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Archives of Applied Science Research, 2013, 5 (1):172-176
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0975-508X
CODEN (USA) AASRC9

Water quality monitoring- Study of seasonal variation of diatoms and their correlation with physicochemical parameters of Lotus Lake, Toranmal (M.S.) India

Patil J. V.[1], Ekhande A. P.[1] and Padate G. S.[2]

[1]SVS's Dadasaheb Rawal College, Dondaicha. Dist. Dhule (M.S.) India
[2]Dept. of Zoology, Faculty of Science, The M. S. University of Baroda, Vadodara

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ABSTRACT

Seasonal variation of diatoms density and species richness was studied of Lotus Lake. This reveled that the density of diatoms was maximum in summer, while it was minimum in post-monsoon. Maximum species richness of diatoms was recorded in summer, while minimum species richness was recorded in winter. The diatoms structure depends on a variety of environmental factors that include biological parameters as well as various physico-chemical factors. The Pearson correlation was calculated by keeping diatoms as dependent variable and other abiotic factors as independent variables.

Key Words: diatoms, correlation, Seasonal variation, Toranmal.

INTRODUCTION

Plankton, particularly phytoplankton, has long been used as indicators of water quality. Because of their short life span and quick responses to environmental changes their standing crops and species composition indicate the quality of water in which they are found [1]. Clean water supports a great diversity of organisms, whereas, very few organisms survive in polluted water with one or two dominant forms [2]. Phytoplankton constitutes the basis of nutrient cycle of an ecosystem hence play an important role in maintaining equilibrium between living organisms and abiotic factors [3].

Plankton is especially important as they form one of the most sensitive component of an aquatic ecosystem that signal environmental disturbances. However, this important biodiversity in aquatic ecosystem has remained neglected [4]. At the base of aquatic ecosystem phytoplankton are the producers, hence, they are looked for as a major component of any freshwater system. They play a key role in solving several environmental problems, understanding aquatic ecosystem and also the production of useful substances [5].

As species composition of phytoplankton communities changes in response to the environmental variations [6] long term studies of phytoplankton component in relation to fluctuations of water quality parameters are useful in developing and evaluating significant general ecological ideas. The phytoplankton abundance is a result of spatial and temporal changes in physical (*e.g.* temperature, light and nutritive levels) and biological variables (*e.g.* grazing pressure and competition), but of the externally imposed or self generated spatial segregation (*e.g.* life cycles) [7].

Algae being sensitive to the pollution or other changes in water serve as bio-indicator of water quality and pollution status [2] and hence are commonly used for monitoring environmental contamination [8]. The pollution in water causes changes not only in physical and chemical variables but also in algal species composition [1], especially in tropical inland waters leading to deterioration of potable potential of water [9]. Hence, study of phytoplankton is also significant to assess the quality of freshwater. [10] has correlated plankton species richness positively with various measures of ecological diversity.

The diatoms (Bacillariophyceae) in Littoral zone are important contributors of the primary production in shallow aquatic ecosystems [11]. Some of the genera of diatoms are pollution tolerant. [12] stated that *Synedra acus*, *Gomphonema sp*., *Cyclotella sp.* and *Melosira sp.* are found in organically rich water and play an important role in water quality assessment and trophic structure. Diatoms are important in Paleolimnological studies to reconstruct the past eutrophication of lakes on basis of paleolimnological evidences [13].

Hence, while studying hydrobiology of the Lotus Lake it is important to evaluate status of primary producers- the phytoplankton (diatoms). The present work deals with density and diversity of diatoms at Lotus Lake.

MATERIALS AND METHODS

Lotus Lake: Lotus Lake is a shallow perennial water body, located at 21^{o} 53′ 20′′ N latitude, 24^{o} 28′ 01′′ E longitude and 900 mAMSL with 1.17 Km perimeter. It spreads in 3.5 hectare. Its North-South linear length is 154 m while East-West is 419 m. It receives water through streams from higher altitudes of Toranmal Plateau. It has a gravel embankment on North side which arrests the main flow of the streams. Water of the Lotus Lake is utilized by the local people for domestic purpose like washing, bathing and also to some extent for agriculture. It is covered with Lotus flowers hence centre of attraction at Toranmal tourist station.

The study site was visited at an interval of fifteen days from December 2006 to November 2008. Surface water samples were collected from three stations of Lotus Lake (LL) namely LL-A, LL-B and LL-C between 8 a.m. to 10 a.m. For each parameter studied the average of these stations are taken. Slandered method was used for qualitative and quantitative analysis of diatoms [14]. Qualitative study of diatoms was carried out up to the genus/species level using the standard keys given by [14, 15]

Statistical analysis

The data of the two year study (from December-2006 to November-2008) was pooled for three months and four seasons and analyzed for seasonal variations, with respect to winter (December, January, February), Summer (March, April, May), Monsoon (June, July, August) and Post monsoon (September, October, November). Further, the Mean, Standard Error of Mean (SEM) was calculated for each season and One-Way ANOVA with no post test The Pearson correlation between the abiotic factors and the plankton density was calculated.

RESULTS

Diatoms shows significant seasonal variations ($F_{3\ 44}$ 67.92). Maximum density of diatoms (Table 1) were recorded in summer (2099 ± 69.25 /l) and minimum in post monsoon (585.8 ± 21.91 /l), while it was 1115 ± 72.81 /l and 1054 ± 115.1 /l in winter and monsoon respectively. Total twenty one species of diatoms (Annexure) were recorded in the Lotus Lake which showed significant seasonal variations ($P < 0.0001$, $F_{3\ 44}$ 135.9) (Table 1). Maximum species of diatoms were also recorded in summer (15.83 ± 0.42) but minimum in winter (5.5 ± 0.45), while it was 11.33 ± 0.25 and 7.16 ± 0.42 in monsoon and post monsoon respectively (Table 1).

Diatoms was positively correlated (Table.2) with AT, WT, TS, TDS, CO_2, Cl^-, TH, pH at .01 level and Trans. at .05 whereas negatively with WC, TSS, DO, NO_2 and NO_3 at .01 (two tailed).

Table 1 Seasonal Variations in density (No. /L) and species richness of Diatoms at Lotus Lake during December 2006 to November 2008

Parameters	F value ($F_{3\ 44}$)	Winter	Summer	Monsoon	Postmonsoon
Diatoms density	67.92	1115 ± 72.81	2099 ± 69.25	1054 ± 115.1	585.8 ± 21.91
Diatoms species richness	35.9	5.5 ± 0.45	15.83 ± 0.42	11.33 ± 0.25	7.17 ± 0.42

Table 2 Pearson correlation of total Phytoplankton density along with individual group with physico-chemical parameters of Lotus Lake during December 2006 to November 2008

Sr.No.	Parameter	Diatoms. density	Diatoms. Spp.richness
1	Atmospheric Temperature	.464**	.791**
2	Water Temperature (WT)	.705**	.859**
3	Water Cover (WC)	-889**	-.621**
4	Total Solids (TS)	.381**	.693**
5	Total Suspended Solids (TSS)	-476**	.102
6	Total Dissolved Solids(TDS)	.816**	.769**
7	Transparency	.300*	-.289*
8	Carbon Dioxide (CO_2)	.556**	.853**
9	Dissolved Oxygen (DO)	-.384**	-.631**
10	Chloride	.788**	.743**
11	Total Hardness (TH)	.798**	.497**
12	pH	.708**	.846**
13	NO_2^-	-.431**	.167
14	NO_3^-	-.583**	-.223
15	PO_4^{-3}	.022	.561**

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

DISCUSSION

Diversity of algae is an indication of purity. The use of community structure to assess pollution is conditioned by four assumptions: 1) the natural community evolves towards greater species complexity, 2) this eventually stabilizes and increases the functional complexity of the system 3) complex communities are more stable than simple communities, and 4) pollution stress simplifies a complex community by eliminating the more sensitive species [16]. Practically, environmental instability with temporal and spatial changes determines the community present in a lake [17]. In addition, not only the physical environment (*i.e*. Light intensity and temperature) influences the distribution of algal populations [18] but nutrients along with chemical compounds like CO_2 and composition and abundance of biotic component like Zooplankton also influence the phytoplankton assemblages in an aquatic ecosystem[19,20,21]. According to [22] lentic Bacillariophyceae communities that show spatial variation in diversity and species composition cannot be solely driven by local environmental conditions but also determined by habitat availability. However, according to [23] Diatom community distribution in a Lake is also determined by the combination of physical, chemical and biological factors which is reflected as their seasonal variations at Lotus Lake. At Lotus Lake diatom appeared maximum density in the summer and minimum in post-monsoon. High density of diatoms in summer is also reported by [24, 25, 26]. Among the chemical parameters, pH and NO_3 are particularly reported to be closely related to diatom growth and some species show good potential as indicators of change in habitat [27]. The Lotus Lake remained alkaline throughout the study period and pH and temperature are positively significantly correlated with density of diatoms (Table.2). Medium nutrient content with the alkaline pH might be the factors that favour the diatoms. [28] has reported that higher pH is favourable for diatom growth. In the present study among the three nutrients NO_2 and NO_3 were negatively correlated while PO_4, non-significantly correlated with the density of diatoms. Diatoms absorb phosphates in large quantities than their requirements. Further, density of diatoms is positively significantly correlated with the transparency of Lotus Lake as is also reported by [29, 30], and with hardness as is reported by [26, 31].

In Indian climatic conditions rains disturb the distribution of plankton in general and result in decline in their density which was also recorded for the Lotus Lake during monsoon. The minimum density of diatoms recorded in the post monsoon (wet summer) indicates dilution due to the maximum water level and water cover when phytoplankton get more distributed and hence reduction in density. Water cover was significantly negatively correlated with the density of total phytoplankton Diatoms also need at least 2µmole silicate/l for successful development [32]. According to [33] dissolved silica is supplied to the lake by drainage water and is also generated by remineralization within lake. Though the silica of Lotus Lake was not estimated the dominance of diatoms indicates sufficient silica in the lake water.

Qualitative estimation of diatoms revealed 21 species that dominate the Lotus Lake. [3] reported that availability of distinct nutritional requirements favour one group over the other. Diatoms are ecologically diverse and colonize virtually all microhabitats in marine and freshwater systems. The study of diatoms in Lotus Lake revealed that

maximum species richness of diatoms was in summer while minimum in winter probably higher temperature of summer favouring the growth. Though optimum temperature for diatoms is 18 - 30˚C [12] ,many species can tolerate a range of temperature between 0.0˚C to 35 ˚C [34]. Since the surface water temperature fluctuations in Lotus Lake varied from 18.38 ± 0.15˚C to 22.2 ± 0.37˚C, temperature regime in the lake was favourable for diatoms. Taxonomic indicators based on Diatom assemblages provide a useful estimate of ecosystem change and have been recommended as a standard mean in biological monitoring[35] and Diatom composition gives more accurate and valid predictions as they react directly to pollutants [36]. [37] has listed diatom taxa in decreasing order of emphasis with reference to pollution index. With reference to this, in the Lotus Lake water the tolerant species in decreasing order of emphasis were *Nitzschia, Navicula, Synedra, Melosira, Gomphonema, Fragilaria, Surirella, Cymbella* and *Pinnularia*. *Nitzschia* species is characteristics of organically rich waters [38]. Though many studies have investigated autecological status of indicator species [13], few studies contribute to species optima of *Nitzschia species* and *Gomphonema sp.* However, the clean water diatom species *Amphora ovalis, Cymbella species* and *Pinnullaria species* were also recorded in Lotus Lake.

In conclusion, Lotus Lake supports good diversity and density of Bacillariophyceae as most common group. The Lotus Lake is not yet polluted. But, in today's modern world, ecotourism is fast growing field and Toranmal area is one of the most favoured centre. If care is not taken Lotus Lake can soon undergo deterioration and may develop into a deteriorated habitat.

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Annexure

Diatom observed in Lotus Lake at Toranmal plateau in Satpura ranges during December 2006 to November 2008

1. *Melosira islandica* (O. Muell)
2. *Synedra ulna* (Nitz) Her. V. biceps Kuetz.
3. *Synedra acus* (Kuetz)
4. *Asterionella spp*
5. *Frustulina spp*
6. *Gyrosigma accuminatum* Kuetz
7. *Navicula cuspidata* Kuetz. V. Conspicua Venkat
8. *Navicula cuspidate* Kuetz. V. major Meister
9. *Navicula rhynchocephala* Kuetz
10 *Amphora ovalis*. Kuetz
11. *Pinnularia interrupta* W. Smith
12. *Pinnularia vidarbhensis* Sarode Kamat
13. *Rhopalodia gibba* Her O. Muell
14. *Nedium longiceps* Grey A. Cl. V.
15. *Stauroneis obtuse* Lagerst. V.
16. *Surirella capronii* Breb.
17. *Surirella robusta* Ehr.
18. *Cymbella ventricosa* Kuetz
19. *Gomphonema intricatum* Kuetz
21. *Fragilaria construens* Ehr. Grun
21. *Nitzschia obtusa* W. Smith