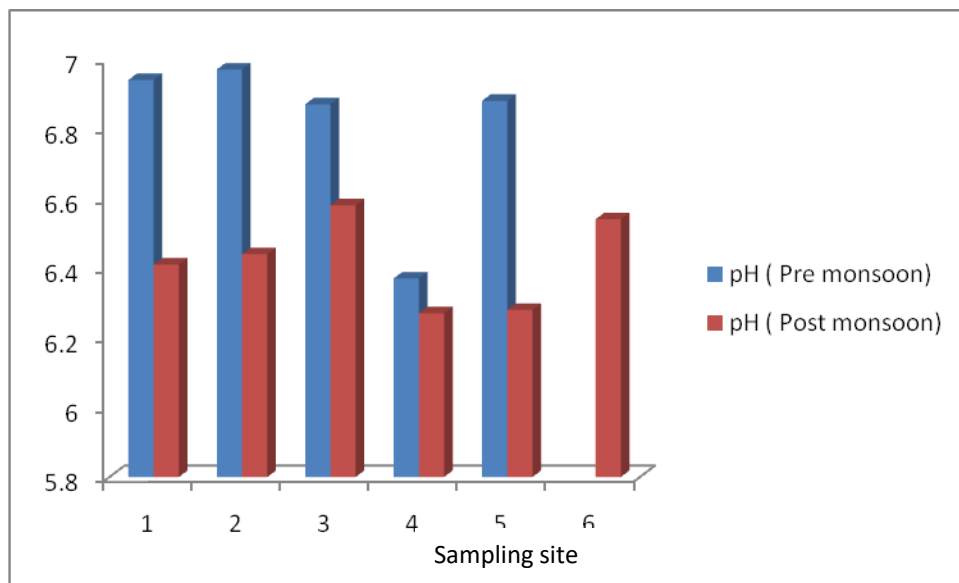


Fig.4. Variation of pH with pre and post monsoons

All the samples collected in the pre and post monsoons showed negligible electrical conductance indicating the absence of any dissolved ion in them and also that the water is not saline.

The alkalinity of the water samples were the same before and after monsoon. All the samples showed phenolphthalein alkalinity value as zero indicating the absence of OH^- and CO_3^{2-} ions in these samples. The methyl orange alkalinity is due to the presence of dissolved HCO_3^- in very trace amounts. The alkalinity is a measure of the buffering capacity of water. Total alkalinity should be between 20 and 200 mg/L CaCO_3 equivalence. Such water samples are good for drinking purpose. Low value of alkalinity is indicative of its tendency to undergo changes in pH with addition of acids. So these two samples are not suitable for drinking purpose. Both the water samples collected from the site opposite to filter house has highest value of alkalinity, i.e., 15 mg/L. The trends of variation of total alkalinity with pre and post monsoon are given in Fig.5.

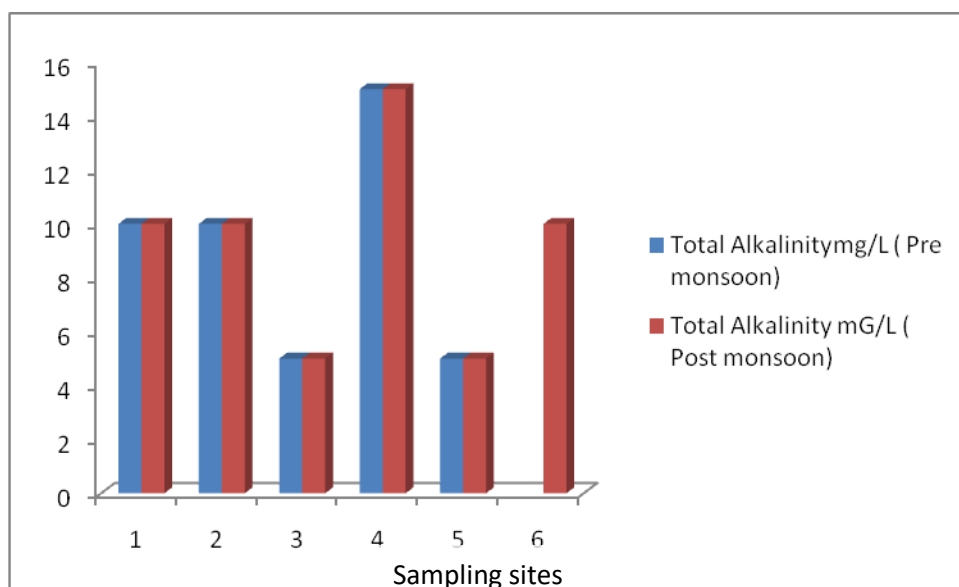


Fig.5. Variation of Total Alkalinity of water samples in the Pre and Post monsoon periods

The methyl orange acidity of all these samples was zero irrespective of season indicative of zero mineral acidity. But the Phenolphthalein acidity or total acidity was 40 mg/L of CaCO_3 equivalence which is due to dissolved carbon dioxide. Among the values the site opposite to filter house had the maximum acidity of 35 mg/L. The variation of acidity of the water samples in the pre and post monsoon periods is given in Fig. 6.

The permissible level for total dissolved solids as per BIS is 500 ppm. All the water samples collected showed a concentration nearly 100 ppm irrespective of season and were found to be in the desirable level for drinking water. The amount of suspended solids is also in the insignificant level. These observations are given in Fig. 7.

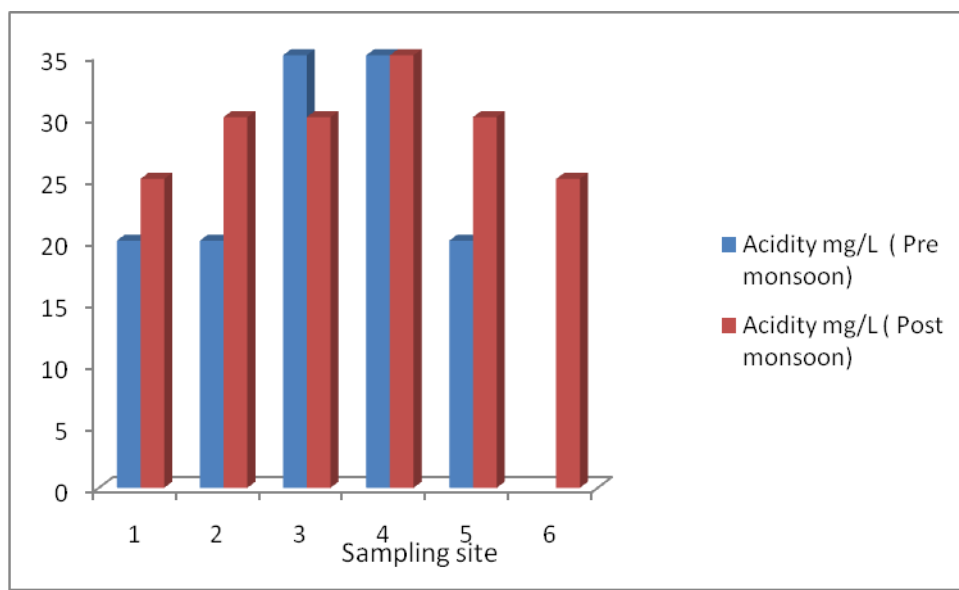
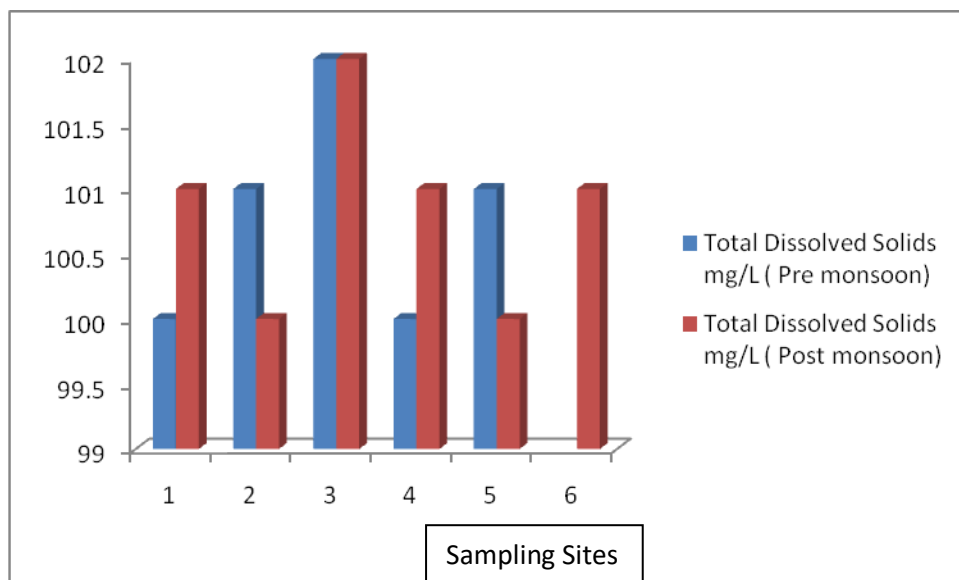


Fig.6. Variation of Total Acidity of water samples in the Pre and Post monsoon periods**Fig.7. Variation of Total Dissolved Solids in the water samples in the Pre and Post periods**

The concentration of various heavy metals in the water samples of pre monsoon are given in Table 3.2. The sites, 3, 4 and 5 (i.e., Opposite Vallakadavu, Opposite of Filter house and Filter House) showed 0.2 mg/L of lead where as the permissible level as per BIS is 0.01 mg/L. All the samples except that collected from Vallakadavu showed 1 mg/mL Cd where as the allowed limit is 0.003 mg/L. The level of chromium should be below 0.05 mg/L. All the samples had the concentration within this limit. The contamination level of Ni was found to be extremely high as the permissible level being 0.02 mg/L. Above this the water may cause allergic reactions. The highest concentration of nickel was in the centre of the lake during pre monsoon. The permissible levels of Fe and Zn are 0.3 and 5 mg/L respectively as per BIS. So contamination by these two heavy metals was not there in these 5 sites. In post monsoon period, the level of contaminant Pb remained the same in sites 3, 4 and 5. The site near the hospital showed maximum concentration of Pb. The concentrations of Cr, Ni and Zn were decreased due to rain water collection. But the levels of Cr and Ni are still above the permissible level in all these sites. The maximum contaminant level for Zinc is shown at site 6 after rain. Another interesting factor is the increase in the concentration of Fe at the sites 2,3 and 4 but still within the permissible limit. The site of study filter house (site 5) showed negligible level of Fe during the post monsoon season. The level of contamination of Fe was increased but to a very little extent

only at the site 4 which is the one opposite to filter house. This result has significance as the presence of Fe was reported to be high in this fresh water body causing the iron bacteria to grow and deteriorate the quality of water by the first week of May 2018! The results of the heavy metal analysis are given in Table 3.

Table. 3. Concentration of Heavy metals in the five sites during pre monsoon

Sampling site	Pb (mg/L)	Fe (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cd (mg/L)
1.Vallakadavu	0	0.01	0.0171	2.5	0.85	0
2.Centre of Lake	0	0	0.0248	4.5	0.9	1
3.Opposite of Vallakadavu	0.2	0	0.0273	1.0	0.75	1
4.Opposite of Filter House	0.2	0	0.0222	1.86	0.7	1
5.Filter House	0.2	0	0.0207	1.86	0.85	1

Table .4. Concentration of Heavy metals in the five sites during pre monsoon

Sampling Site	Pb (mg/L)	Fe (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cd (mg/L)
1.Vallakadavu	0	0.01	0.0069	1	0.7	0
2.Centre of Lake	0	0.01	0.0086	1	0.75	0
3.Opposite of Vallakadavu	0	0.01	0.0094	1	0.7	0

4.Opposite of Filter House	0.2	0.01	0.0083	1	0.7	1
5.Filter House	0.2	0	0.01	1	0.85	2
6.Near MTMM Hospital	0.3	0	0.234	1	0.9	2

The COD value should be lower than 200 ppm as per BIS specifications for drinking water. All the samples, before and after rain had COD values within the permissible limit. But the COD of the sites were decreased after rain. The variation of COD with season at all the sites is given in Fig.8.

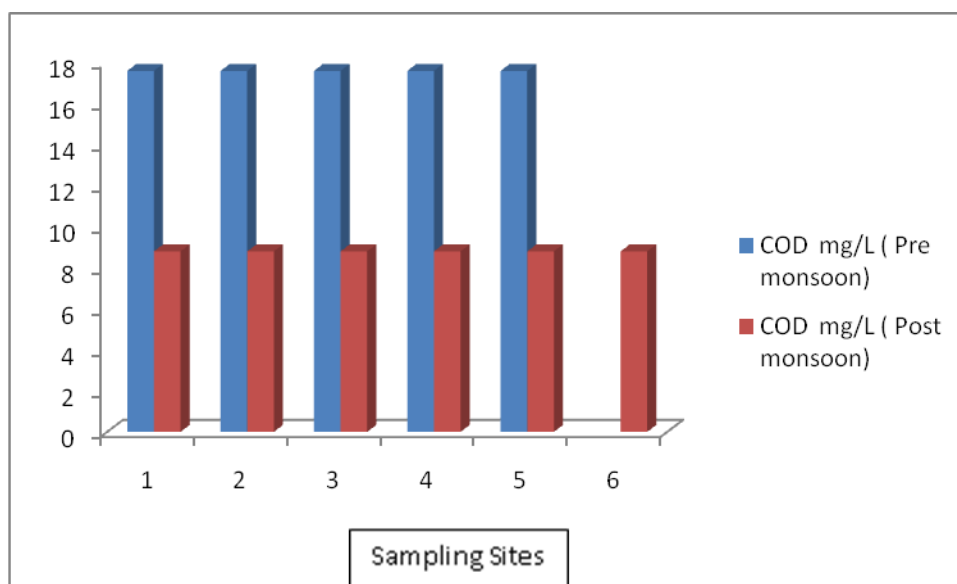


Fig.8. Variation of COD in the water samples in the Pre and Post monsoon periods

The BIS permissible limit for total hardness is 300 mg/L. All the sites before and after monsoon showed only very small quantities of hardness. The site opposite Vallakadavu and the site near MTMM hospital showed the highest value after monsoon. Results of all the physicochemical studies on the water samples collected from the sites during pre and post monsoon periods are compared in Table 5.

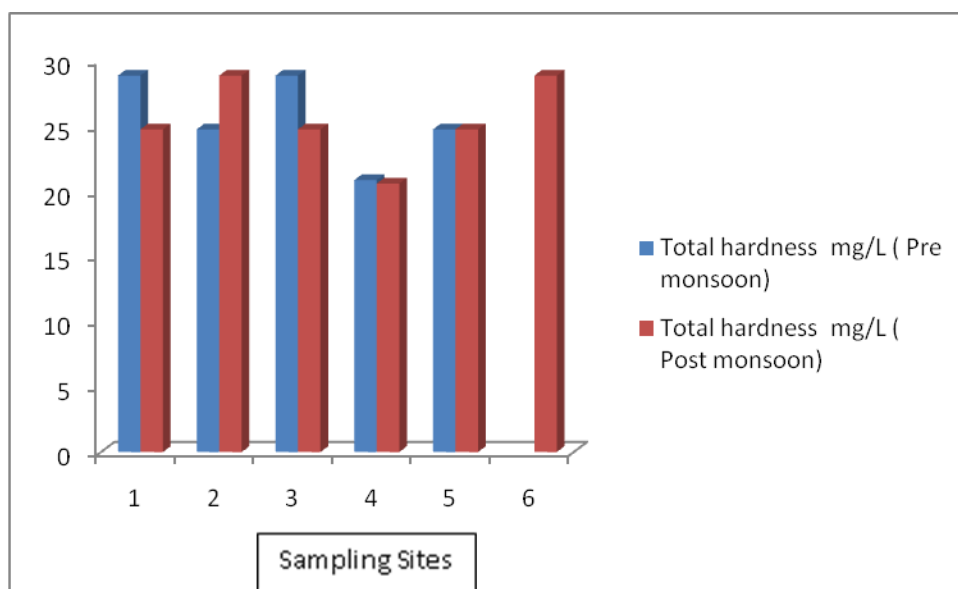


Fig.8. Variation of Total Hardness in the water samples in the Pre and Post monsoon periods

Table.5.Physico–Chemical Parameters Assessed for the sites under study

Sample Code	Acidity (mg/L)	(Alkalinity mg/L)	Conductivity (mg/L)	pH	Total Dissolved Solids (mg/L)	Total Suspended Solids (mg/L)	COD (mg/L)	Total Hardness (mg/L)	Chloride (mg/L)	Concentration of heavy metal in mg/L					
										Pb	Fe	Cr	Ni	Zn	Cd
1	20	10	0	6.94	100	22.93	17.6	3.36	28.8598	0	0.01	0.0171	2.5	0.85	0
2	20	10	0	6.97	101	19	17.6	2.88	24.737	0	0	0.0248	4.5	0.9	1
3	35	5	0	6.87	102	18	17.6	2.4	28.8598	0.2	0	0.0273	1	0.75	1
4	35	15	0	6.37	100	17	17.6	2.88	20.851	0.2	0	0.0222	1.86	0.7	1
5	20	5	0	6.88	101	21	17.6	2.88	24.737	0.2	0	0.0207	1.86	0.85	1
After Monsoon															
1	25	10	0	6.41	101	21.15	8.8	2.88	24.737	0	0.01	0.0069	1	0.7	0
2	30	10	0	6.44	100	17	8.8	2.4	28.8598	0	0.01	0.0086	1	0.75	0
3	30	5	0	6.58	102	17.2	8.8	2.88	24.737	0	0.01	0.0094	1	0.7	0
4	35	15	0	6.27	101	15.98	8.8	2.88	20.5851	0.2	0.01	0.0083	1	0.7	1
5	30	5	0	6.28	100	15.6	8.8	2.88	24.737	0.2	0	0.01	1	0.85	2
6	25	10	0	6.54	101		8.8	3.36	28.8598	0.3	0	0.0234	1	0.9	2

SUMMARY AND CONCLUSIONS

The present investigation is mainly focused on the evaluation of the diffuse pollution in some selected sites within the Ramsar site, Sasthamcotta fresh water lake. For this seasonal effects are studied by selecting the pre and post monsoon periods of April and June 2018.

The general conclusions drawn from these studies are as follows:

- The non point source pollution of Sasthamcotta Lake is deteriorating its quality as a source of fresh water.
- The main contaminants of this Ramsar site are heavy metals. This is a pioneering report on the presence of heavy metals in this potent site.
- The contamination by heavy metal was decreased during post monsoon. The level of Zn and Fe in all the sites were found to be within the permissible limits in pre monsoon.
- The level of contamination by Pb, Ni and Cd were found to be above the limits allowed. These were reduced in the post monsoon periods.
- The potent site 6, near MTMM Hospital needs special attention as it showed high levels of Pb, Ni and Cd.

The results of the study points to the futuristic aspects of control measures to be incorporated to protect this internationally important wetland. Heavy metal concentration above the permissible level in some sites even before monsoon and in the site near the MTMM Hospital underscore an alarming situation where surveillance studies are required urgently. Further studies and strict and periodic monitoring are essential for sustainable development strategies.

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