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HYDROGRAPHY AND SEDIMENTOLOGY OF SASTHAMKOTTA LAKE IN SOUTHERN KERALA, INDIA

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ABSTRACT

Sasthamkotta Lake in Southern part of Kerala is a major wetland of international prominence under Ramsar Convention since 2002. It is an isolated freshwater body mainly nourished by rain and underground water sources. The temporal distinctions in the physicochemical parameters of water and sediments were analyzed. The samples were collected monthly during the period from January to December 2016. Surface area and volume of the lake have a drastic decline. Water quality characteristics exhibited definite temporal fluctuations. Dissolved oxygen was at maximum during post monsoon due to low temperature, high aeration and photosynthetic rate. Nutrients in the waterwere ample for the perseverance of the aquatic life. Most of the physicochemical parameters were within the standard limits. pH and organic content in the sediment was maximum during premonsoon which supported the suitable habitat for benthic organisms. Nutrients such as phosphorus and nitrate in the sediment are copious to maintain a fruitful environment of the lake. Therefore the water in Sasthamkotta Lake is acceptable for drinking, industrial production and domestic purposes by the people in Kollam city and suburban areas.

KEY WORDS : Sasthamkotta Lake, Physicochemical, Water, Sediment

INTRODUCTION

Water is essential for the survival and growth of all forms of life. Population pressure increased the environmental degradation at an alarming rate. The changes in physicochemical parameters of an aquatic system and biotic community are complementary to each other. Nowadays freshwater resources are unsuitable for human consumption. To avoid water crisis it is necessary to assess the health of the aquatic ecosystem. Therefore conservation of freshwater is important for all living beings.

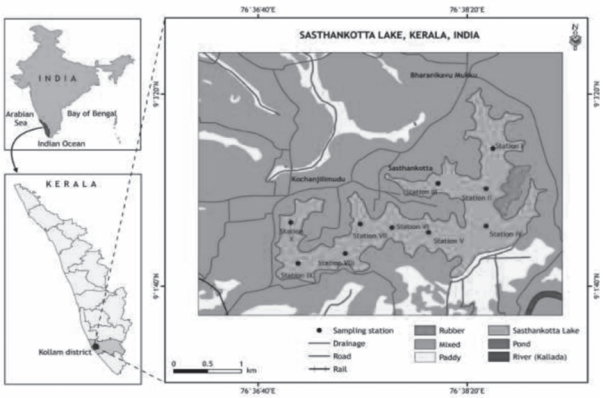
Sasthamkotta Lake is the major freshwater lake in Kerala which caters water for various purposes to the Kollam city. Although taking into account of the previous studies there is changes in hydrochemical and certain geochemical parameters of lake. Since the storage capacity of Sasthamkotta Lake is decreasing. It is necessary to have knowledge on the changes in the water and sediment parameters. Therefore the present study is focused on physicochemical parameters of water and sediments in Sasthamkotta Lake.

MATERIALS AND METHODS

Sasthamkotta Lake (9ˆ00′-9ˆ05′ North latitude and 76°35′-76°40′ East longitude) is the biggest rain fed freshwater lake in Kerala (Map 1). It is lying in the Kunnathur Taluk 29 km north – east of Kollam district of Kerala, India. The lake is bounded on all three sides by hillocks except on the eastern side by earthen bund. This inverted 'F' shaped lake does not have any inlet or outlet with other water bodies. This isolated water body is surrounded by freshwater systems namely Chelurpola *Kayal*, Chirayattu *Kayal*, Chittumala *Chira* and on one side is Kallada river. Ashtamudi Lake is located about 5 km away from the Sasthamkotta Lake.

Water and sediment samples were collected monthly from ten different stations of Sasthamkotta Lake during the period from January to December 2016. Physicochemical parameters of water and sediment samples were analyzed as per the methods

of Trivedy and Goel (1986) and APHA (2005). Data for sediment texture is collected from published literature (Joseph (1994); Krishnakumar *et al.* (2005); Girijakumari (2007) and John E. Sheikh *et al.* (2014). Based on the rainfall data from Meteorological Department, the period of study was divided into three seasons such as premonsoon (January to April), monsoon (May to August) and post monsoon (September to December).



Map. 1. Sasthamkotta Lake, Kollam, Kerala

RESULTS

Seasonal variations of atmospheric and water temperature of Sasthamkotta Lake are depicted in Fig. 1, 2.1 and 2.2. Atmospheric temperature varied from 28.5 °C to 30.0 °C, 26.3 °C to 27.8 °C and 26.4 °C to 28.8 °C during premonsoon, monsoon and post monsoon respectively. Premonsoon period was the season with maximum atmospheric temperature. Surface water temperature varied from 29.4 °C to 30.4 °C, 27.5 °C to 28.5 °C and 27.7 °C to 28.6 °C during premonsoon, monsoon and post monsoon respectively. Bottom water temperature varied from 29.3 °C to 29.8 °C, 27.5 °C to 28.3 °C and 27.6 °C to 28.6°C during premonsoon, monsoon and post monsoon respectively.

Seasonal data on depth of water in the lake is presented in Fig. 3. Depth of the lake varied from 2.38 m to 4.06 m, 3.91 to 9.19 m and 3.03 m to 5.25 m during premonsoon, monsoon and post monsoon respectively. Seasonal variation in transparency is depicted in Fig.4. Transparency was varied from 83.75 cm to 140.00 cm, 144.06 cm to 175.50 cm and 87.50 cm to 110.00 cm during premonsoon, monsoon and post monsoon respectively.

Seasonal variation in pH is illustrated in Fig.5.1 and 5.2. Surface water pH varied from 6.46 to 6.84, 6.39 to 7.12 and 6.36 to 6.79 during premonsoon, monsoon and post monsoon respectively. Bottom water pH fluctuated from 6.39 to 6.89, 6.67 to 7.09 and 6.33 to 6.97 during premonsoon, monsoon and post monsoon respectively.

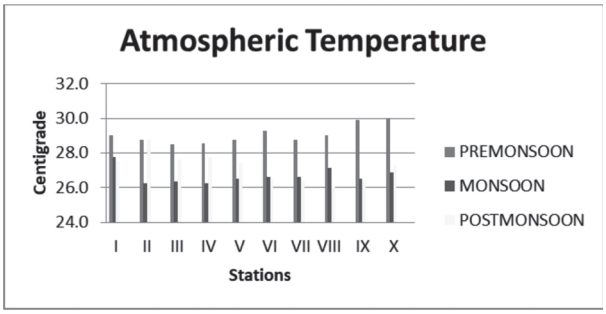


Fig. 1. Seasonal variation in atmospheric temperature in Sasthamkottalake during 2016

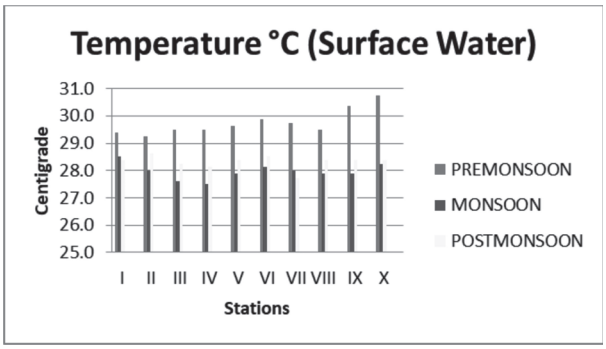


Fig. 2.1

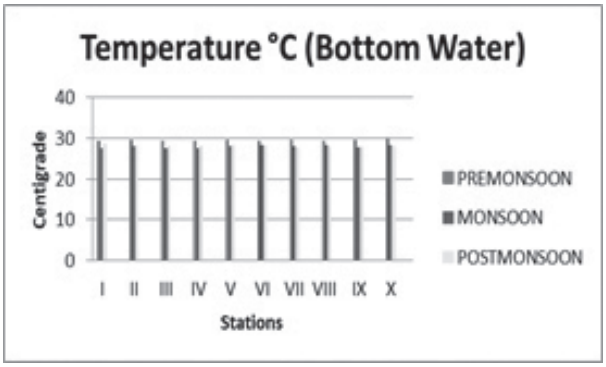


Fig. 2.2

Fig. 2.1 and 2.2. Seasonal variation in temperature of water in Sasthamkotta Lake during 2016

Seasonal fluctuation in dissolved oxygen in water samples is presented in Fig. 6.1 and 6.2. Dissolved oxygen of surface water varied from 5.20 mg/L to 6.45 mg/L, 5.90 mg/L to 7.45 mg/L and 6.75 mg/L to 7.75 mg/L during premonsoon, monsoon and post monsoon respectively. Bottom water dissolved oxygen concentration varied from 4.05 mg/L to 6.45 mg/L, 5.80 mg/L to 7.25 mg/L and 6.65 mg/L to

7.45 mg/L during premonsoon, monsoon and post monsoon respectively. Seasonal variation in carbondioxide concentration is depicted in Fig. 7.1 and 7.2. Concentration of carbon dioxide in surface water varied from 3.42 mg/L to 5.88 mg/L, 3.37 mg/L to 4.78 mg/L and 2.88 mg/L to 3.81 mg/L during premonsoon, monsoon and post monsoon respectively. Carbon dioxide concentration in bottom water fluctuated from 3.01mg/L to 5.86 mg/L, 3.33mg/L to 4.85 mg/L and 3.19 mg/L to 4.73 mg/Lduring premonsoon, monsoon and post monsoon respectively.

Seasonal variation in total alkalinity of water samples is presented in Fig. 8.1 and 8.2. Alkalinity of surface water varied from 20.00 mg/L to 26.25mg/L, 15 mg/L to 18.75 mg/L and 26.25mg/L to 40.00mg/L during premonsoon, monsoon and post monsoon respectively. It followed a seasonal trend with postmonsoon>premonsoon> monsoon. Seasonal difference of alkalinity in bottom water varied from 20 mg/L to 31.25 mg/L, 13.75 mg/L to 21.25mg/L and 23.75 mg/L to 40 mg/L during postmonsoon, premonsoon and monsoon respectively. This followed a seasonal trend with postmonsoon>premonsoon>monsoon

Seasonal distribution in hardness of water samples is presented in Fig. 9.1 and 9.2. Hardness in surface water fluctuated from 10mg/L $CaCO_3$ to 14.5 mg/L $CaCO_3$, 13.5 mg/L $CaCO_3$ to 20 mg/L $CaCO_3$ and 13.5 mg/L $CaCO_3$ to 19 mg/L $CaCO_3$ during premonsoon, monsoon and post monsoon respectively. No significant variations were observed in bottom water and the values ranged from 10 mg/L $CaCO_3$ to 14.5 mg/L $CaCO_3$, 15.5mg/L $CaCO_3$ to 21.00 mg/L $CaCO_3$ and 15mg/L $CaCO_3$ to 19.5mg/L $CaCO_3$during premonsoon, monsoon and post monsoon respectively. Seasonal variation in calcium and magnesium hardness of water samples is illustrated in Fig. 10.1,10.2, 11.1 and 11.2.Calcium in surface water fluctuated from 4.41mg/L $CaCO_3$ to 6.41mg/L $CaCO_3$, 4.81mg/L $CaCO_3$ to 9.42 mg/L $CaCO_3$ and 4.61mg/L $CaCO_3$ 8.22 mg/L $CaCO_3$ during premonsoon, monsoon and post monsoon respectively while the values of bottom water ranged from 4.81 mg/L $CaCO_3$ to 6.01mg/L $CaCO_3$, 4.41mg/L $CaCO_3$ to 9.02 mg/L $CaCO_3$ and 5.81mg/L $CaCO_3$ to 7.61mg/L $CaCO_3$ during premonsoon, monsoon and post monsoon respectively. Magnesium in surface water varied from 7.81mg/L $CaCO_3$ to 10.59 mg/L $CaCO_3$, 10.20 mg/L $CaCO_3$ to 17.07mg/L $CaCO_3$ and 2.03 mg/L $CaCO_3$ to 4.76 mg/L $CaCO_3$during premonsoon, monsoon and post monsoon respectively while the values of bottom water fluctuated from 7.07 mg/L $CaCO_3$ to 11.57 mg/L $CaCO_3$, 11.10 mg/L $CaCO_3$ to 17.95mg/L $CaCO_3$ and 1.87 mg/L $CaCO_3$ to 4.14mg/L $CaCO_3$during premonsoon, monsoon and post monsoon respectively.

Seasonal fluctuation in chloride of water samples is presented in Fig. 12.1 and 12.2. Concentration of chloride in surface water varied from 18.63 mg/L to 23.11mg/L, 15.47mg/L to 17.14mg/L and 17.89mg/L to 21.62mg/L during premonsoon, monsoon and post monsoon respectively, corresponding values in bottom water were 19.75 mg/L to 22.36mg/L, 15.65 mg/L to 17.89 mg/L and 19.02 to 21.24mg/L during premonsoon, monsoon and post monsoon respectively. Seasonal variation in salinity of water samples is presented in Fig. 13.1 and 13.2. Salinity is linked with the chloride content in the lake. The values for salinity in surface water ranged from 0.063 ppt to 0.070 ppt, 0.057 ppt to 0.059 ppt and 0.061 ppt to 0.068 ppt during premonsoon, monsoon and post monsoon respectively, while in bottom water salinity fluctuated from 0.065 ppt to 0.069 ppt, 0.057 ppt to 0.061 ppt and 0.063 ppt to 0.067 ppt during premonsoon, monsoon and post monsoon respectively.

Seasonal variation in nitrite of water samples is presented in Fig. 14.1 and 14.2. The concentration of nitrite in surface waters of the lake varied from 0.0032 ppm to 0.0542 ppm, 0.0041 ppm to 0.0868 ppm and 0.0022 to 0.0145 ppm during premonsoon, monsoon and post monsoon respectively while the values in bottom waters fluctuated from 0.0041 ppm to 0.0099 ppm, 0.0052 ppm to 0.8689 ppm and 0.0041 ppm to 0.0083 ppm during premonsoon, monsoon and post monsoon respectively. Seasonal variation in nitrate of water samples is presented in Fig. 15.1 and 15.2. Nitrate in surface water varied from 0.2529 ppm to 0.6360 ppm, 0.1073 ppm to 0.9376 ppm and 0.2488 ppm to 2.1419 ppm during premonsoon, monsoon and post monsoon respectively. The corresponding values in bottom water varied from 0.4851 ppm to 0.7858 ppm, 0.4184 ppm to 1.7751 ppm and 0.4388 to 0.9339 ppm during premonsoon, monsoon and post monsoon respectively.Seasonal variation in silicate of water samples is depicted in Fig. 16.1 and 16.2. Concentration of silicate – silicon in surface water varied from 2.7417 ppm to 3.7417 ppm, 2.2416 ppm to 3.6250 ppm and 2.1503 ppm to 3.2297 ppm during premonsoon, monsoon and post monsoon respectively while in bottom water it ranged from 2.9417 ppm to 9.1000, 1.9417 ppm to

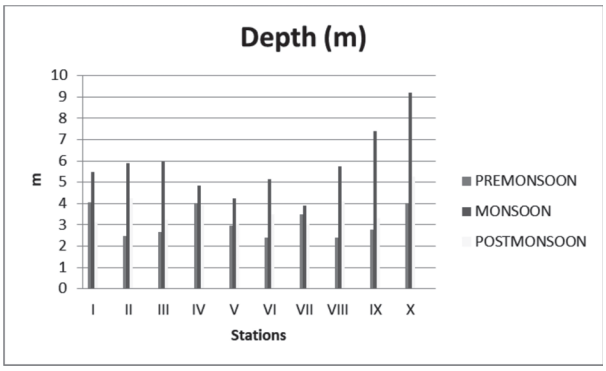


Fig. 3. Seasonal variation in depth of water in Sasthamkotta Lake during 2016

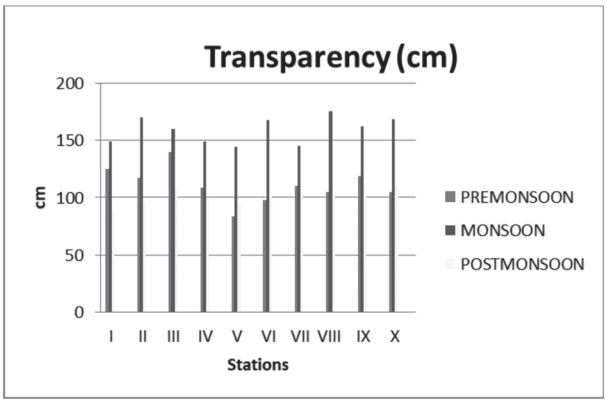


Fig. 4. Seasonal variation in transparency of water in Sasthamkotta Lake during 2016

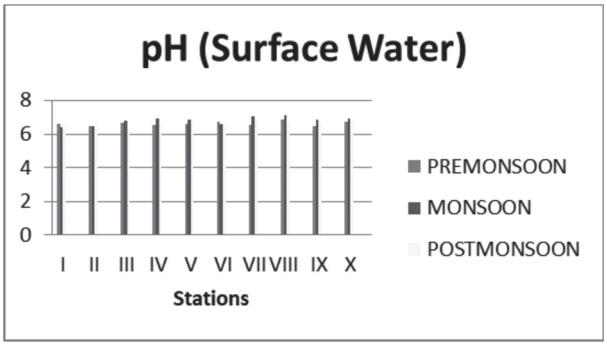


Fig. 5.1

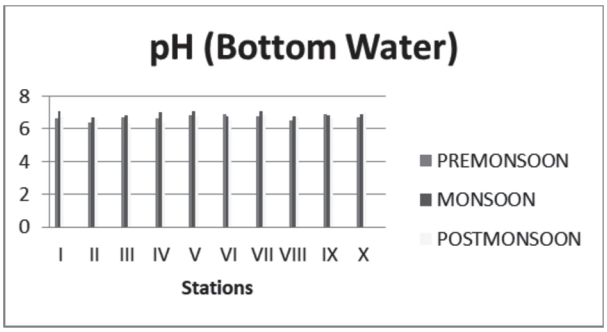


Fig. 5.1 and 5.2. Seasonal variation in pH of water in Sasthamkotta Lake during 2016

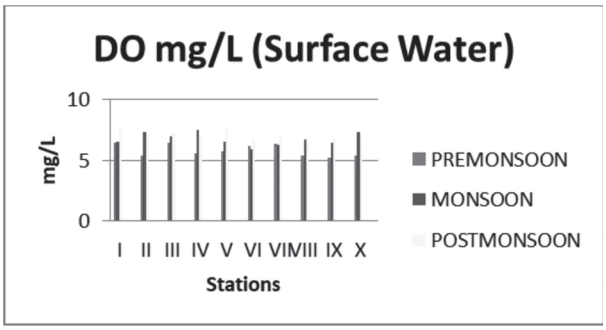


Fig. 6.1

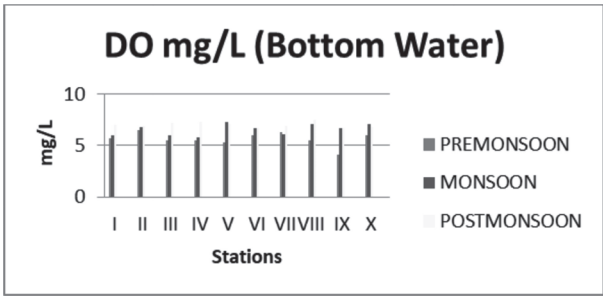


Fig. 6.2

Fig. 6.1 and 6.2. Seasonal variation in Dissolved Oxygen of water in Sasthamkotta Lake during 2016

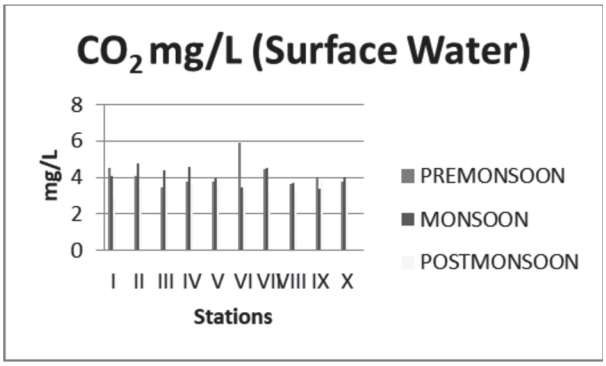


Fig. 7.1

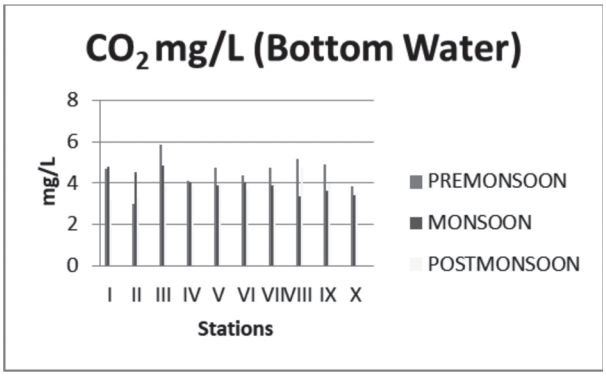


Fig. 7.2

Fig. 7.1 and 7.2. Seasonal variation in Carbondioxide of water in Sasthamkotta Lake during 2016

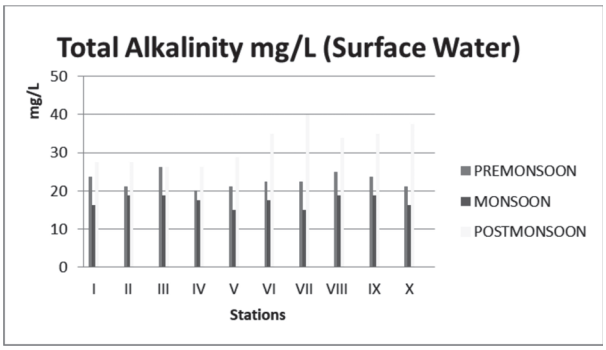


Fig 8.1

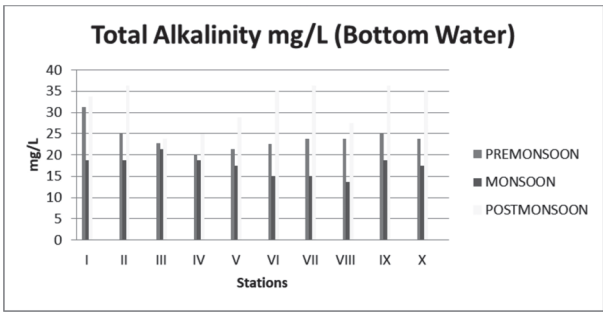


Fig 8.2

Fig 8.1 and 8.2. Seasonal variation in Total Alkalinity of water in Sasthamkotta Lake during 2016

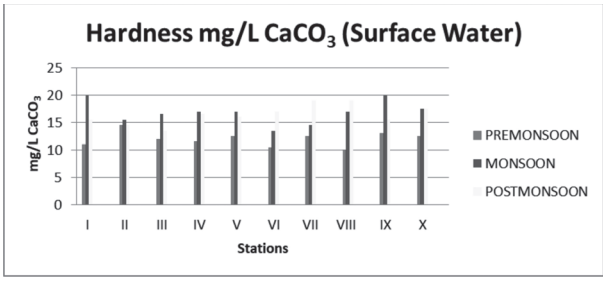


Fig. 9.1

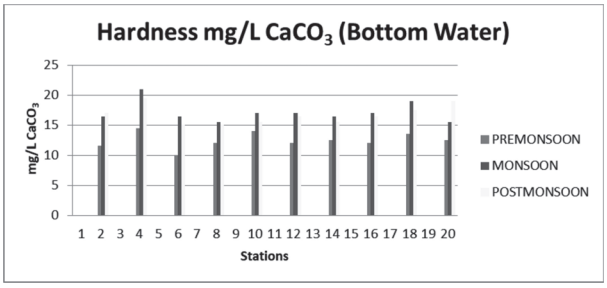


Fig. 9.1

Fig. 9.1 and 9.2. Seasonal variation in Hardness of water in Sasthamkotta Lake during 2016

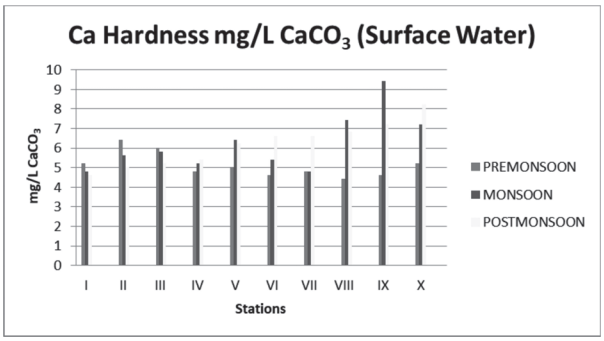


Fig. 10.1

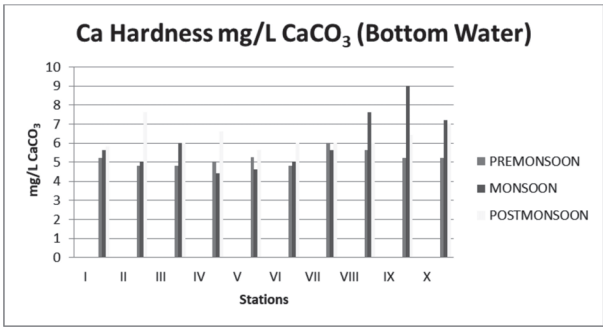


Fig. 10.2

Fig. 10.1 and 10.2. Seasonal variation in Calcium Hardness of water in Sasthamkotta Lake during 2016

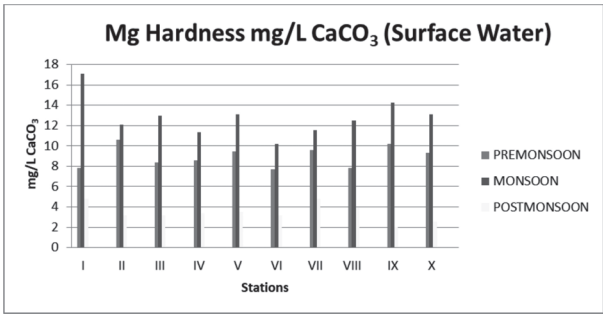


Fig. 11.1

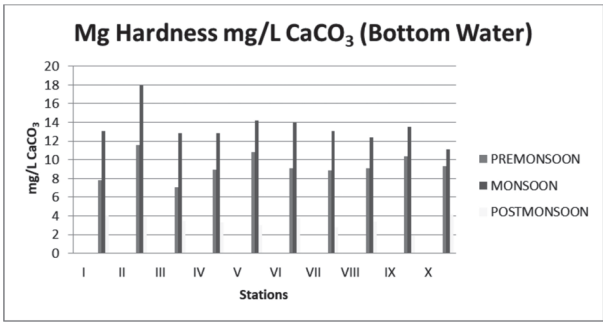


Fig. 11.2

Fig. 11.1 and 11.2 Seasonal variation in Magnesium Hardness of water in Sasthamkotta Lake during 2016

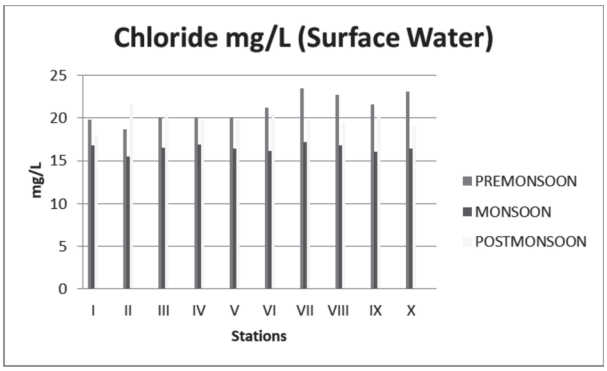


Fig 12.1

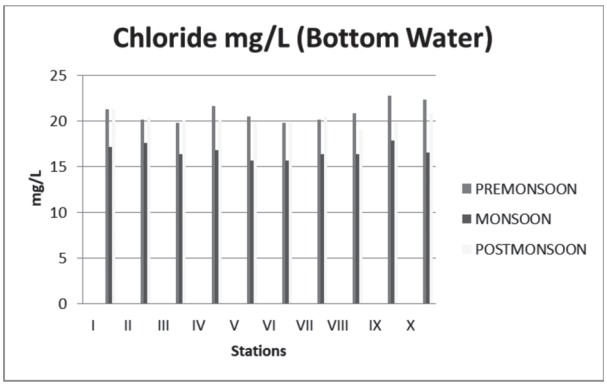
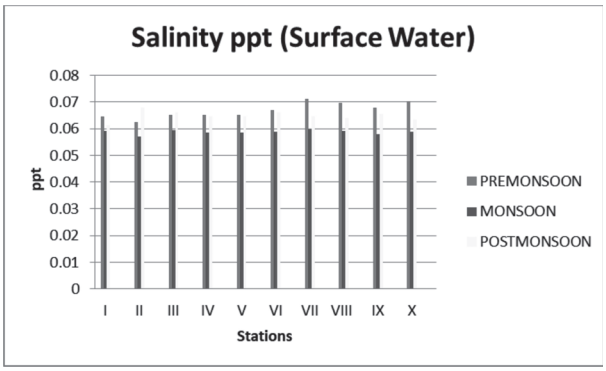


Fig 12.2

Fig. 12.1 and 12.2. Seasonal variation in Chloride of water in Sasthamkotta Lake during 2016



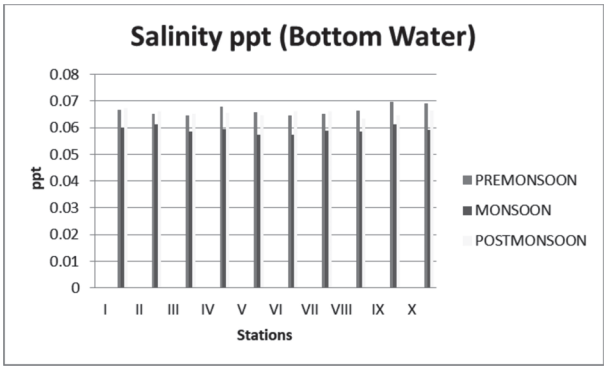


Fig. 13.1 and 13.2. Seasonal variation in Salinity of water in Sasthamkotta Lake during 2016

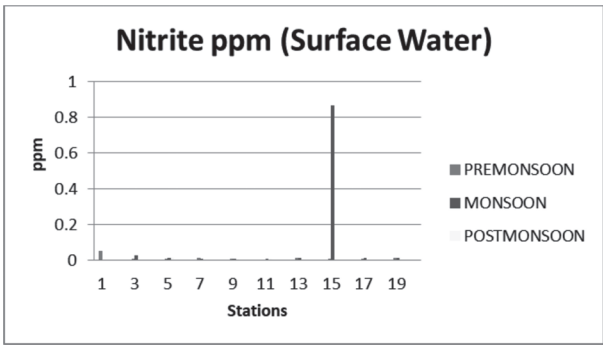


Fig. 14.1

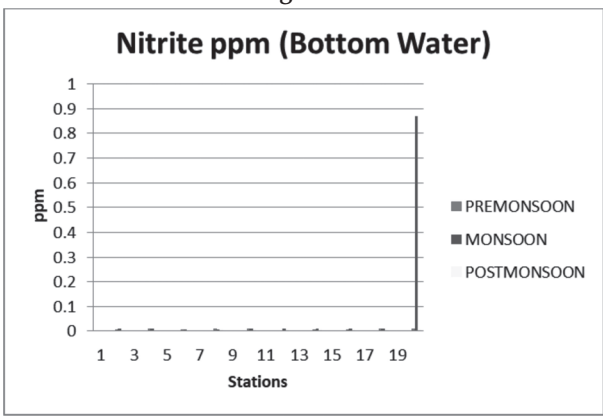


Fig. 14.2

Fig. 14.1 and 14.2. Seasonal variation in Nitrite of water in Sasthamkotta Lake during 2016

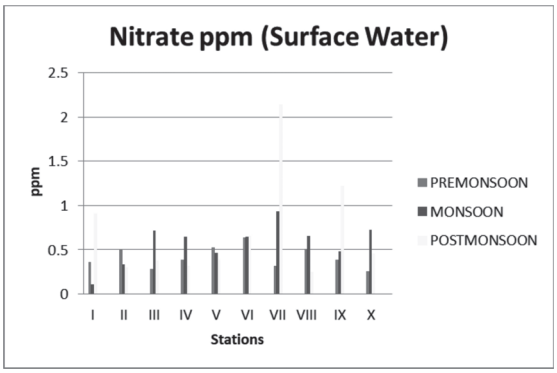


Fig. 15.1

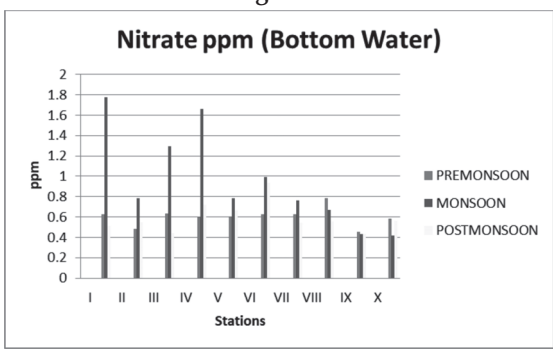


Fig 15.1 and 15.2. Seasonal variation in Nitrate of water in Sasthamkotta Lake during 2016

3.4332 and 2.1724 ppm to 3.6837 ppm during premonsoon, monsoon and post monsoon respectively. Seasonal distribution in phosphate of water samples is presented in Fig. 17.1 and 17.2. Concentration of phosphate-phosphorus in surface water varied from 0.0097 ppm to 0.0563 ppm, 0.0156 ppm to 0.0370 ppm and 0.0189 ppm to 0.0295 ppm during premonsoon, monsoon and post monsoon respectively. A slight increase in phosphate concentration profile in bottom water varied from 0.0084 ppm to 0.0716 ppm, 0.0049 ppm to 0.1847 ppm and 0.0205 ppm to 0.0478 ppm during premonsoon, monsoon and post monsoon respectively.

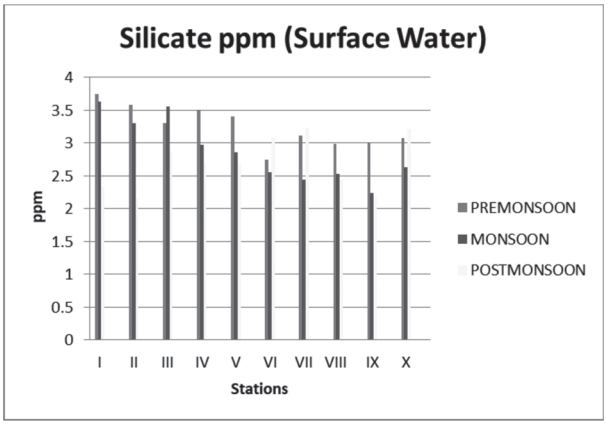


Fig. 16.1

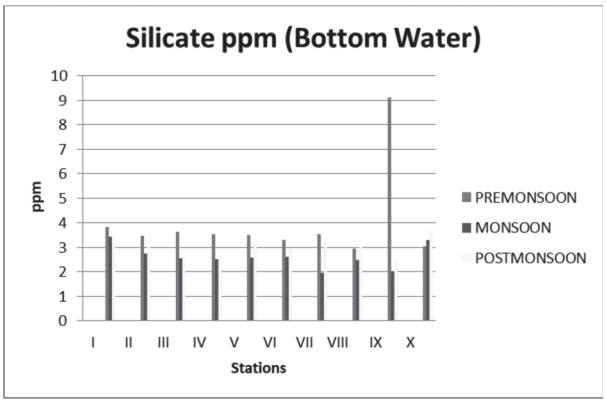


Fig. 16.2.

Fig. 16.1 and 16.2. Seasonal variation in Silicate of water in Sasthamkotta Lake during 2016

Seasonal variation in temperature of sediment samples is presented in Fig. 18. The temperature in the lake bed varied from 28.3 °C to 29.1°C, 27.0°C to 28.5°C and 27.6°C to 28.7°Cduring premonsoon, monsoon and post monsoon respectively.. pH of sediment samples is presented in Fig. 19. Seasonal data on pH in sediments varied from 6.80 to 7.46,

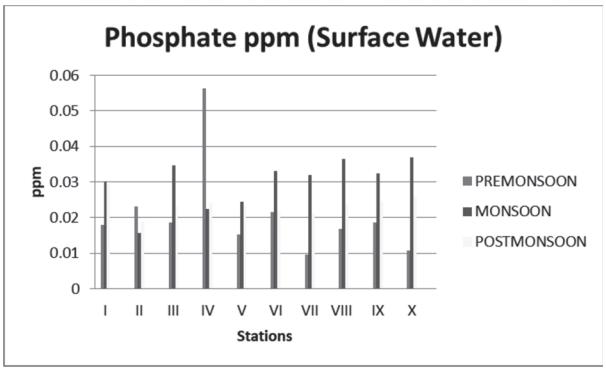


Fig. 17.1

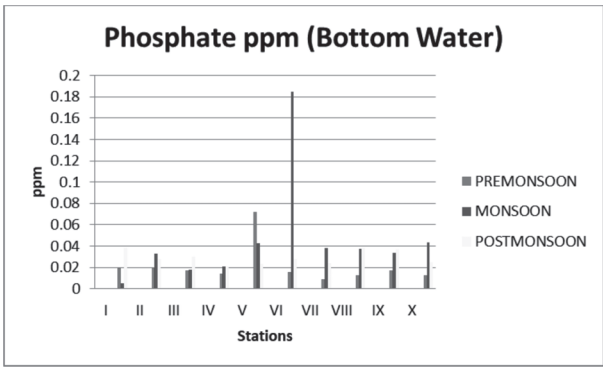


Fig. 17.1 and 17.2.Seasonal variation in Phosphate of water in Sasthamkotta Lake during 2016

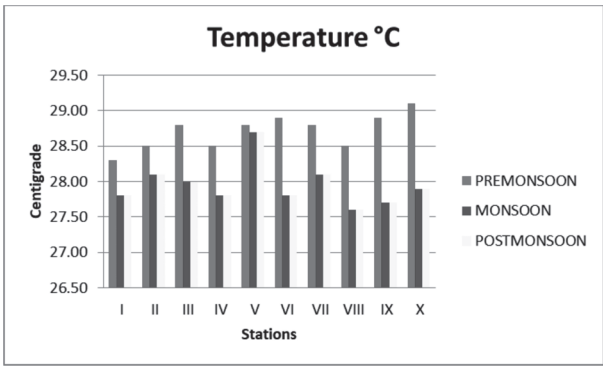


Fig. 18. Seasonal variation in Temperature of sediments in Sasthamkotta Lake during 2016

7.05 to 7.45 and 6.63 to 7.29 during premonsoon, monsoon and post monsoon respectively. Organic carbon of sediment samples is depicted in Fig. 20. Organic carbon in sediments varied from 5% to 12.98 %, 2.32% to 7.44% and 5.69% to 11.11% during premonsoon, monsoon and post monsoon respectively. Seasonal variation in phosphorus of sediment samples is presented in Fig. 21. Phosphorus in sediments varied from 0.0013% to 0.0022%, 0.0012% to 0.0038% and 0.0006% to 0.0052% during premonsoon, monsoon and post

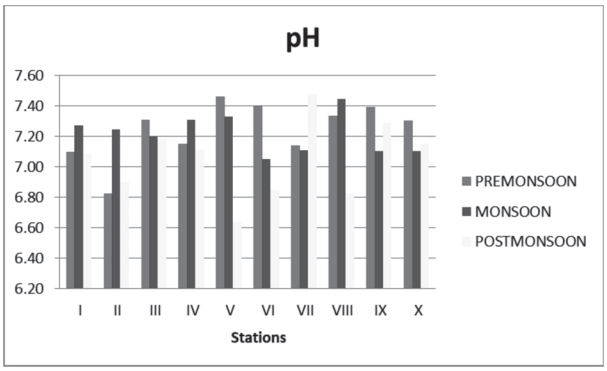


Fig. 19. Seasonal variation in pH of sediments in Sasthamkotta Lake during 2016

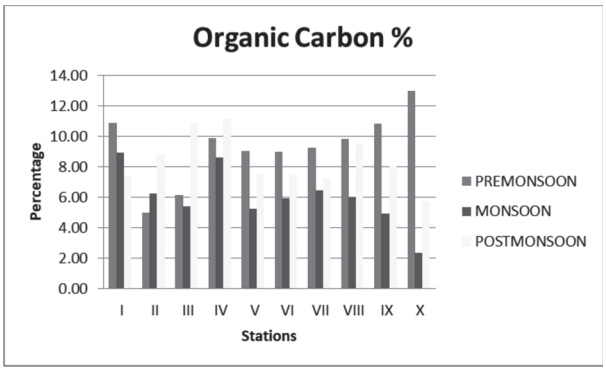


Fig. 20. Seasonal variation in Organic Carbon of sediments in Sasthamkotta Lake during 2016

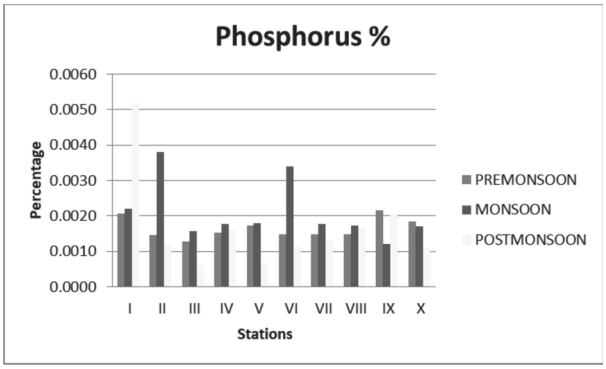


Fig. 21. Seasonal variation in Phosphorus of sediments in Sasthamkotta Lake during 2016

monsoon respectively. Seasonal distribution in nitrate of sediment samples is presented in Fig. 22. Nitrate in sediments varied from 0.0012% to 0.0038%, 0.1511% to 0.2300% and 0.0808% to 0.1225% during premonsoon, monsoon and post monsoon respectively.

DISCUSSION

Air temperature and water temperature is indicated

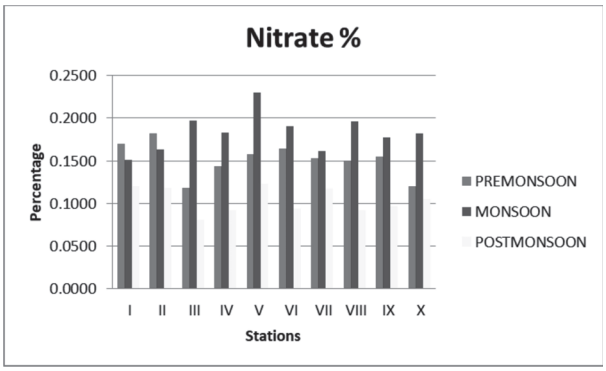


Fig. 22. Seasonal variation in Nitrate of sediments in Sasthamkotta Lake during 2016

by climate change. Atmospheric temperature and heating up of lacustrine environment are parallel to each other. Air temperature and water temperature was directly proportional to each other.Both surface and bottom water temperature followed the temperature profile of the seasons with a higher temperature during premonsoon, lower temperature during monsoon and moderate temperature during post monsoon. Rise and fall in the climate conditions were reflected in the water thermal stability. Turbulent conditions, mixing of surface water, shallowness and location of the lake may account for the variations between air, surface and bottom water temperatures. Major transformations within a lake is associated with water level reduction, degradation, decrease in shoreline length, plant succession and big residential compared to lake area (£awniczak *et al.*, 2011). Water level in the lake increased during the monsoon period due to rainy showers such that the depth of the lake. Reduction in depth was observed during the premonsoon season may be due to the shortage in rain and indiscriminate pumping of drinking water to Kollam areas and nearby suburban regions. Transparency is influenced by colonization by aquatic plants, nutrient availability, concentration of plankton and sediment quality. Decrease in depth of the lake might be responsible for less transparency. Absence of dense algae, dilution of water column by monsoon showers, minimum surface runoff, low suspended particles and low level of dissolved salts might be the cause of maximum transparency during monsoon days. Previous studies of Joseph (1994) in Sasthamkotta Lake and Radhika *et al.* (2004) in Vellayani Lake made related findings. pH of an aquatic system influences the biological activity of aquatic organisms and productivity. The water is slightly acidic and south-west monsoon

slightly shifted the pH value to be alkaline. pH decreased while carbondioxide increased during premonsoon. pH range for domestic water supplies is between 5 to 9 and freshwater aquatic life is between 6.5 to 9 (USEPA, 2004). This variation in pH may be due to leaching and terrigenous runoff.

Dissolved oxygen supports the aquatic life and it is a measuring scale to determine water quality. Low dissolved oxygen in water during premonsoon may be due to high temperature and high organic carbon content. Postmonsoon maxima in dissolved oxygen may be due to the fall in temperature, clear water zone, high aeration and photosynthetic rate. These observations coincided with the studies of Abir (2014) in Rudrasagar wetland and Belkhode (2016) in Kuhi Lake. CO_2 dynamics in lakes are often driven by a combination of internal processes such as photosynthesis and respiration, as well as allochthonous inputs (McGowan *et al.,* 2016). pH and concentration of dissolved oxygen exhibited inverse relationship with carbon dioxide during summer. Maximum carbon dioxide in premonsoon may have resulted from the increased decomposition rate of organic matter during high temperature period.

Total alkalinity is a total measure of the substances in water that have "acid neutralizing" ability (Bheemappa *et al.,* 2015). Both the surface and bottom water showed marked variations in alkalinity during study period. High value on alkalinity in surface water during post monsoon may be due to the impact of waste discharge, agricultural runoff and microbial degradation of organic matter. Low value during monsoon may be due to mixing of water in rainy period.

Hardness in water is due to the presence of dissolved salts of calcium and magnesium, their presence in water leads to many problems such as increase in the boiling point of water, wastage of soap while washing clothes or bathing, wastage of fuel when cooking etc. (Upadhyay and Chandrakala, 2015). Increase in hardness may probably due to the large quantities of soap and detergents used by the residents on the surroundings of lake which drained into the storage area of lake. Higher hardness during monsoon season may also due to the inflow of rainwater from nearby agricultural fields carrying large quantity of suspended salts. Hardness is within the desirable limit. Bathing, washing and domestic activities of humans impart increased concentration of calcium and magnesium to water. The highest amount of calcium content in water was recorded during monsoon season may be due to the addition of sewage waste from the nearby domestic areas whereas the lowest amount of calcium recorded during summer season may be due to the absorption of calcium by aquatic organisms. This observation coincided with the analysis of Umerfaruq and Solanki (2015) in Bibi Lake. The concentration of magnesium remained higher than calcium during the study period. Magnesium was within permissible limit according to ISI standard.

Chloride a major anion in sewage discharges, fertilizers and industrial water has no antagonistic effect on health but become unpotable due to salty taste (Nirmala *et al.,* 2012). The result indicates that the chloride content is less in the lake and also the presence of large amount of organic matter. Maximum chloride concentration reduced dissolved oxygen during premonsoon. Salinity coincides with the concentration of chloride in the lake. The chloride content and salinity concentration in the lake was within the permissible limit.

Nitrite is the reduced form of nitrate and formed from the conversion of ammonia. Maximum nitrite during monsoon may be due to the influence of south-west monsoon. Low nitrite during post monsoon may be due to consumption of nitrite by the plankton as soon as the ammonia degraded. Nitrate is one of the most prevalent chemical constituent in aquatic ecosystem. Elevated nitrate levels are carcinogenic to humans and aquatic life. Excessive nitrate in surface water during post monsoon may be due to the influx of nitrates from agricultural activities and poorly functioning of septic systems. Also after the monsoon showers, nitrate might be drained to water from the terrestrial areas. Low nitrate concentration may be due to the luxuriant growth of aquatic plants in the lake. Radhika *et al.* (2004) had similar findings in Vellayani Lake, it states that higher silicate concentration during premonsoon may be due to increased water temperature, higher evaporation rate and high chloride content. Low silicate concentration may be due to the utilization of silicate by the diatoms in the lake. Phosphate have significant role in eutrophication, regulates primary productivity and degrade water quality. Higher phosphate concentration during premonsoon in surface water may be due to the low water level which might have settled nutrients from nearby agricultural fields and soil runoff. The levels of phosphate indicate the unpolluted status of the lake.

Sediments are particles formed from rock and biological materials which is transported by water and ultimately settles at the bottom of water. It is composed of both organic and inorganic components. The temperature of the sediment coincided with the season prevailed during the study period. pH determines the chemical nature and fertility condition of sediments. It also has impact on the release of nutrients between sediment and overlying water. Sediment is slightly acidic and alkaline in nature. Joseph (1994) observed in Sasthamkotta Lake that high organic carbon content may be due to the supply of organic material into the lake from different sources such as run-off from watershed, drainage discharge, sewage and garbage discharge, leaf fall from the shore-line vegetation and dead remains of plants and animals and their excretory substances. The Lake has the higher concentration of carbon and there is a correlation exists between organic carbon and mud contents (Krishnakumar *et al.,* 2005). This indicates that the silt and the clay rich sediment preserve the organic carbon in Sasthmkotta Lake (Krishnakumar *et al.,* 2005). High organic carbon in Sasthamkotta Lake revealed the bottom sediment was suitable for the survival of sediment-dwelling organisms. The low phosphorus content showed low productivity in the lake.Increase in nitrate content may be due to the inflow of nitrogenous organic material from the catchment through surface run-off (Joseph, 1994). Sediment is dark brown colour and composed of silt and clay. It is smooth during wet and tough and like hard rock when dry. Joseph (1994) observed the composition of texture as sand of 1.10%, silt of 39.08% and clay of 59.82%. The average of textural parameters such as sand was 23.40 %, silt to be 28.33%, clay was on the value of 44.35 % and mud was of 72.71% (Krishnakumar *et al.*, 2005). Spatial distribution of sand, silt and clay at different stations of Sasthamkotta Lake recorded by Girijakumari (2007) exhibited sand of 1.98%, silt of 38.74% and clay of 59.28%. John E. Sheikh *et al.* (2014) recorded average of textural analysis composition such as 0.192% of sand, 27.434% of silt and 72.772% of clay.

Water quality and certain sedimentology parameters of Sasthamkotta Lake revealed that its drinking water potential was well protected. The abiotic and biotic factors are therefore very much eco-balanced in the Sasthamkotta Lake. It is a good environment for the continued existence of the life.

CONCLUSION

The present study revealed that the water quality and sedimentology parameters were maintained in equilibrium. But due to anthropogenic activities the lake is receiving domestic as well as agricultural waste. Also continuous vigorous supply of water and destruction of underground water sprouts have led to the reduction in the water level. Continuous monitoring of lake is necessary to prevent water borne disease outbreaks in Kollam city. It is essential for preserving the health of the aquatic environment.

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