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Diatoms Assemblages Distribution in Cauvery Rivers, Bhavani, Tamil Nadu, India in Relation to Chemical and Physiographical Factors

Venkatachalapathy R.* **and Karthikeyan P.**
Department of Geology, Periyar University, Salem-11, INDIA

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Abstract

The present study assesses the epilithic diatom communities in river in relation to environmental conditions. Epilithic diatoms and water samples were collected in 5 locations during summer season (May 2012). Analysed data were interpreted and the results are represented. Two statistical methods were used in this study; Canonical correspondence analysis (CCA) and Principal component analysis (PCA) were used to determine the species distribution and environmental gradients along vary with physical and chemical variables. A total of 37 diatom species distributed among 17 genera were recorded. The significance of water quality difference among the sampling sites was expressed by four strastical methods. Highly polluted water contain diatom species like Pleurosigma salinarum, Nitzschia thermalis, Gomphonema parvulum, Gomponema lanceolatum, Fragilaria intermedia in the densely populated and highly industrialized locations and slightly polluted water present the diatom species like Achnanthes minutissiuma Kutz, Cyclotella catenata and Cymbella tumida among sampling sites.

Keywords: Benthic diatoms, summer season, Statistical methods, Industrialized.

Introduction

Diatoms are recognized worldwide as one of the most fitting organic components for water quality assessment, due to their constant presence along the aquatic system and also because they give a quick response to environmental changes[1]. There are currently over 260 genera of living diatoms with over 100,000 species[2-3]. Most of the studies carried out on benthic diatoms tends to concentrate on epilithic diatoms (growing on stones) and very little is known about epipsammic diatoms (growing on sand) their environmental importance in the structure and functioning of lotic systems. Diatoms are the essential components of primer productivity in aquatic ecosystems. These organisms are the sources of essential oxygen for aquatic life. Diatoms are so ecologically important that they are used for monitoring environmental conditions of waters. Diatoms have been used in a number of countries as indicators of river pollution[4-5]. The investigations in river diatoms are scanty due to practical difficulties in the survey and sampling of flowing water. However, diatoms of fresh water rivers have been studied extensively in India[6-7]. These Studies are investigating diatoms in relation to urban and other land use impacts typically relate assemblage composition to specific water quality measures such as nutrient concentrations and pH[8]. Certainly, the use of diatoms in most river assessments is controlled in assessing water quality conditions[9-10].

Importance of Diatom Studies in Rivers: A diatom community is a popular tool for monitoring environmental conditions, commonly used in studies of water quality. According to diatoms develop faster when they grow on rocks or hard surfaces, in general cobbles, boulders and pebbles are used in the sampling of these epilithic diatoms[11]. The sensitivity of diatom communities has led them to be used as indicators of environmental conditions, such as water quality and habitat conditions in river systems and stream[12]. Has recorded a total of 60 diatoms belonging to 21 genera from Cauvery river in parts of Tamil Nadu[13-14]. Among these *Achnanthes minutissima* Kutz, *Achnanthidium Plonensis, Aulacoseira distans, Cymbella turgida* (Greg) Cleve, *Cymbella ventricosa* Kutz, *Fragilaria intermedia* Grun var. robusta, *Gomponema lanceolatum* Ehr, *Nitzschia sigma* (Kutz) W Smith, *Synedra rumpen*, *Synedra ulna* (Nitzsch) Ehr were the most abundance species.

Material and Methods

Study area: The study area lies at 77°40' E to 77°42' E longitude and 11°25'N to 11°27' N latitude with an area of 9.05 sq. km (figure 1). The Cauvery River is one of the major rivers of South India. The Cauvery rises at Talakaveri on the Brahmagiri Range of Hill in Western Ghats of India. The river has an approximate length of 760 km flows in the South and East through Karnataka and Tamil Nadu States. The expansion of the city at the moment does not meet the technical standards that should go with it in terms of streets, sewage treatment and collection of garbage, urban drainage, water supply, road system and recreational area. The council also does not have an adequate system of sorting and disposal of waste. River in the study area, therefore, receive untreated or semi-treated effluent from various domestic and industrial sources as well as other diffuse sources as they pass through the city of Bhavani. In 2011, the population of Bhavani was approximately 54,645. The

Kalingarayan Canal is a 90 km long irrigation canal in the Erode region of Tamil Nadu, India. It was constructed by Kongu chieftain Kalingarayan and completed in the year 1823. This runs parallel to Cauvery River. The Canal was designed with a meandering route to maximize the amount of agricultural land which benefited.

Sample collection: Diatom and water quality sampling was done during pre-monsoon (May 2012). The dry season was selected to avoid variable effects of rainy season like great variations in water level and velocity, which affect diatom development, especially growth rate and relative abundance of different species. Parameters like pH, electrical conductance and water temperature (°C) were measured within a few hours of collection by using Elico pH meter and conductivity meter respectively. Calcium and Magnesium were determined titrimetrically using standard EDTA, and chloride was determined by silver nitrate titration. Sodium, Potassium, Phosphates, Biological oxygen demand (BOD), Chemical oxygen demand (COD) and Dissolved oxygen (DO) were analyzed in laboratory and analyses were assessed by using standard methods for the assessment of water quality. Diatom and water samples were collected in polythene bottles from all obtainable habitats such as epilithic (stones). Further, diatom samples were collected by brushing stones with a toothbrush. At least five, pebbles to cobble (5-15 cm) sized stones were collected from the river bottom. They were brushed and the diatom suspension was put in a small plastic bottle. Epilithic diatoms were sampled at five sampling stations during on May 2012. In all studies, diatom samples were preserved in formaldehyde (4%).

Laboratory analysis: Sub-samples of the diatom suspensions were cleaned to remove organic material using wet combustion with concentrated HNO_3 and cleaned using 30% H_2O_2 mounted in Naphrax. Taxonomic identification was performed according to mainly and guidelines given[15]. Statistical analyses comprising Principal component analysis (PCA) was performed using PAST 2.04 version software to explain the water quality variation. Canonical corresponding analysis (CCA) a multivariate statistical technique for analyzing environmental data of a community (using PAST 2.04 versions) was used to study the major patterns of community composition and maximum amount of variation in the diatom distribution across the rivers.

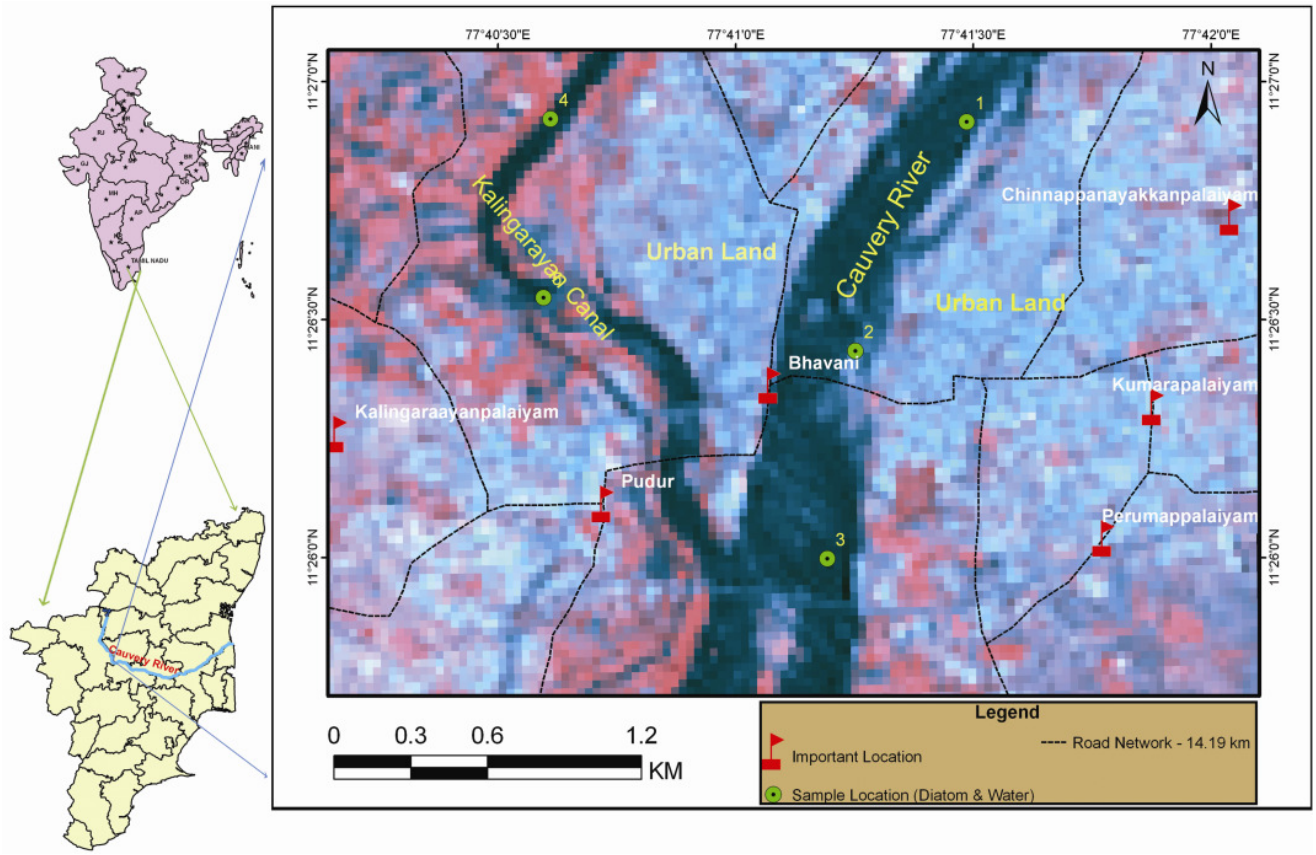

Figure-1
Location of the Cauvery River and the sampling points from Bhavani at each location water with Diatom samples from the river channel (Land sat image 2008)

Species distribution: The present study recorded a total of 37 diatoms belonging to 17 genera species *Achnanthes inflata, Achnanthes minutissima, Amphora ovails, Caloneis pulchra, Cocconeis placentula, Caloneis silicula, Cyclotella catenata, Cyclotella meneghiniana, Cymbella aspera, Cymbella cymbiformis, Cymbella tumida, Cymbella tumidula, Cymbella turgida, Cymbella ventricosa, Eunotia fallax, Fragilaria intermedia, Gomphonema gracile, Gomponema lanceolatum, Gomponema olivaceum, Gomponema undulatum, Navicula mutica, Nitzschia palea, Nitzschia pseudofonticola, Nitzschia recta, Nitzschia sigma, Nitzschia thermalis, Melosira granulata, Pinnularia acrosphaeria, Pleurosigma indica, Pleurosigma salinarum, Stauroneis anceps, Surirella linearis, Surirella robusta, Surirella splendida, Surirella tenera, Synedra rumpens, Synedra ulna* genera with wide range of community composition and species distribution across the river. Among all species (relative abundance >0.05% of all sites), *Achnanthes minutissima* Kutz, *Cyclotella meneghiniana* Kutzing, *Cyclotella catenata* Brun, *Cymbella tumida* (Breb) Van Heurck, *Cymbella turgida* (Greg) Cleve, *Cymbella ventricosa* Kutz, *Fragilaria intermedia* Grun *var. robusta, Gomponema lanceolatum* Ehr, *Gomphonema parvulum,* Nitzschia *sigma* (Kutz) W Smith, *Nitzschia thermalis* Kutz v minor Hilse, *Nitzschia palea (*Kutzing) W. Smith, *Pleurosigma salinarum* Grun, *Synedra ulna* (Nitzsch) Ehr. *Cyclotella meneghiniana* Kutzing, *Gomphonema parvulum* and *Nitzschia palea (*Kutzing) W. Smith were the most abundance species occurred. *Cyclotella meneghiniana,* a pollution tolerant species was abundant at Kumarapalaiyam, representing water quality as rich with ionic concentration. *Gomphonema parvulum* and *Nitzschia palea* with environmental characteristics of highly tolerant to nutrients and ions is abundant at Kumarapalaiyam south, which is having the highest electrical conductivity and ionic concentrations. However Kalingarayan canal, unlike from rest of the river (low ionic level) is dominated by *Achnanthes minutissiuma* Kutz species which occurs in slightly too moderate waters.

Water quality assessment: The Physicochemical analytical results of water sample are given in table 1. The pH, EC, BOD, COD and alkalinity are the parameters showed marked difference among various samples. The pH is ranged from 7.12 to 7.81 highest being 7.81 at Kumarapalaiyam south. Water temperature had a wide range, 24.00 to 27.80 (mean 25.86, SD 1.62) which mainly dependent on the time of sampling. The EC is varying much (mean 937.912, SD 336.1217) having low at Kuduthurai (404 ppm) and high value noticed at Kumarapalaiyam south (1223.33 ppm) which is beyond the permissible limits. High electric conductivity is mainly due to high ionic concentrations. Nutrients such as nitrates and phosphates varied from 0.01-0.12 ppm and 0.002-0.030 ppm respectively within the permissible limits. The alkalinity ranged from 110mg/L at Kuduthurai and high to 159.01mg/L at Kumarapalaiyam south. Both COD and BOD values were high at Angalamman temple (80.01mg/L, 13.80 mg/L) and low at Kuduthurai (10.65 mg/L, 2.92mg/L) respectively. Among 5 sample locations, the Angalamman temple and Kumarapalaiyam south sites recorded with high ionic concentrations while low values within the permissible limit were recorded in Kalingarayan canal and Kuduthurai[16].

Canonical correspondence analysis: The results of CCA are presented in figure 3. The CCA explained a large proportion of the diatom species variance; CCA axis 1, eigenvalue = 0.04 and axis 2, eigenvalue = 0.4. Monte Carlo unrestricted permutation test indicated that axis 1 (100 permutations) and axis 2 (100 permutations of axis 2 with axis 1 as a covariable) were statistically significant ($p<0.05$). The CCA axis 1 and 2 roughly separated relatively less polluted sites (Kalingarayan canal and Kuduthurai) from highly polluted sites (Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south). The former group of sites is associated with slightly pH and DO (which was highly positively correlated with T, EC, TDS and BOD). The parallel Canal, relatively less polluted sites (Kalingarayan Canal and Kuduthurai) were characterised by such species as *Achnanthes minutissima, Fragilaria intermedia* Grun, *Cymbella tumida* and *Cyclotella catenata*. These species were highly negatively associated with CCA axis 1. On the other hand, down river, highly polluted sites (Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south) were characterised by *Gomphonema parvulum* (Kützing) Cleve and *Nitzschia palea* (Kützing) Smith which have been reported to be highly pollution tolerant[2] and *Pleurosigma salinarum* Grun, *Nitzschia thermalis* Kutz v minor Hilse, *Gomphonema parvulum*, *Gomponema lanceolatum* Ehr, *Fragilaria intermedia* Grun were positively associated with CCA axis 2.

Table-1
Major Cations & Anions Concentration in River water Samples
(All values in the table are expressed in ppm except EC in μScm^{-1})

Location	pH	T	EC	TDS	DO	BOD	COD	N	P	TH	CaH	MgH	CHL	ALK
Angalamman Temple	7.52	27.80	1203.23	560.67	5.67	13.80	80.01	0.01	0.02	236.67	91.23	57.83	272.12	151.00
Kumarapalaiyam	7.67	26.57	1015.67	937.00	5.81	12.89	42.32	0.01	0.03	243.97	89.00	56.19	285.34	151.11
Kumarapalaiyam south	7.81	26.60	1223.33	769.33	6.89	7.90	65.08	0.01	0.01	322.93	82.23	57.58	277.81	159.01
Kalingarayan Canal	7.12	24.33	843.33	535.00	3.87	3.20	10.91	0.01	0.01	119.33	79.67	33.35	65.96	115.33
Kuduthurai	7.15	24.00	404.00	270.00	3.60	2.92	10.65	0.12	0.00	131.00	76.93	18.51	42.40	110.00

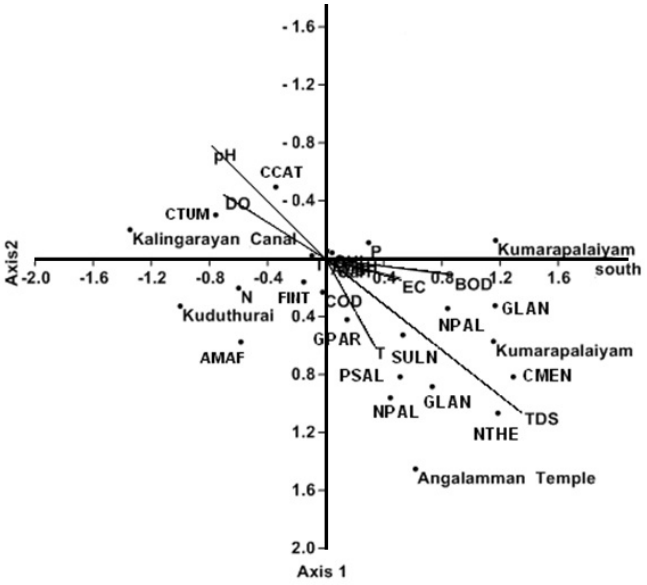

Figure-3

Ordination diagram based on Canonical correspondence analysis (CCA). *Achnanthes minutissima* AMAF, *Fragilaria intermedia* Grun FINT, *Cymbella tumida* CTUM and *Cyclotella catenata* CCAT, *Synedra ulna* (Nitzsch) SULN, *Pleurosigma salinarum* Grun PSAL, *Nitzschia palea* (Kutzing) W. Smith NPAL, *Nitzschia thermalis* Kutz v minor Hilse NTHE, *Gomphonema parvulum* GPAR, *Gomponema lanceolatum* Ehr GLAN, *Fragilaria intermedia* Grun FINT

Principal component analysis: The PCA formed 2 groups of highly polluted among sampling sites (figure 4). Sampling sites, Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south were grouped to the right side along the component 1, characterized by higher concentrations of water temperature, BOD, COD, Phosphate and Calcium. In all sides, most abundance of polluted water species are like *Pleurosigma salinarum*, *Nitzschia thermalis*, *Gomphonema parvulum*, *Gomponema lanceolatum* and *Fragilaria intermedia*. Kalingarayan canal and Kuduthurai were grouped along the component 2 with minimum influence of water chemistry and most abundance fresh water species such as *Achnanthes minutissima, Fragilaria intermedia* Grun, *Cymbella tumida* and *Cyclotella catenata*. These were grouped separately showed pH, EC, DO and magnesium effects moderately or slightly polluted among sampling sites.

Results and Discussion

The equivalent as contamination greater than before, low pollution tolerant species such as *Achnanthes minutissima, Fragilaria intermedia* Grun, *Cymbella tumida* and *Cyclotella catenata* were replaced by high pollution tolerant species such as *Fragilaria intermedia*, *Gomponema lanceolatum*, *Gomphonema parvulum, Nitzschia palea, Nitzschia thermalis* and *Pleurosigma salinarum*. The high pollution group of species has been reported to be associated with waters of comparatively high ionic strength and high conductivity that accompanied the downriver gradient in this study[17]. Similarly, Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south sites are highly polluted due to anthropogenic activities and industrial effluents evidenced by CCA. *Nitszchia palea* to be tolerant of organic pollution due to sewage effluent in the river of Yamuna, Delhi, India[18]. Similarly in this Species is most abundance at Kumarapalaiyam site due to highly sewage effluent in these sites. *Gomphonema parvulum* has also been shown to be tolerant of organic pollution which is also similarly to Kumarapalaiyam South and Kumarapalaiyam are most abundances of the location due to higly sewages effluent and dying factories. Species are indicative of the upper limits of pollution that they can tolerate and not the lower limit. Thus species which develop well in polluted *Fragilaria intermedia*, *Gomponema lanceolatum*, *Gomphonema parvulum, Nitzschia palea, Nitzschia thermalis*, *Pleurosigma salinarum* may also occur in fairly clean water. Their values indicate is their presence in polluted water which was also characteristic of the Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south.

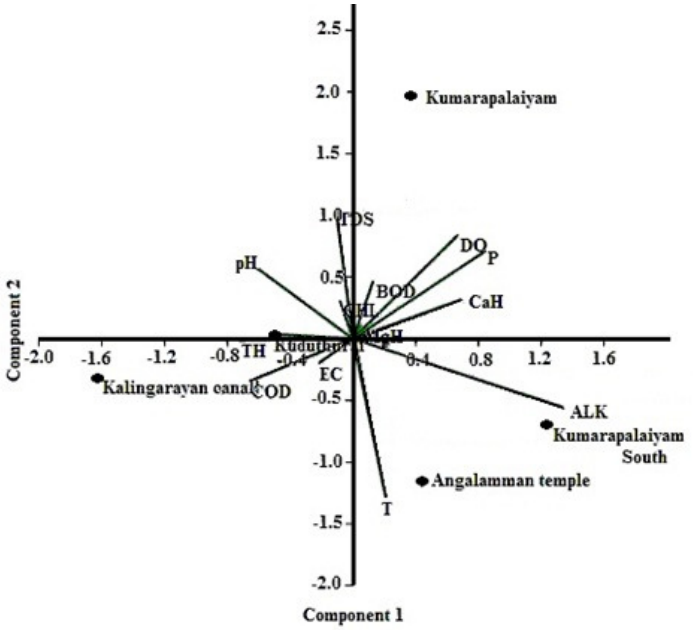

Figure-4

The Principal component analysis (PCA) diagram

Conclusion

The significance of water quality difference among the sampling sites is expressed in CCA and PCA gradient. The highly polluted sites are clearly separated from analysed data. The CCA and PCA analysis demonstrate that sampling sites Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south were grouped to the component 1, characterized by highly polluted water that locations present the water pollution indicated diatom species like *Pleurosigma salinarum*, *Nitzschia thermalis*, *Gomphonema parvulum*, *Gomponema lanceolatum*,

Fragilaria intermedia pollution due to densely populated and highly industrialized (dyes factories). The two locations showed slight but important differences in diatom assemblages. Kalingarayan Canal and Kuduthurai were grouped along the component 2 with slightly polluted water that locations present the fresh water diatom species like *Achnanthes minutissiuma* Kutz, *Cyclotella catenata* and *Cymbella tumida* among sampling sites. Diatom taxa that were abundant in a number of sites and associated with good quality environmental variables were *Achnanthes minutissiuma* Kutz, *Cyclotella catenata* and *Cymbella tumida.* The most important aim of this study is to assess direct measures of urbanization (impervious surfaces, drainage link, septic tanks and water quality changes) and assess their relative contribution to the composition of diatom assemblages in urban rivers. A consequent aim of the development is to assess the potential for using abroad diatom indices in studies on water quality in south India. Although these indices were primarily designed for river improvement studies, the presence of such a split disturbance gradient may provide some initial assessment of their potential use in a province further than their sources.

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