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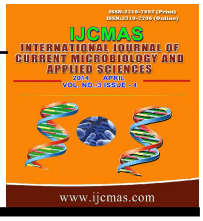

Original Research Article

Distribution and ecology of diatom communities in four lakes using Lange-Bertalot method

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K e y w o r d s

Correlation; Diatoms; Ecology; Lakes; Physico-chemical parameters; Water quality.

A B S T R A C T

Main aim of this experiment is to study the distribution and ecology of diatoms in four lakes of Tumkur district. Diatoms are the primary producers of aquatic ecosystem, respond quickly to environmental changes in streams and lakes and are very good indicators of local conditions. Diatom composition of four lakes was related to seasonal factors, year, location and water quality parameters including nutrient and metals concentrations. Water chemistry parameters like air and water temperature, alkalinity, pH, sulphate, nitrate and silica concentrations were done in order to investigate physicochemical parameters and their relationship with diatom community behaviour and composition. Water quality of these lakes was evaluated using an index composed of Lange-Bertalot pollution tolerance values. Results revealed that, diatoms showed significant positive correlation coefficient with physicochemical parameters like temperature of air and water, sulphate, nitrate and silica. A negative correlation was noticed with dissolved oxygen. Total of 48 species of diatoms were recorded. Diatom community results revealed that, when compared to chemical analyses, proved useful in providing an indication of the quality of waters. Under 17 genera seasonal maxima of diatoms was observed during pre-monsoon months in all the lakes. Present experiment emphasising the need for conservation efforts of lake biota.

Introduction

An anthropogenic change in the ecology of lakes is very common. These physical, chemical, and biological changes have resulted in the loss of biological integrity in Lakes. Changes in the biological communities of these habitats have included long term alteration of diatom community structure (Herdendorf, 1989). Desikachary (1962), Ghosh and Gaur (1993), Juttner *et al*., (1996), Nautiyal and Nautiyal (1999); Karthick *et al*., (2009) have given more attention towards the distribution and periodicity of diatoms. Hosmani and Bharathi (1980) studied

organic pollution using diatom species. Studies using diatom assemblages to predict environmental changes slowly progressed in India through the works of Gopinath (1984) and Juttner *et al*., (2003). Diatoms constitute the most powerful indicators of water quality and the environmental effects of water chemistry parameters. Eloranta and Soininen (2002), Kelly (2006), Taylor *et al*., (2007) have used diatoms as water quality indicators of river water. Tumkur district has large number of lakes and reservoirs. Many are rain fed while a few are connected to channels of rivers that flow through the district. Diatoms are ubiquitous, unicellular micro organisms that form the basic bulk of planktonic population in fresh waters characterized by siliceous cell wall enveloped by an organic case mostly composed of polysaccharides and proteins (Round *et al*., 1990). Diatoms thrive in both freshwater and marine environments and have a very high efficiency of photosynthetic reaction (Fumanti *et al*., 1997; Vincent and James, 1996). The ecology of freshwater diatoms has been studied by Munawar (1974), Ramakrishnaiah and Sarkar (1982), Zutshi and Khan (1988). They are of the opinion that, distribution of diatoms is determined by their internal physiology rather than the external factors. Number of investigators has discussed the role of physico-chemical parameters such as pH, nitrates, phosphates, silica and calcium in the distribution of diatoms. Diatoms have shown to be reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification & metal pollution as well as for general water quality (Bellinger *et al*., 2006; Pan *et al*., 1996; Gaiser *et al*., 2004). Among several groups, diatom-based pollution monitoring has proved to be rapid, efficient and cost-effective technique has been implemented worldwide to monitor rivers, streams and lakes (Juttner *et al*., 2009; Karthick *et al*., 2011). Diatoms are the species-rich group of photosynthetic eukaryotes, with enormous ecological significance and great potential for environmental application. During the last two decades, diatoms have gained considerable popularity throughout the world as a tool to provide an integrated reflection of water quality (Atazadeh *et al.*, 2007). Sensitivity and tolerance of diatoms to specific physical and chemical variables like pH, electrical conductivity, nitrates, phosphates and biological oxygen demand (BOD) and inherent ecological patterns was investigated across countries (Sabater *et al*., 2007; Alakananda *et al*., 2011).

Distribution and abundance of diatoms are influenced by variety of physical and biological factors. Diatoms are sensitive to changes in the water chemistry in which they exist. Thus a change in nutrients, salinity, pH and number of other factors will allow majority of diatom community to grow and reproduce more quickly, thus the community composition changes as a whole in response to changes in environmental conditions. Diatoms would be better for assessment because they attach to substrates and integrate conditions in that local area for the organism life (Stevenson and Lowe, 1986). Many indicators have been developed to infer environmental conditions using diatoms including community composition and autecological indices which evaluate changes in diatom assemblages due to sensitivity and tolerance of the species to environmental variables (Porter *et al*., 1993). Diatoms are the primary producers of aquatic ecosystem, respond quickly to environmental perturbations and hence

used as a bio indicator across continents. Present knowledge of diatom ecology and their importance as a part of environmental monitoring program in Indian lake ecosystems is very meager due to inadequate knowledge on its taxonomy, although a few studies on river ecosystems have been reported. However, no attempts have yet been made to use diatoms to assess the relative health of Lakes in Tumkur district and how similar are the diatom communities in these systems to each other. In the present investigation, main objective was to investigate the relationship between diatom composition and impact of environmental variables and describe the distribution and periodicity of diatoms in four lakes and to test the ability of LBI (Lange-Bertalot Index) to comparatively assess the quality of lakes.

Materials and Methods

Study area

In the present investigation, four lakes such as Gulur lake, B.G.Halli lake, Colony lake and Teetha lake were selected in Tumkur district. Among these, Gulur lake and B.G.Halli lake are located in Tumkur urban taluk and drained with densely populated area. Agricultural runoff contaminated Gulur lake and B.G.Halli lake water is mainly used for drinking purpose of Tumkur town. Two other lakes such as Colony lake and Teetha lake are located in Koratagere taluk of Tumkur district with less human population and more of plantation in catchment area.

Diatom analysis

Diatoms were collected from all the four lakes at monthly intervals for a period of two years (2010-2012). Algal samples were fixed in 4% formalin and diagrams were drawn with the help of camera lucida technique. Identification of diatoms up to the species level was made following the key characters suggested by Welsh (1964); Krammer and Lange-Bertalot (1986-1991); Round *et al*., (1990); Gandhi, (1998); Taylor *et al*., 2005 and Karthick *et al*., 2010. Laboratory processing of the diatoms was carried out by following standard methods suggested by Kawecka (2012). Samples are cleaned following Hot HCl and KMnO4 method and slides were prepared using Pluerax as the mounting medium and examined at 1250X using an Olympus BH2 photomicroscope (Lohman, 1982). Counting of diatoms was done using Sedgwick rafter counting chamber. Relative abundance of each taxon was determined after counting at least 400 valves in each sample using light microscope.

Water analysis

Water samples were collected from all the four lakes at monthly intervals for a period of two years (2010-2012) to conduct physicochemical analysis. Samples collected from 10 cm to 30 cm below the water surface during morning hours. Water temperature, pH, turbidity, electrical conductivity, dissolved oxygen were measured on the spot in the field with a Barnant 30pH meter and DO was measured with an YSI 51B DO meter. Water samples were collected in polypropylene bottles rinsed with distilled water were transported to laboratory for subsequent analysis like silicate, nitrate, ammonia, orthophosphate, sulphate, alkalinity, total hardness, biological oxygen demand and conductivity using standard suggested methods (American Public Health Administration, 1995) except for a modification of the ammonia assay first recommended by Zaborojny *et*

al., (1973). A Unicam UV 2-100 photospectrometer and a Radiometer TTT 80 autotitrator were used in these analyses.

Statistical analysis

Variation in diatom species distribution and water quality across sites is analysed using PAST software, version 2.11. Canonical correspondence analysis (CCA) including data of abundant diatom taxa and environmental parameters across 4 sampling sites during 2 years period to evaluate role of environmental variables in structuring diatom communities.

Results and Discussion

In the results, species diversity of diatoms, values of water quality parameters and correlation co-efficient are tabulated (Table 1, 2, 3). Seasonal and relative abundance of diatoms was recorded (Figure 2).

Diatom analysis

Highest diatoms density was observed in Gulur lake (39%) followed by Teetha lake (24%), B.G.Halli lake (21%) and least density was observed in Colony lake (16%). Diatoms density closely correlated with the concentrations of silica, nitrate and sulphate. Periodicity of diatoms has also been studied. Gulur lake recorded 26 species and are listed in Table 1. Depending on the relative periodicity, diatoms encountered in this lake have been categorized into three groups following the procedures of Hosamani (1975).

A] Constants: Species recorded throughout the period of investigation-*Cymbella cymbiforms*, *Gomphonema garcile* and *Gyrosigma attenuatum*.

B] Ephemerals: Species recorded only during certain seasons of the year-*Cocconeis placentula* and *Navicula salinarum*.

C] Rare: Species represented by- *Melosira granulata* and *Stauroneis anceps.*

Gulur Lake recorded a total of 19658 Organisms/liter during the entire period of investigation. Seasonally, pre-monsoon recorded a maximum density and minimum density was noticed during monsoon period. Colony Lake witnessed poor species diversity with 9species and 6genera and supports better density. Seasonally they appeared in maximum numbers during pre-monsoon and in minimum numbers during post monsoon. Teetha lake ranks second in supporting the species diversity while Gulur lake stood first (Table 2). Seasonal fluctuations in diatoms density showed that maximum density was recorded during pre-monsoon and a minimum density was recorded during post monsoon (Figure 1).

Seasonality is the most important factor, among those measured in this experiment, in determining variability in diatom composition among sites and dates in these Lakes. Distinct seasonal variations in diatom assemblages were observed in the selected habitats (Vinson and Rushforth, 1989; Nautiyal *et al*., 2000). Patric (1977) pointed out the importance of water temperature in diatoms periodicity and observed inverse relationship between temperature and diatoms population. Singh and Swarup (1979) stated that, higher temperature promotes the growth of diatoms. In the present investigation, diatoms were found peak during pre-monsoon season in all the four lakes showing significant positive correlation with the air temperature ($r = 0.723$) and water temperature ($r = 0.695$) respectively at 5% level. Similar observations have made by Manikya Reddy and Venkateshwaralu (1992).

Table.1 Diatoms recorded from four lakes of Tumkur

1. Amphora ovalis	*25. Navicula cuspidate*
2. Anomoeoneis serions	*26. Navicula pupila*
3. Cocconeis placentula	*27. Navicula radiosa*
4. Cocconeis placentula var euglyphyta	*28. Navicula tuscula*
5. Cyclotella kuetzingiana	*29. Navicula reinhardtii*
6. Cyclotella meninghiniana	*30. Navicula salinarum*
7. Cyclotella cymbiformis	*31. Navicula vulpine Kutz*
8. Cymbella ehrenbergii	*32. Navicula crucicula*
9. Cymbella lanceolate Kutz	*33. Navicula rostellata kutz*
10. Cymbella muller Hustedt	*34. Navicula halophile Grun*
11. Cymbella tumida	*35. Navicula gracilis Her*
12. Cymbella turgidula	*36. Nitzchia recta*
13. Cymbella cuspidata Kutz	*37. Nitzchia acicularis*
14. Fragillaria construents	*38. Pinnularia biceps*
15. Fragillaria virescens	*39. Pinnularia acrosphaeria*
16. Fragillaria crotnensis	*40. Pinnularia major*
17. Gomphonema constrictum	*41. Pinnularia nobilis*
18. Gomphonema gracile Eer	*42. Rhopalodia gibberula Her.*
19. Gomphonema intricatum kutz	*43. Tabellaria flocculosa*
20. Gomphonema truncatum	*44. Stauroneis anceps*
21. Gyrosigma accuminatum	*45. Surirella robusta*
22. Gyrosigma attenuatum	*46. Synedra ulna*
23. Gyrosigma kutzingii	
24. Melosira granulate	

Table.2 Physicochemical parameters in four selected lakes of Tumkur

Sl.No	Physicochemical parameters	Gulur Lake	B.G.Halli Lake	Colony Lake	Teetha Lake
1.	pH	7.07	7.04	7.11	7.04
2.	Air Temperature (^{0}C)	29.56	29.57	31.04	30.12
3.	Water Temperature(^{0}C)	26.45	27.16	27.62	26.75
4.	Electrical Conductivity(μScm^{-1})	540.24	661.32	689.00	488.15
5.	Turbidity (NTU)	24.00	17.90	22.58	32.00
6.	Total Hardness	232.21	179.00	168.25	274.16
7.	Calcium(mgL^{-1})	16.45	11.48	21.95	21.45
8.	Phosphate(mgL^{-1})	0.81	0.28	0.18	0.28
9.	Sulphate(mgL^{-1})	73.86	39.91	30.22	30.53
10.	Nitrate(mgL^{-1})	4.48	0.4	0.39	0.69
11.	Silica(mgL^{-1})	35.31	109.85	139.06	40.48
12.	Dissolved Oxygen(mgL^{-1})	7.93	7.60	7.47	8.08
13.	Biological Oxygen Demand(mgL^{-1})	5.42	6.55	7.90	10.20
14.	Carbon Dioxide(mgL^{-1})	10.98	8.0	3.05	1.66

Table.3 Pooled data of correlation coefficient of diatoms with physicochemical parameters

Sl.No.	Factors	r-values
1.	pH	+0.394
		0.057
2.	Air Temperature	+0.723
		0.000*
3.	Water Temperature	+0.695
		0.000*
4.	Electrical Conductivity (μScm^{-1})	+0.742
		0.0216
5.	Turbidity (NTU)	-0.625
		0.220
6.	Total Hardness	-0.321
		0.122
7.	Calcium	-0.129
		0.550
8.	Phosphate	+0.413
		0.045
9.	Sulphate	+0.703
		0.000*
10.	Nitrate	+0.724
		0.000*
11.	Silica	+0.748
		0.000*
12.	Dissolved Oxygen	-0.523
		0.009*
13.	Biological Oxygen Demand(mgL^{-1})	-0.426
		0.006*
14.	Carbon Dioxide	-0.384
		0.064

Figure.1 Seasonal abundance of diatoms in four lakes of Tumkur district
Abundance is expressed interms of organisms/liter

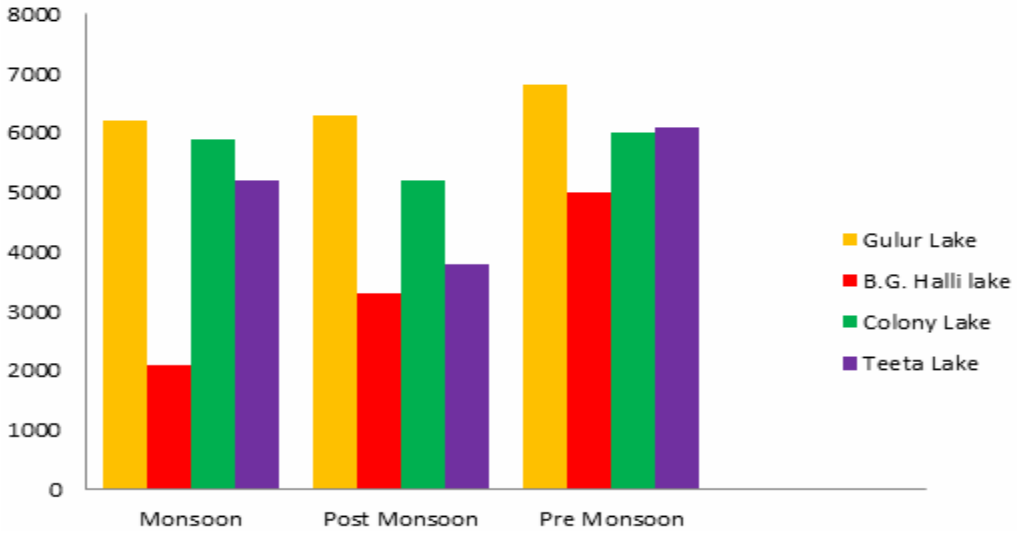
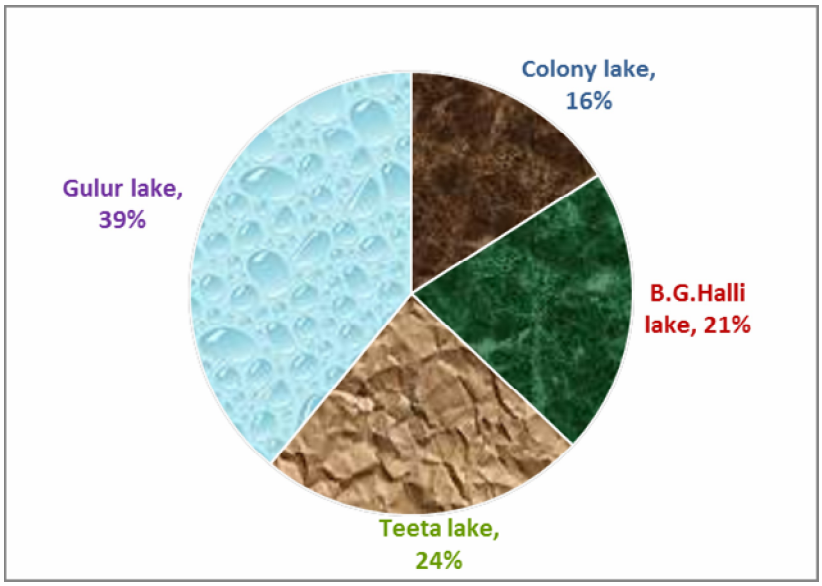


Figure.2 Relative abundance of diatoms in four lakes of Tumkur district



Water analysis

Water quality parameters measured were listed in Table 2. During the investigation, all the lakes recorded pH value of slightly alkaline (above 7.0) with considerable periodicity and density. pH recorded highest in Colony lake. Silica concentration varied from 35.31mg/l in Gulur lake to 139.06mg/l in colony lake. Comparatively calcium and silica concentration were high in Colony lake. However, Gulur lake recorded highest values of sulphate and nitrate. Concentration of phosphorous ranges from 0.23mg/l in B.G.Halli lake to 0.18mg/l in Colony lake.

Statistical analysis showed that pH has no direct bearing on the periodicity and density of diatoms. Silicate, phosphate, nitrate and pH concentrations were correlated with diatom community composition. Phosphorous, nitrogen and pH are usually the most important determinants of algal growth and community composition in streams (Pan *et al*., 1999). Patric (1977) observed that acidic pH do not support the abundance of diatoms, while alkaline waters with pH above 8.0 showed higher density of diatoms. Further, concentration of silica showed significant positive correlation with diatom population (Table 3). Hegde and Bharati (1986), Vaishya and Adoni (1992) reported higher density of diatoms in phosphorous rich waters. It is also noticed that all the four lakes recorded good number of diatoms in accordance with the above researchers. It is noticed that, diatoms population is positively correlated with concentrations of sulphate ($r = 0.703$) and nitrate ($r = 0.724$) and negatively correlated with concentrations of dissolved oxygen ($r = -0.523$) at 5% level. However, no significant relationship could be established between the population of diatoms and concentration of carbon dioxide and phosphate. Meera *et al*., (2010) observed that, diatom based water quality analysis of wetlands resulted with trophic status of wetlands and proves that, diatoms are the suitable indicators of environmental changes and might be incorporated in wet land conservation.

Diatom communities and the use of diatom indices yield significant results in lake water quality monitoring in India. From the results, it is concluded that, selected lakes are at a wide distance apart, many diatom communities in them have similar environmental properties. Water chemistry is related to diatom indices are an indication that, diatoms can be used as indicators of organic and anthropogenic pollution. It is difficult to say whether Kasekera's deltaic diatom assemblages reflected the lake due to differences in its catchment, stream chemistry or the sampling treatments in this study. In spite of the applicability of the European diatom index to local water bodies, there is a need for the development of diatom indices for endemic species applicable to monitoring of tropical Indian lakes. In order to achieve this, identification and preparation of taxonomic list of diatom flora of Indian water bodies needs to be stressed. Further research is needed to determine whether sampling deltaic sediments to study Lake Diatom communities could become a reliable tool for studying lake environments.

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