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Evaluation of Plankton Assemblage of Shanthisagara Lake Using Simpson and Shannon-Weiner Index

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Abstract

The present study focused on the community structure and diversity of phytoplankton species in Shanthisagara lake. In total five sampling sites (S_1, S_2, S_3, S_4 and S_5) were selected in a zigzag manner with corresponding GPS coordinates for plankton collection and analysis. Plankton samples showed 65 genera of phytoplankton to occur in the lake. Of which 26 belong to Bacillariophyceae, 25 belong to Chlorophyceae and 14 belong to Cyanophyceae family. Bacillariophyceae were found to be the most dominant group of phytoplankton in the study period. Plankton diversity was analyzed by different diversity indices. The Simpson index was found to be highest in S_5 (0.901) followed by S_4 (0.891), S_1 (0.864), S_3 (0.862) and lowest at S_2 (0.861). The Shannon-Weiner index (H) for phytoplankton was found to be the highest in S_5 with the index value of 2.393 followed by S_4 (2.257), S_3 (2.072), S_1 (2.034) and S_2 (2.025).

Keywords: Phytoplankton, Diversity indices, Shanthisagara lake, Simpson index, Shannon-Weiner index

Shanthisagara, Asia's second-largest man-made lake, is located at Sulekere of Channagiri taluk, Davanagere district in Karnataka. The lake has a water spread area of 6,550 acres with a total drainage basin of 81,483 acres. It irrigates 4,700 acres of land and benefits more than 170 villages for drinking water. There are about 400 fishermen actively engaged in fishing throughout the year. The tank receives the drainage of twenty square miles and is fed by surplus water from Bhadra Dam. It plays an important role as the nursery and breeding grounds of many fishes.

Water maintains an ecological balance between the various group of living organism and their environment (Dhembare *et al.,* 2011). Phytoplankton is the primary producer for the entire aquatic body and comprises the major portion of the ecological pyramids (Odum, 1971). Phytoplankton is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change (Sayeed *et al.,* 2017).

Variations in the aquatic environment accompanying anthropogenic pollution are the cause of growing concern and require monitoring of the surface waters and the organisms inhabiting them (Lekhashree *et al.,* 2016). Changes in species diversity and population abundance resulting from either direct or indirect environmental stressors may be used to interpret changes in the environment. A biodiversity index seeks to characterize the diversity of a sample or community by single number. The concept of the 'species diversity' involves two components: The number of species or richness and the distribution of individuals among species (Doddabasava and Murthy,2017). In this context, there are indicator species that indicate the prevailing environmental conditions through their presence or abundance (Thakur *et al.,* 2013).

The present study aims to analyze the phytoplankton assemblage in the selected sampling stations at Shanthisagara lake using diversity indices like Shannon-Weiner index and Simpson index. Based on the species richness and the abundance of different plankton observed, environmental status of lake has been determined. More emphasis is given to the species diversity than the biological monitoring of the lake ecosystem.

Material and Methods

Study area: Five distinct sites around Shathisagara lake were chosen (Fig. 1) based on the visible condition of the lake ecosystem, infrastructure and surrounding activity (Table 1).

Fig.1 : Map showing location of sampling stations

Table 1

Name of the sampling sites with corresponding GPS coordinates

Sites	Environmental condition	GPS co-ordinates
S_1	Near temple	14°8'36.74"N, 75°52'52.77"E
S_2	Near fishing area	14°8'57.52"N, 75°53'36.02"E
S_3	Near the agriculture field	14°7'50.54"N, 75°52'5.53"E
S_4	Domestic discharge area	14°8'32.07"N, 75°53'57.29"E
S_5	Boating area	14°7'52.55"N, 75°52'40.29"E

Sample Collection: Water samples were collected from the lake, during the early hours (6 to 8 am) during January 2020. The surface plankton were collected by filtering 100 liters of water through standard planktonic net (60µ) and the concentration samples were preserved in 5 per cent formalin for further analysis.

Biological identification: The counting of phytoplankton was done by direct census method (Jhingran *et al.,* 1969). A Sedgwick-Rafter type plankton counting cell made to hold 1 ml of the sample was used. The counting cell is made up of transparent plastic and its area divided into 100 equal squares. Plankton present in all 100 cells were counted. The Phytoplankton was identified up to generic level with the help of standard literature (Smith, 1950; Davis, 1955; Tomas, 1996 and Bellinger & Sigee, 2010) and are expressed in No/m^3

Diversity indices analysis: To evaluate the diversity indices of phytoplankton species Shannon-Weiner index and Simpson index were used. The species diversity and species richness were estimated.

Simpson index: It quantifies the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species.

$D=1- \Sigma ni(ni-1)/N(N-1)$ Simpson (1949)

Where,

ni: The number of organisms that belong to species *i*

N: The total number of organisms

Shannon-Weiner index: The Shannon-weiner index (H) is a measure of diversity that combines species richness and their relative abundances.

$H = -\Sigma pi * ln\ (pi)$ Shannon (1948)

Where,

H = the Shannon-Weiner index

Pi = fraction of the entire population made up of species i

Σ = sum from species 1 to species S

ln : Natural log

Results and Discussion

Plankton community: List of phytoplankton families with their different genus are presented in Table. 2. A total of 65 genera of phytoplankton belonging to family Bacillariophyceae (26 genera), Chlorophyceae (25 genera) and Cyanophyceae (14 genera) were recorded during the present investigation. The number of genera of Bacillariophyceae, Chlorophyceae and Cyanophyceae family representing the phytoplankton community at different sites are depicted graphically in Fig. 2.

Investigation on Tungabhadra river water Suresh *et al.* (2013) noticed the diatom genera *Nitzschia,*

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TABLE 2

Family wise different genera of Phytoplankton observed at different study sites

	Microalgae	Sample Sites				
		1	2	3	4	5
I	**Bacillariophyceae**					
	Asterionella	-	P	P	-	-
	Cyclotella	P	-	P	P	P
	Cymbella	-	-	P		P
	Diatom	P	P	-	-	P
	Fragllaria	-	-	P	-	P
	Melosira	-	-	P	-	P
	Meridion	-	-	-	-	-
	Navicula	P	-	P	P	-
	Nitszchia	-	P	P	-	P
	Pinnularia	-	-	-	P	-
	Pleurosigma	P	-	P	-	P
	Surirella	-	-	P	-	-
	Tabellaria	-	-	-	-	-
II	**Cholorphyceae**					
	Actinastrum	-	-	-	-	-
	Ankistrodesmus	-	-	-	-	P
	Cholorococcum	-	-	-	-	P
	Closterium	-	P	P	P	P
	Coelastrum	P	-	-	P	-
	Cosmarium	-	-	-	-	P
	Desmidium	-	-	-	-	-
	Micrasterias	P	-	-	-	P
	Oedogonium	-	-	-	-	P
	Pediastrum	-	-	-	P	-
	Scenedismus	P	P	P	P	-
	Selanastrum	-	-	-	-	-
	Spirogyra	P	P	P	P	-
	Staurastrum	-	-	-	-	-
	Tetraspora	-	-	-	-	-
	Ulothrix	-	-	-	-	-
	Volvox	P	-	P	P	P
	Zygnema	-	-	-	-	-
III	**Cyanophyceae**					
	Agmanellum	-	-	-	-	-
	Anabeana	-	-	-	-	-
	Lyngbya	P	P	P	P	-
	Microcystis	-	-	P	P	-
	Oscillotoria	P	P	P	P	-
	Rivularia	-	-	-	-	-
	Spirulina	P	P	P	P	-
IV	**Euglenophyceae**					
	Euglena	-	-	-	-	-
	Phacus	-	-	-	-	-

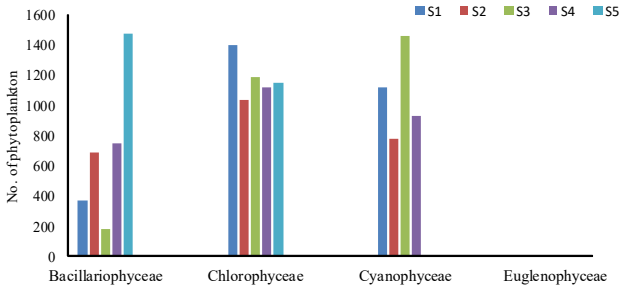

Fig. 2 : Distribution of Phytoplankton at different study site

Navicula, Pinnularia, Fragilaria, Melosira. In River Seetaat-Seetanadi, Ramesha and Sophia (2013) observed the presence of diatoms belonging to genera *Diploneis, Gyrosigma, Navicula, Pinnularia, Gomphonema, Asterionella, Fragilaria, Tabellaria, Surirella, Nitzschia* spp.

Robiul *et al.* (2017) reported the presence of phytoplankton families such as Cholorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, Myxophyceae and Xanthophyceae. Thakur *et al.* (2013) observed the presence of 148 species belonging to nine groups of phytoplankton in Prasharwetland, Kuntbhyog Lake and Rewalsar Lake of Himachal Pradesh.

During the present investigation, the Phytoplankton genera that were encountered in Shanthisagara lake included *Asterionella*, *Cyclotella, Cymbella, Diatom, Fragllaria, Melosira, Navicula, Nitszchia, Pinnularia, Pleurosigma* and *Surirella* from Bacillariophyceae family. *Coelastrum, Micrasterias, Scenedismus, Spirogyra, Volvox, Closterium* and *Pediastrum* from Chlorphyceae family. *Lyngbya, Microcystis, Oscillotoria* and *Spirulina* from Cyanophyceae family. Bacillariophyceae were found as the most dominant group of phytoplankton in the study period.

Investigation on Nethravati riverine waters, Madhavi *et al.* (2014) reported that diatom includes *Campylodiscus, Coscinodiscus, Cymbella, Diploneis, Melosira, Planktoniella* spp. Among Centrlales and *Asterionella, Fragilaria, Gomphonema, Gyrosigma, Navicula, Nitzschia, Pinnularia, Pleurosigma, Surirella, Tabellaria, Thalassionema* and *Thalassiothrix* spp. among Pennales. Shruthi *et al.* (2011) reported diatom genera such as *Cyclotella, Gomphonema, Melosira, Navicula, Nitzschia, Pinnularia, Pleurosigma, Pseudo-nitzschia, Rhizosolenia, Skeletonema* spp. in Dakshina Kannada estuarine waters, Karnataka.

In the present study total number (species abundance) of Bacillariophyceae were recorded highest in the site S_5 followed by S_4, S_2, S_1 and least at S_3. Chlorophyceae were maximum at S_1 and minimum at S_2. The abundance of Cyanophyceae were recorded maximum at S_3, minimum at S_2 and no Cyanophyceae were found at S_5 (Fig. 2). All the five sites showed difference in species abundance due to change in physico-chemical characteristics (Temperature, Salinity, pH, Nitrate, Nitrite, Ammonia, Silicate, Inorganic phosphate and Dissolved oxygen) by the surrounding activities. Changing seasons vary the amount of light and nutrients that phytoplankton can consume throughout the year.

Primary production is directly linked to the net supply of the limiting resource, Therefore phytoplankton diversity increases with the resource supply until it saturates (Vellina *et al*., 2014). The abundance of phytoplankton influenced by water quality parameters (Akter *et al.*, 2018).

Simpson Index (D)

It is commonly used to measure diversity of living beings in a given place. Simpson index is usually expressed as its inverse (1/D) or its compliment (1-D) which is also known as the Gini-Simpson index. Its value ranges between 0 and 1. Greater the value, greater is the species diversity (Simpson, 1949). Boyle *et al.* (1990) showed that responses of Simpson index do not interpret adequate changes in community diversity.

The Simpson Index (D) for phytoplankton was found to be high in S_5 (0.901) followed by S_4 (0.891), S_1 (0.864), S_3 (0.862) and low at S_2 (0.861). Index values are presented graphically in the Fig.3. Findings of the present study with respect to species diversity are in agreement with the reports published by Robiul *et al.* (2017) during the study conducted to analyze the

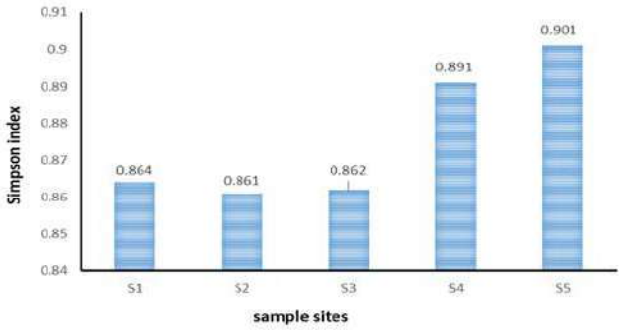

Fig. 3 : Simpson index of phytoplankton in the selected sampling sites

phytoplankton and zooplankton community structure in the selected sampling stations on the River Meghna using various diversity indices.

Shannon-Weiner Index (H)

The Shannon- Weiner Index (H) takes a value between 1.5 and 3.5 in most ecological studies and the index is rarely greater than 4. (Shannon, 1948). The study related to determine the relative sensitivity of 16 commonly used diversity and similarity indices by Boyle *et al*. (1990) revealed Shannon-Weiner index seemed to be mostly a function of changes in species richness and analysed the behavior of the indices, differential response due to initial community structure. Greater the index value, the greater is the sample diversity.

In present study highest Shannon diversity index was observed in S_5 with the index value of 2.393 followed by S_4 (2.257), S_3 (2.072), S_1 (2.034) and S_2 (2.025) revealing that diversity differs insignificantly among the sample sites (Fig. 4). The high value in site S_5 indicates that phytoplankton species were more evenly distributed. Dhembare (2011) reported that Shannon-Weiner index indicates conditions of intermittent surface distribution where certain zooplankton species have better environmental conditions to reach higher individual numbers. Shannon-Weiner index value above 3 indicates clean water, whereas values lower than this would indicate pollution.

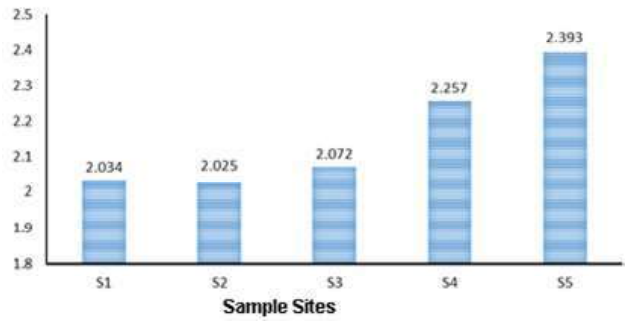

Fig. 4 : Shannon-Weiner index for Phytoplankton community in the study area

A comparison of the biodiversity indices in the lakes suggested that the diversity indices were higher in the Site S_5 (near boating area) which is related to the restrictive environmental conditions associated with the eutrophication process. Index value of the Shanthisagara lake is between 2.02-2.39 which indicates light pollution level of water.

Investigating on freshwater lake in Mandi, Himachal Pradesh, Thakur *et al*. (2013) reported that minimum species diversity was due to elimination of sensitive forms and the flourishing of tolerant forms, indicating a higher pollution load. Paturej (2006) reported that species diversity for the whole planktonic community decrease with the increase in eutrophication.

Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologist trying to understand community structure. The present study showed phytoplankton diversity in the selected sampling sites of Shanthisagara lake. Here diversity indices indicated that the lake under study has well balanced phytoplankton community that enjoyed an even representation of several species and indicating the dynamic nature of this aquatic ecosystem. However, remedial measures should be undertaken to minimize the impact of pollution load as revealed by Shannon-Weiner index.

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