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INFLUENCE OF BENTHIC FAUNA ON HYDROCHEMISTRY AND SEDIMENT IN SASTHAMKOTTA LAKE IN SOUTHERN KERALA, INDIA

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ABSTRACT

Sasthamkotta Lake is the largest freshwater water body of Kerala with great ecological significance, playing also pivotal role in the supply ofwater for drinking, agriculture, fishery exploitation, industrial activities, frivolous navigation and water tourism. Due to their importance, the environmental conditions in the Sasthamkottalake have engrossed an better public attention in present society.The concentrations of various physico-chemical parameters of water and sediment are not exceeding environmental standards. Benthic samples revealed 8 species belonging to Order Diptera, Order Trichoptera and Order Tubificida. The results obtained from thestudy showed good ecological condition despite numerous local and regional natural and anthropogenic interventions.

KEY WORDS : Water, Sediment, Benthic organisms, Sasthamkotta Lake

INTRODUCTION

Water quality impairment are increasing at an alarming rate with subject to anthropogenic stressors.The balance of the aquatic ecosystems is also likely to have been altered extensively by economic development and farming (Hatvani *et al.,* 2014). There is a lot of indication of water quality deterioration, stated in sedimentological, biotic, geochemical, etc. studies that reveal the water quality alterations (Istvánovics *et al.,* 1989) of different water systems.Sediment is also a major site of pollutants which cause lethal effects to overlying water, organisms and also other sediment-dwelling fauna (Adesuyi *et al.,* 2016).

Sasthamkotta Lake being a Ramsar site is it important to monitor the benthic environment. Sediment associated benthic fauna is an integral part of aquatic environment which plays an important role in preserving the water quality and biological factors. These benthic organisms can acquire the climatic and environmental changes so essential for the protection of aquatic environment. The results from the study will provide database for the management of water and benthic environment.

MATERIALS AND METHOD

Sasthamkotta Lake is located in Kunnathur Taluk of Kollam District, between 76°35′-76°40′ East longitude and 9^00′-9^05′ North latitude at an elevation of 33 m above mean sea level (Fig.1). Monthly collection of surface, bottom water and sediment samples from randomly selected ten stations of Sasthamkotta Lake for a period of one year from January 2016 to December 2016. The physicochemical parameters of water and sediment samples were analyzed as per the methods of Trivedy and Goel (1986) and APHA (2005). Bottom sediments were collected with Ekman dredge. The Ekman dredge is a standard instrument restricted to soft bottoms and deep water areas. The area of the dredge is measured to be 210 cm^2. The benthic organisms from each sediment sample are preserved in 70% ethyl alcohol and stained with Rose Bengal. Organism from each sediment sample is sorted and picked manually. Quantitative and qualitative analysis of the organisms were done as per the

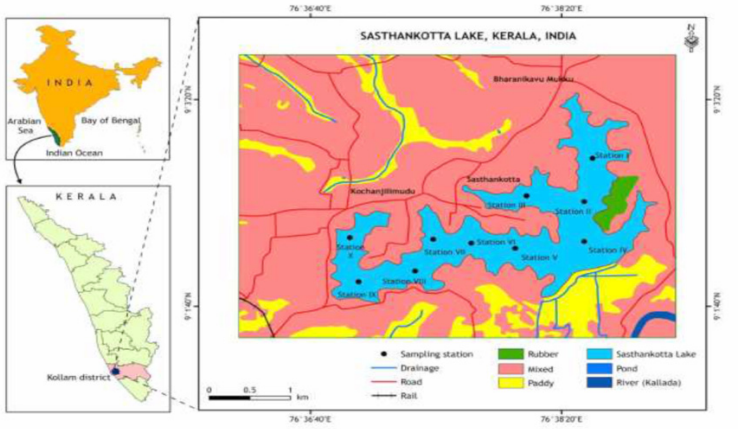

Fig. 1. Map of Sasthamkotta Lake

methods of Michael (1976), Morse *et al*. (1994), Merrit and Cummin (2008) and Tonapi (1980).

RESULTS

Hydrography

The monthly, annual mean and standard error (SE) of physicochemical parameters of water in Sasthamkotta Lakeis depicted in Table 1. Atmospheric temperature was maximum (31.30 °C) in April and minimum (25.1 °C) in July. Depth of the lake was ranged between 5.40 m in April to a maximum of 8.75 m in June. The highest transparency (182.70 cm) was observed in June and lowest (87.50 cm) in December.

The values for surface water temperature obtained ranged between 26.85 °C (July) and 31.25 °C (March). Bottom water temperature was recorded between 26.70 °C (October) and 30.85 °C (April).

The highest value of surface water pH (7.06) was noticed during May whereas lowest value (6.33) was observed during November. The bottom water pH was maximum (7.12) in July and minimum (6.39) in November.

The highest dissolved oxygen in surface water (7.76 mg/l) was noticed in July and lowest (5.30 mg/l) in March. The values for bottom water dissolved oxygen was ranged between (5.12 mg/l) in March and (7.60 mg/l) in October.

Highest concentration of carbondioxide in surface water (5.66 mg/l) was observed in July and lowest (2.08 mg/l) in November. The values for bottom water carbondioxide was ranged between (2.27 mg/l) in November and (5.47 mg/l) in July.

The total alkalinity in surface water was less (11.50 mg/l) in July and more in (44.50 mg/l) in October. The lowest value of total alkalinity in bottom water 14.00 mg/L was observed in July and August and highest value 38.00 mg/l recorded in October.

Hardness in surface water was maximum (26.60 mg/l $CaCO_3$) in August and minimum (6.80 mg/l $CaCO_3$) during December. Highest concentration of hardness in bottom water (26.80 mg/l $CaCO_3$) was observed in September and lowest (7.00mg/l $CaCO_3$) in December.

Surface water Ca hardness was low (3.61 mg/l $CaCO_3$) in April, June and high in (9.22 mg/l $CaCO_3$) during July. Bottom water Ca hardness was ranged between (3.53 mg/l $CaCO_3$) during June, December and (8.58 mg/l $CaCO_3$) in July.

Mg hardness in surface water was ranged between 1.31mg/l $CaCO_3$ in October and 22.84 mg/L $CaCO_3$ in August. Mg hardness in bottom water was observed between 1.36 mg/l $CaCO_3$ in September and 19.35 mg/l $CaCO_3$ during August.

The concentration of chloride in surface water was noticed between 3.73 mg/l in August and 24.15 mg/l during April and September. Bottom water chloride concentration was ranged between 3.88 mg/l in August and 25.34 mg/l during September.

Salinity in surface water was maximum (0.072 ppm) during April and September and minimum (0.036 ppm) in August. Bottom water salinity was maximum (0.075 ppm) during September and minimum (0.037 ppm) in August.

The value of surface water nitrite concentration was low (0.004 ppm) in May, September, November and high during (0.344 ppm) in July. The lowest bottom waternitrite concentration was 0.002 ppm in

Table 1. Physico-chemical parameters of water in Sasthamkotta Lake

Parameters		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	SE
Atmospheric Temperarture (°C)		26.35	28.10	30.35	31.30	29.30	25.25	25.14	27.05	29.20	25.30	26.53	27.60	27.62	0.206
Depth (m)		6.29	6.04	5.70	5.40	6.24	8.75	8.74	8.40	8.25	7.90	7.80	7.33	7.235	0.1648
Transparency (cm)		105.50	89.00	134.00	116.00	141.43	182.70	165.58	146.35	122.20	97.00	94.00	87.50	123.44	3.656
Water temperature (°C)	SW	27.40	29.45	31.25	30.90	29.30	27.55	26.85	28.15	29.25	27.30	28.24	28.45	28.67	0.14
	BW	27.35	28.95	30.70	30.85	28.75	27.30	27.33	28.45	29.40	26.70	28.09	28.10	28.5	0.12
pH	SW	6.62	6.58	6.67	6.60	7.06	6.75	6.83	6.56	6.82	6.52	6.33	6.69	6.67	0.03
	BW	6.72	6.57	6.66	6.85	6.97	6.96	7.12	6.57	6.76	6.75	6.39	6.67	6.75	0.03
Dissolved Oxygen (mg/l)	SW	5.92	6.48	5.30	5.50	5.62	6.42	7.76	7.16	6.96	7.28	7.04	7.12	6.55	0.11
	BW	5.52	5.92	5.12	5.90	5.30	7.00	6.90	6.92	6.54	7.60	6.94	6.84	6.38	0.11
Free Carbondioxide (mg/l)	SW	4.25	3.48	3.80	4.41	3.09	3.41	5.66	4.16	3.98	4.57	2.08	2.97	3.82	0.12
	BW	4.83	5.28	3.57	4.45	3.26	3.65	5.47	3.76	4.62	4.87	2.27	3.37	4.12	0.13
Total Alkalinity (mg/l)	SW	21.00	22.50	23.50	24.00	26.00	16.50	11.50	15.00	23.00	44.50	34.00	25.50	23.92	0.96
	BW	23.00	22.10	26.50	24.00	24.50	17.50	14.00	14.00	26.50	38.00	36.00	26.50	24.38	0.85
Hardness (mg/l $CaCO_3$)	SW	9.40	8.80	20.80	9.00	15.60	13.20	12.00	26.60	26.00	23.20	9.60	6.80	15.08	0.72
	BW	11.00	10.00	19.20	9.60	16.40	13.40	14.20	24.60	26.80	24.00	9.00	7.00	15.43	0.66
Ca Hardness (mg/l $CaCO_3$)	SW	6.09	6.17	4.57	3.61	5.85	3.61	9.22	6.17	7.94	7.13	5.93	3.77	5.84	0.23
	BW	6.74	6.27	3.85	3.93	5.45	3.53	8.58	6.49	8.50	7.13	6.09	3.53	5.84	0.22
Mg Hardness (mg/l $CaCO_3$)	SW	5.69	5.24	18.02	6.80	11.04	11.00	6.38	22.84	1.51	1.31	6.38	4.50	8.39	0.64
	BW	6.70	6.39	16.86	7.21	13.08	10.70	8.22	19.35	1.36	1.51	5.68	4.85	8.49	0.58
Chloride (mg/l)	SW	19.23	21.02	19.98	24.15	21.91	20.05	20.13	3.73	24.15	20.42	17.89	16.85	19.12	0.5
	BW	19.83	21.02	19.98	22.81	22.01	21.02	19.68	3.88	25.34	19.23	17.15	18.93	19.24	0.48
Salinity (ppm)	SW	0.064	0.067	0.065	0.072	0.068	0.065	0.065	0.036	0.072	0.066	0.061	0.060	0.06	0
	BW	0.064	0.067	0.065	0.070	0.069	0.067	0.064	0.037	0.075	0.064	0.060	0.063	0.06	0
Nitrite (ppm)	SW	0.009	0.014	0.025	0.007	0.004	0.021	0.344	0.018	0.004	0.008	0.004	0.006	0.04	0.03
	BW	0.006	0.010	0.008	0.007	0.002	0.014	0.345	0.019	0.007	0.007	0.004	0.005	0.04	0.03
Nitrate (ppm)	SW	0.614	0.287	0.530	0.239	0.253	0.957	0.188	0.890	0.826	0.250	0.611	1.120	0.56	0.06
	BW	1.186	0.377	0.587	0.258	0.235	2.346	0.303	0.946	0.695	0.146	0.542	0.975	0.72	0.08
Phosphate (ppm)	SW	0.046	0.003	0.007	0.028	0.006	0.026	0.042	0.045	0.047	0.025	0.007	0.016	0.02	0
	BW	0.048	0.002	0.007	0.026	0.072	0.022	0.030	0.059	0.060	0.032	0.006	0.018	0.03	0.01
Silicate (ppm)	SW	3.747	2.660	3.177	3.383	3.427	3.663	3.617	0.777	2.730	4.263	1.907	1.833	2.93	0.11
	BW	6.217	2.867	3.447	3.407	3.077	2.620	3.803	0.990	3.320	5.003	1.787	1.737	3.19	0.24

May and highest value 0.345 ppm in July.

Nitrate concentration in surface water was maximum (1.120 ppm) in December and minimum (0.188 ppm) in July. Bottom water nitrate concentration was maximum (2.346 ppm) in June and minimum (0.146 ppm) in October.

The phosphate concentration in surface water was ranged between 0.003 ppm in February and 0.047 ppm in September. Concentration of phosphate in bottom water was ranged between 0.002 ppm in February and 0.072 ppm in May.

The values for surface water silicate obtained recorded between 0.777 ppm (August) and 4.263 ppm (October). Bottom water silicate concentration was recorded between 0.990 ppm (October) and 6.217 ppm (January).

Sediment characteristics

Table 2 Illustrated the monthly, annual mean and standard error (SE) of sediment characteristics in Sasthamkotta Lake. Temperature of sediment was ranged between 26.13°C in July and 30.05°C in April. Sediment pH was observed between 6.90 in December and 7.37 in March. Organic carbon content was recorded between 2.96% in April and 13.73% in January. Concentration in phosphorus was noticed between 0.0007% in February and 0.0034% in April. Nitrate concentration in sediment was ranged between 0.1024% in November and 0.2103% in May.

Biological characteristics of sediments

Table 3 presents the monthly, annual mean and standard error (SE) on the abundance of benthic fauna in Sasthamkotta Lake. A total number of eight benthic dwelling larvae, belonging to three order, five families and eight genera were identified. The chironomid larvae of Sashamkotta Lake mainly consisted of Chironominae comprising 97.927% of *Phaenopsectra* sp. This is followed by *Sumatendipes tobaterdecimus* (1.233%) and *Pristina leidyi* (0.745%).

DISCUSSION

Hydrography

The composition of sediment-dwelling invertebrates can determine the quality of water and sediment characteristics as it is forms stable and strong communities in the sediments under the influence of changes in abiotic and biotic factors. There are several aspects which affect the population density and structure of benthic invertebrates such as

Table 2. Sediment characteristics in Sasthamkotta Lake

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	SE
Temperarture (°C)	26.99	27.95	29.75	30.05	28.30	27.15	26.13	28.30	28.55	27.60	27.69	28.00	28.04	0.11
pH	7.12	7.26	7.37	7.22	7.27	7.25	7.31	6.99	6.99	7.09	7.22	6.90	7.17	0.03
Organic Carbon (%)	13.73	10.67	9.75	2.96	5.39	4.14	7.73	6.79	6.86	7.22	11.13	8.27	7.88	0.4
Phosphorus (%)	0.0012	0.0007	0.0013	0.0034	0.0013	0.0015	0.0029	0.0028	0.0029	0.0009	0.0008	0.0020	.0.00	0
Nitrate (%)	0.1573	0.1370	0.1198	0.1907	0.2103	0.1689	0.1556	0.1978	0.1066	0.1027	0.1024	0.1031	0.15	0

Table 3. Population abundance of benthic fauna in Sasthamkotta Lake

Benthic Fauna	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	SE
Phaenopsectra sp.	5693.1	13082.4	18086.1	8983	11473.7	7059.6	4622.3	2727.3	5540.8	6435.8	5255.1	7426.1	8032.11	576.98
Sumatendipes tobaterdecimus	23.7	9.4	85	156.7	28.4	623.3	28.5	114	61.7	71.3	0	14.2	101.35	21.05
Chironomidae	0	0	0	0	0	0	0	0	0	0	4.7	0	0.39	0.392
Procladius sp.	0	0	0	0	0	0	23.4	0	0	0	4.7	0	2.34	1.986
Chaoborus asiaticus	0	0	0	0	0	0	0	0	0	0	0	14.2	1.18	0.88
Ceratopogonidae	0	0	0	0	0	4.7	0	0	0	0	0	4.7	0.78	0.552
Ecnomus sp.	0	0	0	0	0	0	0	0	0	0	4.7	0	0.39	0.392
Pristina leidyi	0	23.7	47.4	37.9	52.3	261.6	61.8	0	128.3	109.3	0	0	60.19	16.368

temperature, pH, substratum, depth of water, dissolved oxygen, predation (Hammerton, 1972; Talling, 1976; Delince, 1992; Minshall, 1984; Reice, 1980; Samaan, 1977; Allen *et al.,* 1958 and Bell, 1980).

Climatic conditions have profound interactions on the overall health of the aquatic system. Rainfall pattern in the lake area distributed the periods into January to April as premonsoon, May to August as monsoon and September to December as postmonsoon. Atmospheric temperature agreed with the solar radiation and season overcame during the time of collection period. Sasthamkotta Lake is an isolated water body mainly fed by the rainfall. The deficit in rainfall, rapid sedimentation of the lake and indefinite water supply from the lake to Kollam city and suburban areas resulted in the reduction of water level creating drying up of lake area during summer months. Besides these reasons, unscientific mining in nearby freshwater bodies affected the aquifers and groundwaterrecharging of the lake. The depth of the lake, intensity of sunlight, algal population and dilution of water by intermittent rain in turn influenced the transparency of water.

The water temperature distribution was constant with the expected seasonal variations. Many biological activities function within a suitable environment of hydrogen ion concentration. pH of a wetland is greatly influenced by respiration, decomposition and photosynthesis (Heimann and Femmer, 1998).The pH values of the water within suitable range of 6.5-9.0 for aquatic life (Kamran *et al.,* 2003). In the natural water pH is between 6 and 9 (Hem, 1985). The pH of Sasthamkotta Lakeis slightly acidic and southwest monsoon marginally shifted the value to be alkaline. It is within the desirable limit of drinking water standards. Temperature is inversely proportional to dissolved oxygen. High temperature decreases dissolve oxygen concentration in water. Deficit in dissolved oxygen content occur if the aquatic ecosystem collects more organic matter. The water in lake is well-aerated with suitable amount of dissolved oxygen. Levels of dissolved oxygen throughout the sampling period were in consistent with the temperature prevailed at that time.

The major source of carbondioxide in surface water bodies is mainly respiration from aquatic plants and decomposition of organic matter (Abir, 2014). In Sasthamkotta Lake the concentration of carbondioxide of surface water showed the same trend in concentration as that of bottom water. There was also slight difference in concentration in carbondioxide between the surface and bottom water. Alkalinity of water resources means the buffering ability of acid and it is characterized by the hydroxyl ions which surpasses the hydrogen ions (Michael, 1976). A decrease in alkalinity may be as a result of dilution of water. Increased alkalinity might be due to mixing of domestic and agricultural waste discharge and microbial degradation of organic matter. In addition to this, the water was used for washing, bathing and recreational purposes.

Total hardness of water is the sum of the concentration of alkaline metal cations that exists in it (Ramachandra *et al.,* 2006). 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. Calcium is the main constituent in the cell wall of aquatic organisms. This inorganic cation regulates the physiological processes in animals (Kumar *et al.,* 2006). Domestic and municipal sewage and garbage disposal and industrial wastes contribute for the source of calcium. The same trend in calcium was followed in Pookot Lake (CWRDM, 1998). The water remains potable for all the domestic purposes. Krishnakumar *et al.* (2005) reported that high leaching from the sources of soil and rock formation affected the higher content of calcium and magnesium in Sasthamkotta Lake. Bathing, washing and domestic activities of humans impart increased concentration of calcium and magnesium in water.

Chloride may occur in freshwater as a result of salt deposits in the soil being dissolved (Michael, 1976). The water in the Sasthamkotta Lake is fresh and imparts no salty taste to water. Chloride in water affects salinity and ionic exchange and is contributed by the domestic, agricultural, industrial, laterite brick effluents and irrigation drainage to natural waters (Radhika *et al.,* 2004). Chloride content in Pookot Lake was also similar to Sasthamkotta Lake. Salinity is negligible in the lake. Salinity coincided with the chloride content in the lake. Low salinity was recorded throughout the study period.

Dissolved nutrients are the substantial constituents for aquatic primary production. High nitrite concentration may be due to the reduction in nitrate, oxidation of ammonia and decrease in phytoplankton production (Kannan and Kannan, 1996). High concentration in nitrate may be due to the natural water runoff from the adjacent cultivated

land of catchment areas. Watershed region of Sasthamkotta Lake includes different cultivated crops, the runoff from these agricultural fields carries fertilizers, manures and livestockwastes into the lake which increases the nitrate concentration. Lower nitrate concentration may be due to the less decomposition rate of dead organic matter. Nitrite concentration in lake water was within the permissible limit. Inorganic phosphate concentration is a fundamental constituent for plant and algal growth and to control primary productivity. Excess of phosphate into the lake system may be due to the anthropogenic activities coupled with the decomposition of organic deposits by the microbial action. Abundant growth of macrophytes in the lake also contributes to the increased concentration of phosphate. Silicate content in Sasthamkotta Lake was moderately high. Joseph (1994) noted that since Sasthamkotta Lake is an isolated lentic system the silica content might be correlated with edaphic characteristics of Lake Basin. Increased silicate concentration may be due to high water temperature, evaporation rate and high chloride content. Low silicate value may be due to the utilization of silicate by diatoms. Seasonal silicate concentration demonstrates that it has as fluctuating pattern. Similar observation was found in the previous studies of Radhika *et al.* (2004) in Vellayani Lake. In Pookot Lake the concentration of silica is below 1 mg/l in all the water samples (CWRDM, 1998).

Sediment Characteristics

The present investigation aimed to assess the sediment quality in a lentic environment with reference to strong influences from natural and anthropogenic factors. Sediment temperature varied with depths and seasons coincided at the collection period. Sediment pH plays an important role in regulating nutrient cycling such that optimum quantities of food is available to fish maintaining a healthy aquatic environment (Das, 2000). The sediment is alkaline in nature. Gupta and Shaikh (2014) reported that sediment pH in Sasthamkotta Lake was found to be neutral to alkaline nature with pH in the range of 7.8 to 8.91. High organic carbon content in Sasthamkotta Lakemay be either allochthonous or autochthonous origin. The bottom sediment was suitable for the survival of plentiful sediment-dwelling organisms. The low phosphorus content in Sasthamkotta Lake showed low productivity in Sasthamkotta Lake. Excess nitrate in Sasthamkotta Lake may include discharges from septic systems, animal remains and food stuffs, leaching, cultivated land nitro-fertilizers, manure, excessive macrophyte growth, industrial wastes, sanitary landfills, domesticsewage and garbage dumps and decomposed organic matter at the bottom.

Biological characteristics of sediments

The biological analysis aimed to present the quantitative distribution of the benthic organisms in the lake. The composition of the sediment invertebrate community is a useful tool for assessing environmental health and biogeographic changes in aquatic ecosystems (Karr, 1999). During this biological investigation abundant of Chironomids larvae is noticed. The presence of large abundance *Phaenopsectra* sp. larvaesuggests a significant quantity of organic load in the lake. The biological evaluation in terms of composition, relative abundance and diversity of the benthic invertebrate communities, determined that within the examined area *Phaenopsectra* sp. developed as the bioindicator tool in shaping the ecological status of the lake.

CONCLUSION

In spite of the large regional and native pressures in terms of natural and anthropogenic pressures, the present study supported that the Sasthamkotta Lake is in near good ecological form.Both physico-chemical and biological status assertedgood ecological status. The lake is well oxygenated with alkaline character. The physico-chemical parameters agreed thatbenthic environmentof the lake is of special concern.

With reference to sediment quality assessment the physicochemical parameters are within the permissible limit. Sediment has rich organic carbon content that meet the survival requirements of benthic organisms.

The results of the biological assessment recommendedthat the anthropogenic conflicts progressively damage the functioning of the lake system. Generally, lake ecosystems are rightaway connected to the complex physical, chemical and biological progressions taking place within its environment. Anappropriate functioning of a lake system is mainly considered by their degree of involvement between biotic and physicochemical factors.

The acquired results are of specific significance

since the majority of the physicochemical factors are key indicators in providing a supportable habitat that endure environmental conditions for the existence of aquaticfauna.

Finally, this study improved and increased the database on the environmental conditions of the Sasthamkotta Lake, a region of great ecological prominence to the preservation of benthic ecosystems, taking into attention the great variability and heterogeneity in theseveral variables that control and characterize lentic system.

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