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Seasonal Variation In Diatoms Density And Their Correlation With Physicochemical Parameters Of Yashwant Lake, Toranmal (M.S.) India

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Abstract:Seasonal variation of diatoms density and species richness was studied for two years from Yashwant Lake, located in the Satpura Reserve Forest at Toranmal (Maharashtra) India. The density of diatoms was minimal in post-monsoon which increased gradually and culminated in summer. Species richness of diatoms was maximal in summer and found to be minimal in winter. The Pearson correlation was calculated by keeping phytoplankton as dependent variable and other abiotic factors as independent variables. The diatoms structure depends on a variety of environmental factors that include biological parameters as well as various physico-chemical factors. The Yashwant Lake, located in subtropics, receives maximum photoperiod during summer that invigorates growth of the diatoms. In post monsoon the water cover and water level were higher which distribute the phytoplankton and leads to decrease in their density, while opposing situations occurs in summer leading to increase in density of total phytoplankton.

Keywords: Toranmal, Diatoms, Seasonal variation, density, species richness

INTRODUCTION

The Phytoplankton of the open water ponds, lakes and large streams consist of a diverse assemblage of microscopic autotrophs. Many of them have different physiological requirements, which may vary in response to physical and chemical parameters such as light, temperature and nutritional regime (Wetzel, 2001). The dominant genera in algal groups not only change spatially (vertically and horizontally within a lake) but also show seasonal variations in response to seasonal changes in physical, chemical and biological conditions of the water body. Hence a general pattern of seasonal succession of phytoplankton of many lakes has been correlated with environmental factors. The precise reasons for many of these changes are not well known (Wetzel, 2001).

The studies on phytoplankton distribution are pivotal in understanding the health of particular water body. They are important source of fish diet, as pollution indicator and they project the trophic status of the water body (Naik and Neelkanthan, 1990).This heterogenous microscopic group include members of different families such as Cyanophyceae, Chlorophyceae, Bacillariophyceae(diatom), Dinophyceae and Euglenophyta.

At present, altogether fourtyone functional freshwater phytoplankton groups are described worldwide with more or less precisely defined ecological demands (Padisak et al, 2009). Further, field and laboratory evidences indicate that phytoplankton react rapidly not only to the climate but also to the changes in nutrient loading. Therefore, they either mimic eutrophication by increasing phytoplankton production carrying capacity of ecosystem (Mooij et al, 2005) or contribute to it by inducing phosphorus release from sediments and accelerating the nutrient cycling (Pettersson et al, 2003).

The diatoms in Littoral zone are important contributors of the primary productivity in shallow aquatic ecosystems (Wetzel, 1990). According to Palmer (Palmer, 1980) Ulnaria 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 (Taylor et al, 2006).

In the present study, an attempt is made to find out the effect of season on the distribution of phytoplankton in Yashwant Lake that receives the southwest monsoon and has altitudinal effect.

MATERIAL AND METHODS

Yashwant Lake is a perennial water body, located on Toranmal Plateau, one of the important plateaus in mid Satpura. This plateau forms a table land on the summit, covering about 41 Sq. Km. area at 1155 meter altitude (AMSL) extending between 21o 54´ North to 21o 61´ latitude and 74o 26´ to 74o 34´ East longitude. Yashwant Lake has a perimeter of 2.75 Km. and spreads in 39 hectares. It was constructed during British period by damming the dip gorge. The littoral zone of Yashwant Lake is covered with various macrophytes. The Lake on the west and northwest is surrounded by forested land.

Google Sat. Image of Yashwant Lake

The diatoms along the periphery of Yashwant Lake were collected after the interval of every fifteen days from three stations namely Yashwant Lake –A-site (YLA), Yashwant Lake –B-site (YLB) and Yashwant Lake –C-site (YLC). Ten liters of water was filtered through the plankton net No. 25 of bolting silk with mesh size 64 micron. Net was washed with the water by inverting it to collect the phytoplankton attached to the net and the volume of sample was made to 100 ml. The samples were taken in separate vials and fixed in the field with 1 ml of 4 % formalin and 1 ml of Lugol's Iodine at the collection site. Ten ml of sample from each station was further concentrated by centrifuging at 2000 RPM for 10 min. For quantitative estimation of plankton, one ml of well mixed sample was taken on 'Sedgewick Rafter Cell'. To calculate density of diatoms the averages of 5 to 10 counts were made for each sample and the results are expressed as numbers of organisms per liters of sample. Qualitative study of diatoms was carried out up to the genus/species level using the standard keys given by (Edmondson, 1963; Philipose, 1960; Sarode and Kamat, 1984; APHA, 1998). Species richness of each group of plankton is considered as number of species of each group observed per visit. The number of species present in a region may be considered as its 'species richness' a frequently used measure. Species richness can be correlated positively with some measures of ecological diversity (Hurlbert, 1971).

Two years (from December-2006 to November-2008) data was pooled and separated for three months and analyzed for seasonal variations, with respect to winter (December, January, February), Summer (March, April, May), Monsoon (June, July, August) and Postmonsoon (September, October, November). Mean, Standard Error of Mean (SEM) and One-Way ANOVA with No post test for various parameters for four seasons was performed. The correlation between the abiotic factors and the plankton density was calculated. The Pearson correlation was calculated by keeping diatoms as dependent variable and abiotic factors as independent variables. The P value for ANOVA is non-significant if $P > 0.05$ (ns), Significant if $P < 0.05$ (*), significantly significant (**) if $P < 0.001$ and highly significant if $P < 0.0001$.

RESULTS AND DISCUSSION

Hydrological changes are noted here with seasonal changes from dry to wet. The southwest monsoon starts by mid June and stabilizes in July and August. The stream drainage input fills the Lake, and maximal water level is in post monsoon.Water level decreases in summer due to evaporation, percolation and domestic utilization by villagers. Geologically, the area covers Deccan trap basalt rock formation and lies under monsoon semiarid deciduous forest cover.

Bacillariophyceae (Diatoms) was the most dominant family in the total phytoplankton abundance (Table.1). Density of diatoms was recorded higher in summer with 1783 ± 96 ind./L, 2035 ± 57 ind./L and 2313 ± 122 ind./L at YLA, YLB and YLC respectively (Table.1, Fig.1)while it was decreased in monsoon and showed variations at the three stations with 871 ± 122 ind./L, 1069 ± 172 ind./L and 1167 ± 194 ind./L respectively. The density was recorded minimal in post monsoon with non-significant differences (516 ± 28 ind./L at YLA, 566.3 ± 19.37 ind./L at YLB and 587 ± 37 ind./L at YLC) on all three sites investigated. The diatom densities increased in winter with insignificant differences among the three stations (1042 ± 100 ind./L at YLA, 1054 ± 91.96 ind./L at YLB and 1198 ± 120 ind./L at YLC).

Table 1. Seasonal Variations in density (ind. /L) and species richness (no. of species) of Diatoms at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008

Parameters	Stations with F value	Winter	Summer	Monsoon	Postmonsoon
Diatoms Density.	YLA $F_{3\ 20}$ 31.77	1042 ± 100.8	1783 ± 96.63	871 ± 122.9	516.3 ± 28.73
	YLB $F_{3\ 20}$ 36.06	1054 ± 91.96	2035 ± 57.76	1069 ± 172.6	566.3 ± 19.37
	YLC $F_{3\ 20}$ 30.28	1198 ± 120.6	2313 ± 122.3	1167 ± 194.3	587.8 ± 37.95
Diatoms Spp. Richness	YLA $F_{3\ 20}$ 22.05	6.33 ± 0.76	15.67 ± 1.2	12.0 ± 0.68	7.33 ± 0.95
	YLB $F_{3\ 20}$ 38.54	7.33 ± 0.66	16.83 ± 0.94	14.0 ± 0.57	9.0 ± 0.57
	YLC $F_{3\ 20}$ 48.55	8.0 ± 0.89	21.0 ± 0.36	15.0 ± 0.96	10.83 ± 0.87

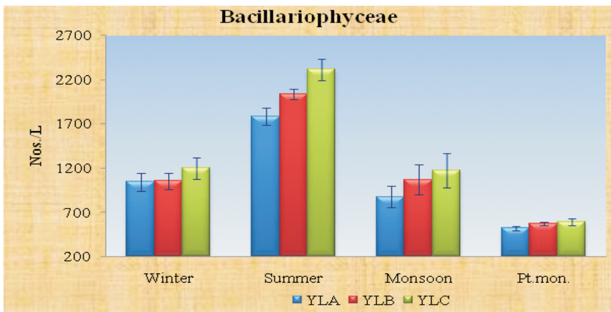

Figure 1. Seasonal variation in density of Diatoms (no. /L) at Yashwant Lake during December 2006 to November 2008

Twenty four species of diatoms (Annexure) belonging to 16 genera were recorded at Yashwant Lake. Maximal number of species were recorded in summer with 15.6 ± 1.2, 16.8 ± 0.9 and 21.0 ± 0.3 at YLA, YLB and YLC respectively. Which started decreasing in monsoon with 12 ± 0.6, 14 ± 0.5 and 15 ± 0.9 to postmonsoon with 7.3 ± 0.9, 9 ± 0.5 and 10.8 ± 0.9 and were minimal during winter with 6.3 ±

0.7, 7.3 ± 0.6 and 8 ± 0.9 at YLA, YLB and YLC respectively (Table.1, Fig.2). Both, density and species richness of Bacillariophyceae showed significant seasonal variations with $P < 0.0001$ at all the stations.

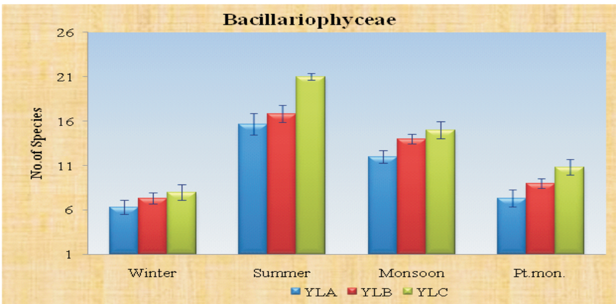

Figure 2. Seasonal variation in species richness of Diatoms (no. of species) at Yashwant Lake during December 2006 to November 2008

Table 2. Annual variation of Physico-chemical parameters of Yashwant Lake from December 2006 to November 2008.

Parameter	YL-A		YL-B		YL-C	
	Max.	Min.	Max.	Min.	Max.	Min.
AT °C	26.25	16.75	26.25	16.75	26.25	17.25
WT °C	23	18	26	16.2	22.7	18.7
WC %	95	60	95	60	95	60
TDS mg/l	132	99	122.5	92	138	102.5
TS mg/l	162.5	128	156	123	182	133
TSS mg/l	42.5	18.5	41	18	46	21
Trans. M	1.42	1.12	1.51	1.13	1.47	1.13
Acidity mg/l	20.5	9.25	19.5	8.25	18.75	7.5
Alkalinity mg/l	122.5	83.75	120	81.25	117.5	77.5
TH mg/l	71	48	69	49	67	46
pH	8.6	7.4	8.5	7.3	8.4	7.2
CL mg/l	33	14	30.5	13	29	12
CO_2 mg/l	4.8	1.3	4.8	0.2	4.9	0.4
DO mg/l	12.8	7.9	13.6	8.6	14.1	9
NO_2 mg/l	0.37	0.07	0.4	0.08	0.41	0.09
NO_3 mg/l	0.18	0.05	0.17	0.05	0.2	0.03
PO_4 mg/l	0.2	0.07	0.2	0.07	0.2	0.08

Table 3. Pearson correlations of Diatoms density with physicochemical parameters at YLA, YLB and YLC of Yashwant Lake during December 2006 to November 2008

Sr. No	Parameters	YLA-Site Density	YLB-Site Density	YLC-Site Density
1	**Atm.Temperature**	.900**	.768**	.914**
2	**Water Temp.**	.837**	.912**	.934**
3	**Transparency**	-.610**	-.536**	-.569**
4	**Total Dissolved Solids**	.919**	.933**	.885**
5	**Total Solids**	.919**	.836**	.824**
6	**Total Suspended Solids**	.367	.194	.230
7	**Acidity**	.905**	.956**	.904**
8	**Alkalinity**	.780**	.912**	.862**
9	**pH**	.890**	.919**	.909**
10	**Total Hardness**	.061	.217	.175
11	**Chloride**	.873**	.914**	.860**
12	**CO_2**	.897**	.864**	.876**
13	**DO**	-.653**	-.603**	-.625**
14	**NO_2**	.773**	.512*	.537**
15	**NO_3**	.233	-.076	-.056
16	**PO_4**	.856**	.736**	.783**

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

Phytoplankton forms the basic link of food chain between abiotic and biotic factors in the aquatic ecosystem as the metabolic activities of these organisms depend on the physicochemical factors of the aquatic environment. The quality and quantity of phytoplankton and their seasonal succession patterns have been successfully utilized to assess the quality of water and its capacity to sustain heterotrophic communities, virtually all the dynamic features of lakes such as colour, clarity, trophic state, zooplankton and fish production depend to a large degree on the phytoplankton (Goldman and Horne, 1983).

Biodiversity conservation seeks to maintain the human life support system provided by nature and the living resources essential for development. As far as water reservoirs in India are concerned three distinct plankton pulses are reported which coincide with southwest post-monsoon (September-November), winter (December-February) and summer (March-May) (Sugunan, 2000). First, the South-West Monsoon (June-August) flushing disturbs and often dislodges the standing crop of plankton. However, the destabilizing effects does not wean away immediately (as dam outlets are closed), and the allochthonous nutrient input favours some plankton growth in postmonsoon (e.g. Euglenophyceae). Second, as the post-monsoon merges into winter, the turbulence decreases and water becomes clean, the phytoplankton community progresses through a series of succession to culminate in a peak Cyanophyceae and Chlorophyceae. Third, at the end the summer plankton maxima coincide with the drastic drawdown, bringing the deep, nutrient rich areas into the fold of tropholytic zone. High temperature, bright sunlight and rapid tropholytic activities also accelerate the multiplication of phytoplankton during summer (e.g. Diatoms and Dinophyceae (Sugunan, 2000).

Diatoms are also being used increasingly as indicators of environmental changes, including studies of past climatic changes (Smol and Cumming, 2000; Wim et al, 1924 -1931). The environmental factor such as physico-chemical and biological factors influence the density and species richness of diatoms, which is reflected in their seasonal variations. Maximal diatom densities were recorded in summer at all the three stations as is also reported by earlier researches Sunkad (2002); Hujare (2005); Hulyal and Kaliwal (2009); Hafsa and Gupta (2009) and Jawale and Patil (2009). The temperature has been reported as the most important factor affecting diatom growth positively (Pearsall, 1932; Yoshitake and Imahori, 1980). In addition to temperature, George, (1961) observed that the high pH value promotes the growth of algae in general. Kamat (1965) also reported that high pH is favourable for abundant growth of diatoms. Our results are in agreement with the previous studies and it is found that For alkaline pH is favoures to flourish the members of Bacillariophyceae (Table 3). Perusal of literature indicates that Diatoms absorb large quantity of phosphates than their requirements (Rutner, 1963 and Munawar, 1970). Philipose, (1960) has reported direct relation of phosphate with diatoms. In present study, minimal to moderate phosphates were recorded in winter and summer respectively when the diatom populations were moderate to maximal. In additions, Nitrates have been given the prime importance in diatom ecology (Patrick, 1948, Rao, 1955) and considered as the main controlling parameter in the periodicity of diatoms. However, all the three stations showed negative correlation with the diatom density with the nitrate in the present study on (Table.3). Nitrate may be utilized by diatoms. This needs further investigation in relation to other abiotic and biotic parameters.

Earlier investigation reported two peaks (i.e. in summer and winter) diatoms density George (1966); Patil (2005); Nandan and Magar (2007) and Sharma (2009) in their annual studies. In present seasonal study no such peak was observed, rather there was a steady increase in their density from winter to summer at the higher Altitudinal Lake. The effect of rains on the distribution and decline of the plankton density in general stands true for diatoms too. On the contrary, Pennak (1949, 1955) did not find any regular diatom pulse throughout the year.

Dissolved silica has a specific role in diatom growth; therefore, adequate silica supply is essential for bacillariophyceae in general. Dissolved silica is supplied to the lake by drainage water (Kobbia et al., 1992; Gad, 1992) and is also generated by remineralization within the lake. In the present study the silica is not estimated, but high density of diatoms is indicative of sufficient silica content of Yashwant Lake.

The diatoms of Yashwant Lake were represented by 24 species belonging to16 genera which indicates availability of their distinct nutritional requirements at Yashwant Lake that favours one group over other as indicated by (Wetzel, 1990). Patrick (1973) concluded that many species of diatoms can tolerate a temperature range from 0.0 to 35oC. The study of Yashwant Lake indicates that these groups of species are found abundantly when water temperature fluctuated between 18.75 ± 0.3 C of winter to 22 ± 0.4 C of summer.

Palmer (1969) has listed the taxa in decreasing order of emphasis with reference to pollution index. In the present study some of these pollution tolerant species were also observed in the order of density as follows: Nitzschia, Navicula, Ulnaria, Melosira, Gomphonema, Fragilaria, Surirella, Cymbella, Pinnularia. Similar taxa were also recorded by Nandan and Mahajan, (2007) at Suki Dam, Maharashtra. Available literature indicates that Cymbella, Fragilaria species, Gomphonema are commonly found in organically rich waters while Richardson, (1968) recorded Nitzschia species is characteristic of organically rich waters. However, the clean water species of diatom such as Amphora ovalis, Cymbella sp., Pinnularia sp. were also observed in the waters of YSL. Their presence in YLA indicates that though it is not yet polluted, if care is not taken may get polluted in near future as it is having potential for deterioration and eutrophication under the influence of pollution and anthropogenic pressures.

In conclusion, present studies shows that lentic diatom communities, their temporal variation cannot be solely driven by local environmental conditions but is also determined by habitat availability in other words potential habitat is available at Yashwant Lake.

ANNEXURE

Diatoms of Yashwant Lake observed during December 2006 to November 2008

Bacillariophyceae (Diatoms)

1. Melosira islandica (O. Muell)
2. Ulnaria ulna (Nitz) Her. V. biceps Kuetz.
3. Ulnaria 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. Surirella sabsalsa W. Smith
19. Cymbella ventricosa Kuetz
20. Gomphonema gracile Ehr.
21. Gomphonema intricatum Kuetz
22. Fragilaria construens Ehr. Grun
23. Fragilaria zafarii Sarode Kamat
24. Nitzschia obtusa W. Smith

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