Eco. Env. & Cons. 28 (May Suppl. Issue) : 2022; pp. (S338-S343)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i03s.049

Ecology of Lakebed in Relation to Benthic Organisms in Sasthamkotta Lake in Southern Kerala, India

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(Received 3 October, 2021; Accepted 1 November, 2021)

ABSTRACT

Sasthamkotta Lake is the drinking water resource to Kollam city and suburban areas.The lake is designated as Ramsar site since November 2002. The present study aims to assess the sediment quality and proportion of sediment-dwelling organisms in the lake. The physicochemical characteristics of sediment were within the desirable limit. Sediment particle size distribution showed that they have higher percentage of clay (clay > silt > sand). Order Diptera is dominant group in Sasthamkotta Lake. *Phaenopsectra* sp. is the abundant organism accounting to about 97.927% in the total of benthic invertebrates. The study revealed that the lakebed is suitable for the survival of benthic organisms and maintains a healthy aquatic ecosystem.

Key words : *Sediment, Benthic Organism, Diptera, Phaenopsectra sp.*

Introduction

The entire ecological status of a lacustrine environment depends on watermass, biota andsediments (Rzetala *et al.,* 2019). These in turn are subjected to many natural and anthropogenic factors. Organic matter decomposition is carried out by bacteria in the sediments (Adesuyi *et al.*, 2016). Nutrients such as nitrogen and phosphorous are constantly being exchangedamong sediment and overlying water (Abowei and Sikoki, 2005). Sediment in aquatic ecosystem provides habitat, nourishing ground, breeding and rearing areas for many aquatic fauna. Contaminated sediment can cause harmful effect in benthic and other sediment-dwelling fauna (USEPA, 2001). Information from the sediment physicochemical characteristics in Sasthamkotta Lake in Kollam will enable for preserving the bottom deposits and benthic fauna. It will also offer base line records for advance studies.

Materials and Methods

Sasthamkotta Lake, lies between 9°00′-9°05′ North latitude and 76°35′-76°40′ East longitude and falls under the Kunnathur Taluk of Kollam district of Kerala, India (Fig. 1). The lake spread over a huge area of 375 hectares and an average breadth is 0.5 km. The average depth of the lake varies between 6.8 meter and 13.9 meter. The lake is surrounded by freshwater bodies namely Chelurpola Kayal, Chirayattu Kayal and Chittumala Chira on both sides of the Kallada River. It is a major source of drinking water to half a million people of Kollam district. Underground aquifers and rainfall is the source of water to lake. The lake has no inlet and outlet connections with other water masses, the lake is completely isolated.

Monthly collection of sediment samples from the selected ten stations of Sasthamkotta Lake for a period of one year from January 2016 to December 2016. Bottom sediments were collected with Ekman

dredge. Physicochemical parameters of bottom sediments such as temperature, pH, organic carbon, phosphorus and nitrates were analyzed as per the standard methods of Trivedy and Goel (1986).

Benthic organisms were collected from lake sediments. The 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 estimation is as per Quadrate method of Michael (1986). Qualitative analyses of the organisms were done as per the methods of Morse *et al.,* (1994), Merrit and Cummin (2008) and Tonapi (1980).

Results

Sediment Characteristics

The physicochemical characteristics of sediments collected from Sasthamkotta Lake are shown in Table 1. The highest temperature 28.4 °C was recorded at Station II and the least 27.8 °C at Station VIII. The mean annual for sediment temperature was 28.04 ± 1.25 °C. There were no spatial significant difference and noticed seasonal significant differences ($p < 0.01$) in temperature level of the study area.

The maximum pH 7.26 was observed at Station IX and the minimum 6.99 was noticed in Station II. The mean annual for pH was 7.17±0.34. There were no significant differences across stations and noticed seasonal significant differences ($p < 0.05$) in pH.

The organic carbon content ranged between 6.69% in Station II and 9.87% in Station IV. The mean annual was 7.88±4.38% for organic carbon. Significant differences were observed in the ANOVA results between seasons ($p < 0.01$) and no significant interaction between stations in Sasthamkotta Lake.

The phosphorus concentration was varied from 0.0012% at Station III and 0.0032% at Station I. The mean annual value for phosphorus concentration is 0.0020±0.002%. ANOVA showed no significant difference in phosphorus concentrations between stations and seasons.

The lowest value 0.1319% for nitrate concentration was observed in Station III and the highest value 0.1699% was recorded at Station V. The annual value for nitrate concentration was 0.1500±0.05%. Significant differences ($p < 0.01$) were observed in nitrates between seasons and no significant difference across stations.

The results from secondary data on particle size distribution of the sediments are depicted in Table 2. Joseph (1994) observed composition of texture which showed that 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%. Shiekha E. John *et al.* (2014) recorded average of textural analysis composition such as 0.192% of sand, 27.434% of silt and 72.772% of clay.

Correlation between variables in sediment samples is shown in the Table 3. Pearson correlation matrix for sediment parameters revealed that a few parameters showed significant difference from each other. Temperature is positively correlated with

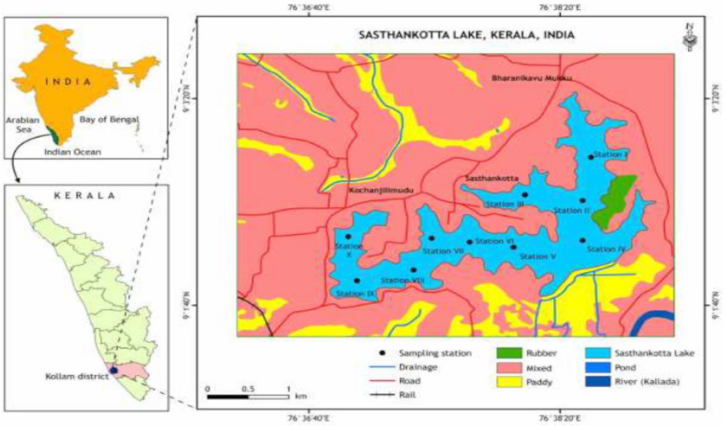

Fig. 1. Map of Sasthamkotta Lake

Table 1. Annual Variation in physicochemical characteristics of sediment in Sasthamkotta Lake

Parameters	Station I	Station II	Station III	Station IV	Station V	Station VI	Station VII	Station VIII	Station IX	Station X	Mean	SD
Temperature (°C)	27.9	28.4	27.9	27.9	28.4	28	28	27.8	28	28.1	28.04	1.25
pH	7.15	6.99	7.23	7.19	7.14	7.10	7.24	7.2	7.26	7.19	7.17	0.34
Organic Carbon (%)	9.07	6.69	7.48	9.87	7.26	7.48	7.64	8.42	7.94	7.00	7.88	4.38
Phosphorus (%)	0.0032	0.0021	0.0012	0.0016	0.0014	0.0020	0.0015	0.0016	0.0018	0.0015	0.0020	0.002
Nitrate (%)	0.1471	0.1544	0.1319	0.1392	0.1699	0.1495	0.1437	0.1461	0.1429	0.1356	0.1500	0.05

phosphorus. Organic carbon is negatively correlated with nitrate.

Benthic Fauna

The annual variation in the abundance of benthic fauna is presented in Table 4. The predominant benthic fauna of Sasthamkotta Lake comprised of eight species. Order Diptera is the dominant group consisting of six species, each species belong to Order Trichoptera and Order Tubificida. The order Diptera consists of *Phaenopsectra* sp., *Sumatendipes tobaterdecimus*, *Procladius* sp., *Chaoborus asiaticus*, family Chironomidae and family Ceratopogonidae. Order Trichoptera include the species *Ecnomus* sp. and *Pristina leidyi* identified in Order Tubificida. A higher proportion of benthic organisms are characterized by Chironomid larvae of *Phaenopsectra* sp. (97.927%). This is followed by *Sumatendipes tobaterdecimus* (1.233%) and *Pristina leidyi* (0.745%). Species belonging to Ceratopoginidae family (0.010%), species in Chironomidae family (0.037%), *Procladius* sp.(0.029%), *Chaoborus asiaticus* (0.014%) and *Ecnomus* sp. (0.005%) were the least groups found throughout the study period.

Correlation coefficient of benthic fauna revealed that very few benthic fauna showed significant difference from each other (Table 5). *Sumatendipes tobaterdecimus* is positively correlated with Ceratopogonidae and *Pristina leidyi*. Chironomidae is positively correlated with *Procladius* sp. and *Ecnomus* sp. *Procladius* sp. is positively correlated with *Ecnomus* sp.

Discussion

Temperatures of lake water are mainly determined by heat exchange with the atmosphere therefore it can be inferred that lake sediment temperatures are also influenced by atmospheric solar inputs (Fang and Stefan, 1996). Sediment temperature varied with depths. The temperature variations can be related to the seasonal trend throughout the study. The chemical nature of the sediment is determined by its pH. Sediment pH controls many chemical processes such as absorption and distribution of various nutrients and solubility of many soil particles (Michael, 1976). High organic matter in the sediment accounts for acidic nature in the sediment. The sediment is slightly acidic and alkaline in nature. Acidic nature may be due to high organic matter and poor oxygenated bottom water. Acidic pH (5.6 to 6.6) of surface sediments in Sasthamkotta lake was reported by Joseph, 1994) and acidic and alkaline pH (4 to 7.06) by Girijakumari (2007). Organic carbon compounds are either allochthonous or autochthonous origin. The fractions of organic carbon derived from various sources exhibits the characteristics of the lake catchment area and in turn influence the productivity (Hakanson and Jansson, 1983). 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

Table 2. Secondary data on Textural Analysis in Sasthamkotta Lake

Sand (%)	Silt (%)	Clay (%)	Mud (%)	Reference
1.10	39.08	59.82		Joseph, 1994
23.40	28.33	44.35	72.71	Krishnakumar *et al.,* 2005
1.98	38.74	59.28		Girijakumari, 2007
0.19	26.83	72.77		Shiekha E. John *et al.,* 2014

Table 3. Correlation coefficient of sediment characterististics in Sasthamkotta Lake

Parameters	Temperature	pH	Organic Carbon	Phosphorus	Nitrate
Temperature	1.000				
pH	0.029	1.000			
Organic Carbon	-0.128	0.106	1.000		
Phosphorus	0.193*	-0.008	-0.138	1.000	
Nitrate	0.027	0.071	-0.333**	0.134	1.000

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2- tailed)

Table 4. Annual Variation in the Abundance of Benthic Fauna (No/m²) in Sasthamkotta Lake

Benthic Fauna	Stations										Mean	SD
	I	II	III	IV	V	VI	VII	VIII	IX	X		
Phaenopsectra sp.	10541	7702	7383	7208	6446	7034	8005	9410	8033	9391	8032.10	6320.00
Sumatendipes tobaterdecimus	47	103	143	79	155	135	83	35	143	99	101.40	230.60
Family-Chironomidae	4	0	0	0	0	0	0	0	27	0	0.39	4.29
Procladius sp.	4	0	0	0	20	0	0	0	0	0	2.34	21.75
Chaoborus asiaticus	4	0	0	8	0	0	0	0	0	0	1.18	9.64
Family - Ceratopogonidae	0	0	0	0	0	0	0	0	8	0	0.80	6.00
Ecnomus sp.	4	0	0	0	0	0	0	0	0	0	0.40	4.30
Pristina leidyi	75	59	63	52	28	52	16	59	40	173	60.20	179.30

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 in Sasthamkotta Lake showed low productivity in Sasthamkotta Lake. The low primary productivity may be due to shortage of phosphorus and nitrate concentration and slightly acidic pH. In the previous studies of Joseph (1994) observed that Sasthamkotta Lake has low phytoplankton. Dissolved forms of nitrates take part in nitrogen cycling and nitrate pollution. 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, domestic sewage and garbage dumps and decomposed organic matter at the bottom.

Sediment is dark brown in color and composed of silt and clay. It is smooth while it is wet and tough like hard rock when it is dry. It mostly contains sand and in small quantity followed by silt and clay. Clay is the major portion of Sasthamkotta Lake.

The biological characteristic of the sediments is aimed to present the quantitative distribution of the benthic organisms in theSasthamkotta Lake. The presence and absence of benthic species within their habitats is a unique tool in measuring environmental characteristics (Bhattacherjee, 2008). In the present study two groups of aquatic insects such as Diptera and Trichoptera was found in Sasthamkotta Lake. The larva of these insects was found within the sediments of lake bed. These larvae survived and spend a part of their life within these sediments. Spatial variation of benthic population may depend on the availability of food resources, habitat quality, water quality and biotic factors (Karr, 1991; Mackay, 1992; Sweeney, 1993; Townsend *et al.*, 1997; Wallace *et al.,* 1997). The same observation coincided with the distribution pattern of benthic invertebrates in Sasthamkotta Lake. *Phaenopsectra* sp. is the abundant organism in the study area. It can inhabit in both lentic and lotic environment with a wide range of sediment types and has been connected with macrophytes and hard substrata (Pinder and Ress, 1983). Krishnakumar *et al.* (2005) reported that Sasthamkotta Lake comprised of 72.71% mud in the bottom sediment. The heterogeneous lake bed with silty clay (Shiekha E. John *et al.,* 2014) and muddy

Table 5. Correlation coefficient of benthic fauna in Sasthamkotta Lake

Benthic Fauna	*Phaenopsectra sp.*	*Sumatendipesto baterdecimus*	*Chironomidae*	*Procladius sp.*	*Chaoborus asiaticus*	*Ceratopogonidae*	*Ecnomus sp.*	*Pristina leidyi*
*Phaenopsectra*sp.	1.000							
Sumatendipestobaterdecimus	-0.127	1.000						
Chironomidae	-0.044	-0.040	1.000					
Procladius sp.	-0.055	-0.048	0.189	1.000				
Chaoborus asiaticus	0.009	-0.046	-0.011	-0.013	1.000			
Ceratopogonidae	-0.046	0.307**	-0.012	-0.014	-0.016	1.000		
*Ecnomus*sp.	-0.044	-0.040	1.000**	0.189*	-0.011	-0.012	1.000	
Pristina leidyi	0.005	0.279**	-0.031	0.059	-0.042	0.060	-0.031	1.000

**. Correlation is significant at the0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2- tailed)

habitat is accompanied with decomposed fragments of macrophytes or water plants and animal materials. This environment is optimum for luxurious growth of *Phaenopsectra* sp. larva. This is thesole detritivores in Sasthamkotta Lake. All the other organisms are generally predators and collector- gatherers which have least significance in the lake.

Conclusion

Monitoring the quality of sediment is a very important process in the restoration and conservation of the biodiversity of our nation's aquatic as well aswildlife resources. Both sedimentological and biological analysis affirmed a good ecological status is maintained in the lake. A minimal anthrogenic influence is sustained in the lentic environment. It is essential to take actions such as to gather, evaluate and regularly disseminate biotic data in order to examine some possible areas of environmental concern. This study improved the database on the environmental conditions of the Sasthamkotta Lake.

Acknowledgement

The authors express their gratitude to Kerala University for awarding J.R.F. during the tenure of which this work has been carried out. Also grateful to The Principal, Sree Narayana College, Kollam, Kerala, India for providing facility in the PG & Research Department of Zoology to complete the work.

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