International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-3, February 2013

Benthic Diatoms in River Influenced by Urban Pollution, Bhavani Region, Cauvery River, South India

R.Venkatachalapathy, P. Karthikeyan

***Abstract-** The present-day study assesses diatom communities in river with relation to environmental conditions. Diatoms are susceptible to environmental conditions in river and their distribution is mainly governed by the physicochemical composition of the water. Diatoms and water samples were collected in 5 locations during summer season (May 2012). Analysed data were interpreted and the results are represented. Four statistical methods were used in this study, Cluster analysis, Canonical correspondence analysis (CCA), Principal component analysis (PCA) and Detrended correspondence analysis (DCA) were determined the species distribution and environmental gradients along polluted and unpolluted area 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:** Diatom, Statistical method, Polluted water.*

I. INTRODUCTION

Diatoms are single-celled, microscopic algae (Bacillariophyta) whose siliceous, glass-like cell walls preserve well in various sedimentary environments allowing reconstructions of past environments from subfossil diatom assemblages. They are a very successful group of organisms that can be found in virtually every aquatic habitat. Accordingly, diatom analysis is applicable across a wide range of aquatic environment, including freshwater, brackish, estuarine, ocean and includes lentic and lotic environments, wetlands and their associated damp, marginal and littoral zones. Diatoms are sensitive to environmental conditions in water ecosystems and their distribution is mainly governed by the physicochemical composition of the water which is a significance of regional lithology, topography, climate, vegetation and anthropogenic influences. Chemical analyses of water present a good indication of the chemical quality of the aquatic systems, but do not integrate environmental factors such as altered vegetation or altered flow regime and therefore, do not necessarily reproduce the environmental state of the system.

Manuscript published on 28 February 2013.
***Correspondence Author(s)**
R. Venkatachalapathy, Department of Geology, Periyar University, Salem-636011, Tamil Nadu State, India
P. Karthikeyan, Department of Geology, Periyar University, Salem-636011, Tamil Nadu State, India

The chemistry of large rivers of India and its relationship with weathering and exogenic cycling of elements have also been described fairly well. The assemblage of geographical, environmental and chemical data included in the study explained all of the variation observed within the diatom communities. Wide geographic distribution and well-studied environmental science of most diatom species are cited as major advantages of using diatoms as indicator organisms. These assumptions imply that diatom-based water-quality assessment tools should have universal applicability across geographic areas and environments. Diatom communities are a popular tool for monitoring environmental conditions, commonly used in studies of water quality. Natural assessment is a useful alternative for assessing the environmental quality of aquatic ecosystems since organic communities integrate the environmental effects of water chemistry, in addition to the physical and geomorphological characteristics of rivers (Stevenson and Pan, 1999). Epilithic 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 (Salomoni, 2004). Diatoms are so ecologically important that they are used for monitoring environmental conditions of waters. However, diatoms of fresh water rivers have been studied extensively in India (Trivedy and Khatavkar, 1996).

II. METHODS

A. 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 (Fig.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 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.

B. Diatom sampling, preparation and analysis

Diatom samples collected in polythene bottles from all obtainable habitats such as plants and stones. Diatom samples were taken by brushing the undersurfaces and petioles of at least five plant leaves and roots.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

In all studies, diatom samples were preserved in formaldehyde (4%). For Polarizing microscopy analysis, a 10 ml epiphytic and epilithic subsamples were extracted and cleaned using 30% H_2O_2 and concentrated HNO_3. Identification of diatoms was carried out using taxonomic guides. Continuous preparations of diatoms were used to identify their genera and their counts with a polarizing microscope.

C. Site characterization

The sites were selected to cover a large gradient ranging from pristine to polluted with different levels of human disturbance, covering the major types of geomorphological and physiographical conditions. Chemical data (conductivity, pH, BOD_5, COD_5, Ca^{2+}, PO_4^{3-}_P, Mg^{2+}, NO^{3-}, N^-, NO_2–N, K^+, Na^+, SO_4^{2-}) of the sites were obtained. Water samples were analyzed following standard procedures (APHA, 1989).

D. Data analysis

Statistical analyses comprising Principal component analysis (PCA) was performed using PAST 2.04 version software to explain the water quality variation. Detrended correspondence analysis (DCA), 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. Diatom data were analyzed with detrended correspondence analysis (DCA) to determine the length of the gradient for the first two axes. DCA indicated that the gradient length was greater than 2 standard deviation units; therefore, the use of unimodal ordination techniques would be appropriate. Constrained ordination, canonical correspondence analysis (CCA) was used to relate diatom assemblage structure to all predictor environmental variables and to explore the relationships among and between species and the environment.

III. RESULTS

A. Environmental characteristics of sites

Rivers of the study area varied widely in water quality and habitat characteristics (Tables 1). Some study sites were located in densely populated, heavily industrialized or intensive agricultural areas, thus receiving high inputs of organic matter and industrial sewage. Other sites were less disturbed, fast-flowing and with a stony or stony-gravel bottom, characteristic of mountainous areas. Finally, others have a lowland character, being slow-flowing.

B. Species composition of diatom assemblages

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.

C. Important environmental variables

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 110 mg/L at Kuduthurai and high to 159.01 mg/L at Kumarapalaiyam South. Both COD and BOD values were high at Angalamman temple (80.01 mg/L, 13.80 mg/L) and low at Kuduthurai (10.65 mg/L, 2.92 mg/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 (WHO 1996) were recorded in Kalingarayan canal and Kuduthurai. 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 (Duong et al., 2006) 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 (Figure 3). Taxa were observed in more than 5% of the samples of all sites, *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 ulna* (Nitzsch) Ehr were the most abundance species occurred. *Amphora ovails* (Kutzing) Grunow was the most abundant taxon and occurred in up to 45% of all samples. The second most abundant species were *Achnanthes minutissima Kutzing* and *Navicula symmetrica*.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

The 15 environmental variables altogether explained 100% of the total variation within the species data. The first two axes explained a significant portion of variance in the diatom taxa data (P>0.01). 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. These species were cosmopolitan which is reported from North America (Stevenson and Pan, 1999) Europe (Bella et al., 2007) & Africa (Facca and Sfriso, 2007) and well recognized diagonally inhabiting sensible to extremely polluted in the river. *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. The PCA formed 2 groups of highly polluted among 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 (Figure 4). The first DCA axis summarized the distribution of the diatom communities throughout the conductivity and nutrient gradient of the moderately polluted sites at the top of the plot (Figure 5). The highly polluted sites were clustered on the bottom side of the axis with dominant tolerant taxa and corresponded to Angalamman temple, Kumarapalaiyam, Kumarapalaiyam south sites located in densely populated and highly industrialized (dyes factories) areas.

IV. DISCUSSION

The environmental distinguishing of every diatom taxa in occurrence and distribution as community composition is significant at every sampling location. 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, PCA and DCA 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.* Diatoms taxa showing maximum abundance of species like *Cymbella meneghiniana*, *Gomphonema lanceolatum* and *Synedra ulna* in these samples. Sites on the upper left side of the axis 2 corresponded to communities in moderate pollution in the locations of Kalingarayan Canal the most abundant species are *Achnanthes minutissiuma* Kutz, *Cyclotella catenata* and *Cymbella tumida*. Kalingarayan canal is appeared as the least influenced as it is slightly affected by local agricultural and domestic activities. Based on Cluster analysis suggestion site 5, which was the furthest downriver side, tended to be more similar to the parallel canal relatively less polluted sites compared to the other sites in terms of community structure and water quality. This could be due to the process of river self-alteration, which is a group look for a huge amount of biogeochemical and hydrological processes that for the moment reduces, decompose, humiliate, alter or permanently slow down and remove pollutants from the river. This self- alteration process is very effectual and the system will suffer no permanent damage as long as its ability has not been exceeding (Bere 2007). 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 (Biggs and Kilroy, 2000; Potapova and Charles, 2003) that accompanied the downriver gradient in this study. Similarly, Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south sites are highly polluted due to anthropogenic activities and industrial effluents evidenced by CCA and DCA. *Nitszchia palea* to be tolerant of organic pollution due to sewage effluent in the river of Yamuna, Delhi, India (Dakshine and Soni, 1982). 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 (Lobo et al., 2004) which is also similarly to Kumarapalaiyam South and Kumarapalaiyam are most abundances of the location due to higly sewages effluent and dying factories.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

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 (R. Venkatachalapathy and P. Karthikeyan, 2013). Their values indicate is their presence in polluted water which was also characteristic of the Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south.

V. CONCLUSIONS

The most important aim of this study is to assess direct measures of urbanization (impervious surfaces 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.

VI. ACKNOWLEDGEMENT

The authors are expressing their sincere thanks to Periyar University for all the supports rendered to carry out the investigation at Advanced Micropaleontology Lab.

REFERENCE

1. APHA (American Public Health Association) (1996), Standard methods for the examination of water and wastewater, 19th eds. Public Health Association, Washington, dc.
2. V. D Bella, Benthic diatom communities and their relationship to water chemistry in wetlands of central Italy. 2007, Ann. Limnol. - Int. J. Lim. 43(2): 89-99.
3. T. Bere, Epipsammic diatoms in streams influencedby urban pollution, São Carlos, SP, Brazil. 2010, Braz. J. Biol. vol. 70, no. 4, p. 921-930
4. B. J. F. Biggs, Stream priphyton monitoring manual. New Zealand: NIWA. 2000.
5. K. M. M. Daskshine, Diatom distribution and status of organic pollution in sewage drains. *Hydroniologia*, vol. 87, 1982, no. 3, p. 205-209.
6. T. T. Duong, Impact of Urban Pollution from the Hanoi Area on Benthic Diatom Communities Collected from the Red, Nhue and Tolich Rivers (Vietnam). Hydrobiologia, vol. 563, 2006, no. 3, p. 201-216.
7. C. Facca, Epipelic diatom spatial and temporal distribution and relationship with the main environmental parameters in coastal waters, Estuarine, Coastal and Shelf Science. 75: 35–49. 2007.
8. E. A. Lobo, Use of epilithic diatoms as bioindicators from lotic systems in southern Brazil, with special emphasis on eutrophication. Acta Limnol. Bras. vol. 16, no.1, 2004, p. 25-40.
9. M. Potapova, Distribution of benthic diatoms in US rivers in relation to conductivity and ionic composition. Freshwater Biology, vol. 48, no. 2, 2003, p. 1311-1328.
10. R. Venkatachalapathy and P. Karthikeyan, Environmental impact assessment of Cauvery river with diatoms at Bhavani, Tamil Nadu, India. International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online), 2012, Vol. 2 (3) Sept-Dec, pp.36-42
11. R. Stevenson, Assessing environmental conditions in rivers and streams with diatoms. In: The Diatoms: Applications for the Environmental and Earth Sciences. Cambridge University Press, Cambridge, (eds Stoermer, E. F. and Smol, J. P.). 1999, 11-40.
12. R. K. Trivedy, Phytoplankton Ecology of the River Krishna in Maharashtra with Reference to Bio indicators of Pollution. In: Assessment of Water Pollution, Mishra, S.R (Ed.). APH Publishing Corporation, New Delhi, pp: 299-328. 1996.
13. World Health Organization (WHO) (1996) Guideline for drinking water quality. Vol.2. Health criteria and other supporting information, Geneva. Pp.973.

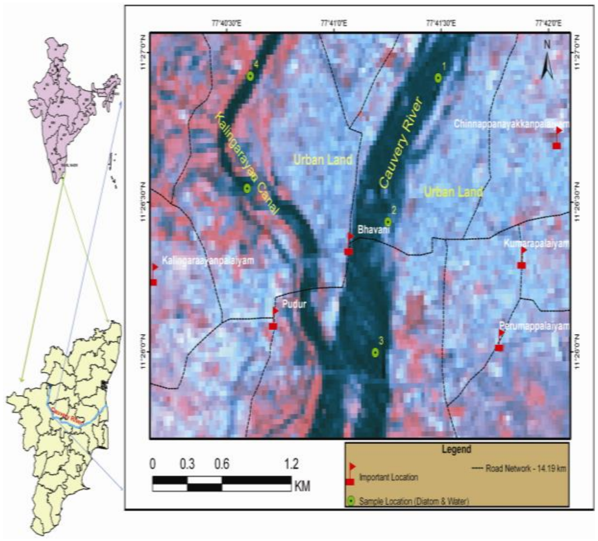

Figure 1. Location of the Cauvery River and the sampling points from downstream in and around Bhavani (Land sat image 2008).

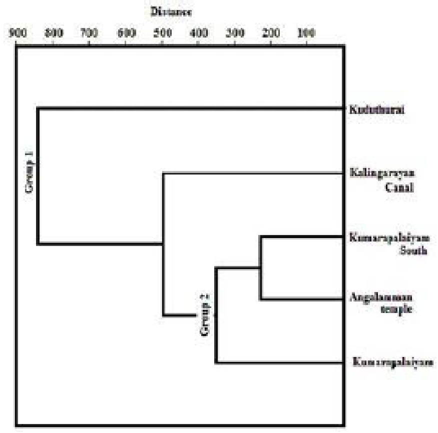

Figure 2. The output of the single linkage, Euclidean distance classification is given in figure. This diagram formed 2 groups like highly polluted and slightly among sampling sites. Sampling sites Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south were grouped to the lower linkage distance along th`

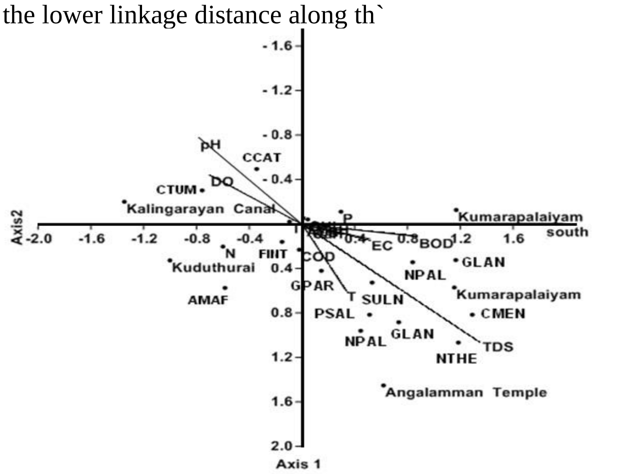

Figure 3. Ordination diagram based on Canonical corre-spondence analysis (CCA) of most frequently occurring diatom species composition in 5 sampling sites with respect to five environmental variables

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-2 Issue-3, February 2013

(pH, T, EC, TDS, DO, BOD and COD). 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.

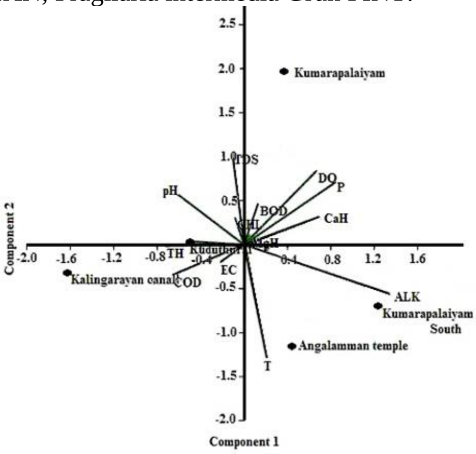

Figure 4. The Principal component analysis (PCA) diagram shows that considerable movement away in water chemistry transversely river explaining 56.691% and 37.209% of the variance from 1st and 2nd component respectively. PCA formed 2 groups of highly polluted among sampling sites. Sampling sites Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south were grouped to the right side along the component 1. Kalingarayan canal and Kuduthurai were grouped along the component 2 with minimum influence of water chemistry.

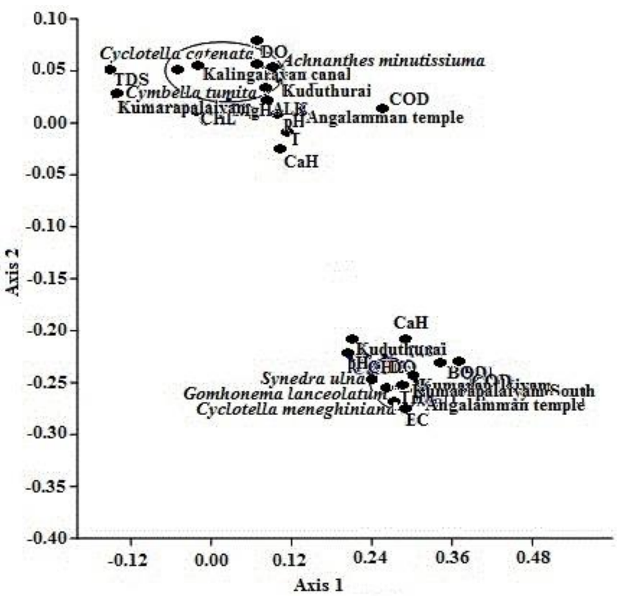

Figure 5. The Detrended correspondence analysis (DCA) plot shows diatom community composition and its relationship with varying environmental variables across river sampling sites. The first DCA axis summarized the distribution of the diatom communities throughout the conductivity and nutrient gradient of the moderately pollutes sites at the top of the plot. The Highly polluted sites were clustered on the bottom side of the axis with dominant tolerant taxa and corresponded to (Angalamman temple, Kumarapalaiyam and Kumarapalaiyam south) those sites located in densely populate.

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	13.8	80.01	0.013	0.024	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	0.014	0.030	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	0.012	0.014	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	0.014	0.005	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	0.123	0.002	131.00	76.93	18.51	42.40	110.00

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)