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Physical, Chemical and Environmental Studies on Cauvery River in Parts of Tamil Nadu (Mettur and Bhavani)

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Abstract:

Studies on diatom of river Cauvery water, Mettur and Bhavani Salem District, Tamil Nadu was made to assess the pollution of water from May 2011. Our work was focused on Physico-chemical and environmental studies of Cauvery River in parts of Tamil Nadu. Macrophytes and water samples were collected from unpolluted and polluted sites along Cauvery River course, some ions from water also analyzed. Analysis of diatom communities has been performed in order to quantity the level of pollution in Cauvery River. The present study revealed that the water of Cauvery in Mettur and Bhavani are highly polluted by direct contamination of sewage and other industrial effluents. The source of pollution is most probably the dying factory and sewage from Kumarapalaiyam. The structure of diatom communities is strongly influenced by the different pollution source from this area.

Keywords: Diatom, Diatom Communities, Environmental Studies, Water Pollution,.

1.0 Introduction:

Diatom research in India has a history of over one hundred and fifty years (Ehrenberg 1845). Notable work on diatom taxonomy from this region includes the publications of Skvortzow (1935), Gonzalves and Gandhi (1952, 1953, 1954), Desikachary (1988, 1989) provided detailed illustrations and photomicrography of many recent marine and fossils centric forms from the Indian Ocean. Most of the freshwater centric forms are, however, often overlooked in plankton samples or fitted to the classical genera described from Europe (*viz Cyclotella* (Kützing) Brébisson*, Aulocoseira* G.H.K. Thwaites*, Melosira* C. A. Agardh and *Coscinodiscus* Ehrenberg), without further examination.

The investigations in river planktons are scanty due to practical difficulties in the survey and sampling of flowing water. However, phytoplankton of fresh water rivers have been studied extensively in India (Mishra and Saksena, 1993, Somasekar, 1988, Trivedy and Khatavkar, 1996) various phytoplankton groups prefer to exist in various kinds of water. The development of a phytoplankton community in a river depends directly upon the physical factors of flow and turbidity, and when either or both of these are too great, no appreciable populations can be formed. This study was therefore designed to determine if various anthropogenic stressors actually impact the water body and if they do, in what way and to determine if there is any significant difference in the abundance and diversity of the phytoplankton population at different stations as a result of these stressors. High population densities and multiplicity of industrial and agricultural activities expose most hydrographic basins to heavy and rising environmental impacts especially to pollution by domestic and industrial waste residues (Salomoni et al., 2006).

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 (Soininen et al., 2004). Venkatachalapathy & Karthikeyan (2012, 2013) has recorded a total of 60 diatoms belonging to 21 genera from Cauvery river in parts of Tamil Nadu. 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.

1.1 **Study Area**

The present study was carried out in the Cauvery River, not for entire river but selected in two segments named as Mettur and Bhavani. The first segment area lies at 77°48'6.86'' E to 77°49'31.94" E longitude and 11°46'53.53'' N to 11°48'12.58" N latitude with an area of 6.17 sq. km (Fig.1). The Mettur Dam is a large dam in India built in 1934. It was constructed in a gorge, where the Kaveri River enters the plains. The dam is one of the oldest in India. The second segment area lies at 77°40'8.64'' E to 77°42'5.93" E longitude and 11°25'43.39'' N to 11°27'4.13" N latitude with an area of 9.05 sq. km (Fig.1). The Kalingarayan Canal is a 90km 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 land which benefited.

2.0 Material and Methods

2.1 Diatom Sampling

Five Diatom samples were collected from study area I and II. Samples collected in polythene bottles from all obtainable habitats such as plants (epiphytic) and stones (epilithic) following Taylor et al., 2007a and Karthick et al., 2010. Diatoms were sampled by brushing stones with a tooth brush, following recommendations of Kelly *et al.* (1998). At least five, pebbles to cobble (5-15cm) sized stones were collected from the river bottom. They were brushed and the diatom suspension was put in a small plastic bottle. Epilithic and epipelic diatoms were sampled at five sampling stations during May 2011. Epilithic diatoms were sampled by the method of following Kelly *et al.* (1998). Epiphytic samples were taken by brushing the undersurfaces and petioles of at least five plant leaves and roots. 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 (Gandhi, 1957, 1961, 1962, 1967; Karthick *et al.,* 2008). Continuous preparations of diatoms were used to identify their genera and their counts with a polarizing microscope.

2.2 Water Quality Analysis

Five river water samples from above said same locations of the study area I and II were collected during pre-monsoon season (May 2011). The locations of water sampling stations are shown in the Fig. 1. Samples were stored in polythene bottles and were standardized to laboratory for further analysis. Parameters viz., pH, electrical conductance and water temperature (°C) were measured within a few hours of collection by using Elico pH meter and conductivity meter respectively. Ca and Mg were determined titrimetrically using standard EDTA, and chloride was determined by silver nitrate titration (Volgel, 1968). Sodium, potassium, phosphates, Bioogical demand oxygen (BOD), chemical demand oxygen (COD) and dissolved oxygen (DO) were analyzed in laboratory and analyses were assessed by using standard method for the assessment of water quality as mentioned in Trivedy and Goel (1986).

2.3 Statistical 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 diatom community (using PAST 2.04 versions) was used to study the major patterns of diatom community composition and maximum amount of variation in the diatom distribution across the rivers.

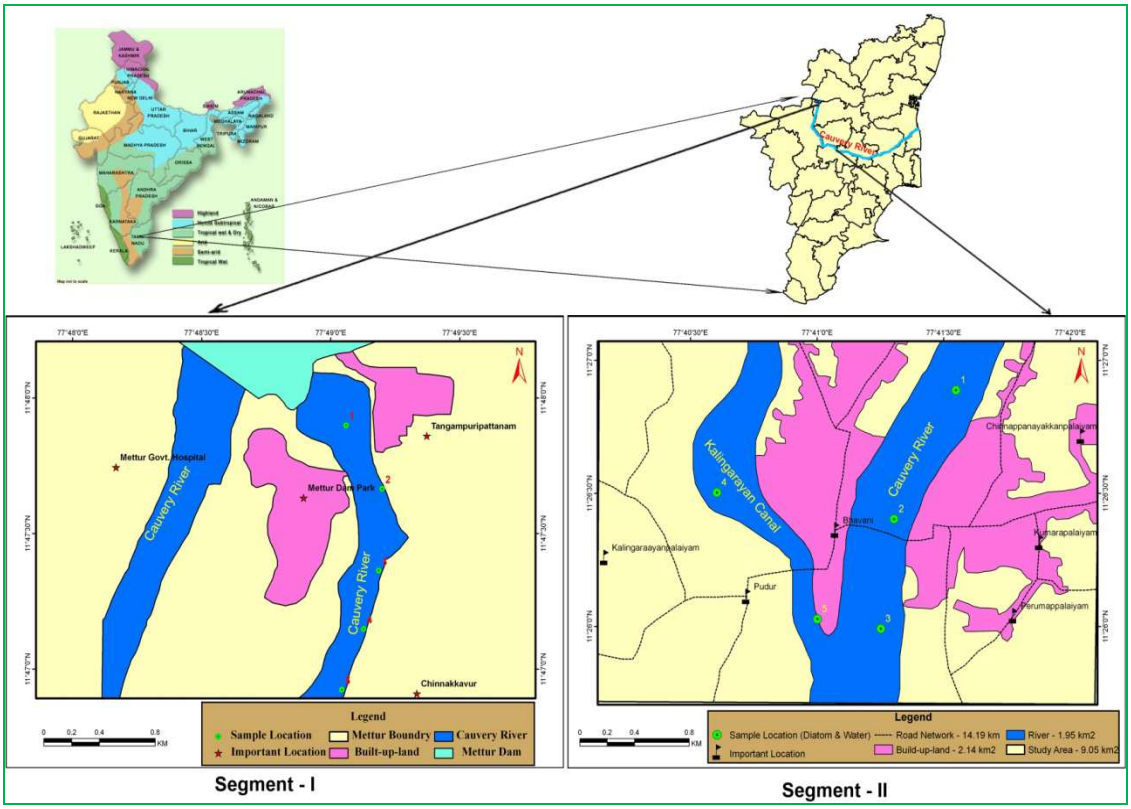

Fig.1: Key Map of Study Area

3.0 Results and Discussion:

3.1 Water Quality Analysis

Segment I (Mettur)

The physico chemical analysis of river across 5 sites has been listed in table 1. The water chemistry differed across sampling sites. pH, electric conductivity, biological oxygen demand (BOD), chemical oxygen demand (COD) and alkalinity were the parameters showed marked difference among the river. The pH ranged from 7.01 to 7.56, highest being 7.56 at four roads. Water temperature had a wide range, 24.23 to 25.30 (mean 24.28, SD 0.69) which mainly dependent on the time of sampling. Electric conductivity was varying much (mean 443.042, SD 15.27) having low at Mettur dam (405 ppm) and high value noticed at four roads (480 ppm) which is beyond the permissible limits. High electric conductivity was mainly due to high ionic concentrations. Nutrients such as nitrates and phosphates varied from 0.011 to 0.123 ppm and 0.003 to 0.021 ppm respectively within the permissible limits. The alkalinity ranged from 110 to 113.33 mg/L at four roads west site and high 113.33 at four roads. Among the Cauvery river sampling sites, Mettur dam and Bridge sites reflected low ionic concentrations while low values within the permissible limit was in four roads west site.

Segment II (Bhavani)

The physico chemical analysis of river across 5 sampling sites is listed in table 2. The water chemistry differed across sampling sites. pH, electric conductivity, biological oxygen demand (BOD), chemical oxygen demand (COD) and alkalinity were the parameters showed marked difference among various samples. The pH ranged from 7.12 to 7.81, highest being 7.81 at Kumarapalaiyam. 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. Electric conductivity 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 to 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 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 the Cauvery River sampling sites, Angalamman temple and Kumarapalaiyam south sites reflected high ionic concentrations while low values within the permissible limit was in Kalingarayan Canal.

Table 1: List of water quality variables in Cauvery River, Mettur

Sample Location	pH	T	EC	TDS	DO	BOD	COD
Mettur dam	7.01	25.30	405.00	445.00	4.35	2.49	25.23
Bridge	7.45	24.23	410.21	280.00	4.23	2.34	41.32
Bridge west site	7.23	23.34	470.00	250.46	4.12	2.43	56.08
Four roads	7.56	24.32	480.00	240.54	4.21	2.54	12.91
Four roads west site	7.43	24.24	450.00	250.12	4.12	2.32	10.65
	N	**P**	**TH**	**CaH**	**MgH**	**CHL**	**ALK**
Mettur dam	0.011	0.021	226.27	71.23	16.63	32.12	112.00
Bridge	0.024	0.020	216.27	73.00	26.43	21.34	112.11
Bridge west site	0.120	0.012	233.33	75.21	26.48	42.44	111.01
Four roads	0.024	0.003	120.33	76.34	21.35	32.36	113.33
Four roads west site	0.123	0.004	121.00	76.53	20.61	31.40	110.00

Table 2: List of water quality variables in Cauvery River, Bhavani

Sample Location	pH	T	EC	TDS	DO	BOD	COD
Angalamman Temple	7.52	27.80	1203.23	560.67	5.67	13.8	80.01
Kumarapalaiyam	7.67	26.57	1015.67	937.00	5.81	12.89	42.32
Kumarapalaiyam South	7.81	26.60	1223.33	769.33	6.89	7.90	65.08
Kalingarayan Canal	7.12	24.33	843.33	535.00	3.87	3.20	10.91
Kuduthurai	7.15	24.00	404.00	270.00	3.60	2.92	10.65
	N	**P**	**TH**	**CaH**	**MgH**	**CHL**	**ALK**
Angalamman Temple	0.013	0.024	236.67	91.23	57.83	272.12	151.00
Kumarapalaiyam	0.014	0.030	243.97	89.00	56.19	285.34	151.11
Kumarapalaiyam South	0.012	0.014	322.93	82.23	57.58	277.81	159.01
Kalingarayan Canal	0.014	0.005	119.33	79.67	33.35	65.96	115.33
Kuduthurai	0.123	0.002	131.00	76.93	18.51	42.40	110.00

3.2 Diatom Analysis

Segment I (Mettur)

The study represents a total of 28 species are like that *Achnanthes brevipes*, *Achnanthidium binodis*, *Achnanthidium minutissima*, *Amphora holsatica*, *Amphora ovalis*, *Anomoeoneis sphaerophora*, *Ctenophora pulchella*, *Cymbella Lanceolata*, *Cymbella tumida*, *Eunotia curvata*, *Eunotia pectinalis*, *Gomphonema affine*, *Gomphonema lanceolatum*, *Gomphonema Parvulum*, *Gomphonema Truncatum*, *Gomphonema undulatum*, *Mastogloia braunii*, *Melosira moniliformis*, *Melosira varians*, *Navicula radiosa*, *Navicula symmetrica*, *Navicula virudila*, *Nitzschia acicularis*, *Nitzschia linearis*, *Nitzschia microcephala*, *Nitzschia palea*, *Tabellaria flocculosa*, belonging to 14 genera with wide range of community composition and species distribution across the river. Among all species (relative abundance >40% 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. Among the species found in the study area, the species belong to genera *Aulacoseira, Navicula, Gomphonema, Nitzcshia, Pinnularia* are reported and associated with relatively clean to less polluted waters. The Similar results were reported by Round (1991) from Brazil; Biggs and Kilroy (2000) from New Zealand; Potapova and Charles (2003) from US rivers. These species are reported from less polluted, tolerant and associated with natural substrates i.e. Macrophytes. *parvulum* and *Nitzschia palae* with environmental characteristics of highly tolerant to nutrients and ions was abundant at Mettur dam, which is having the lowest Electrical conductivity and ionic concentrations.

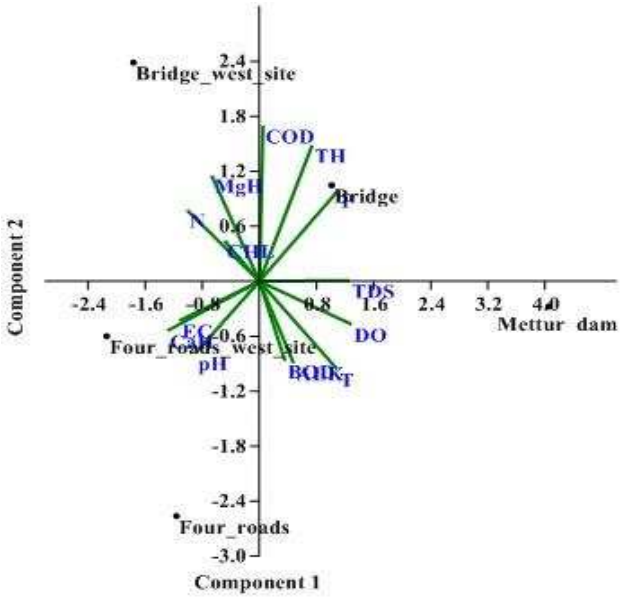

Fig. 2 Principal Component Analysis PCA

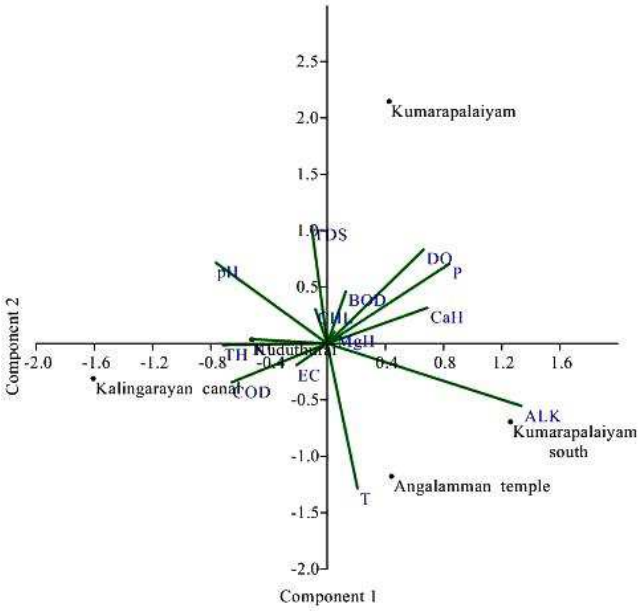

Fig. 3 Principal Component Analysis PCA

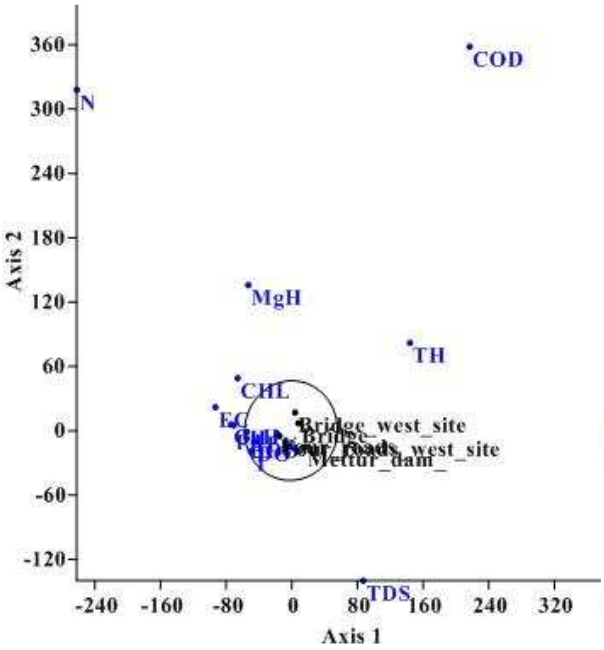

Fig. 4 Detrended correspondence analysis for species distribution across the river

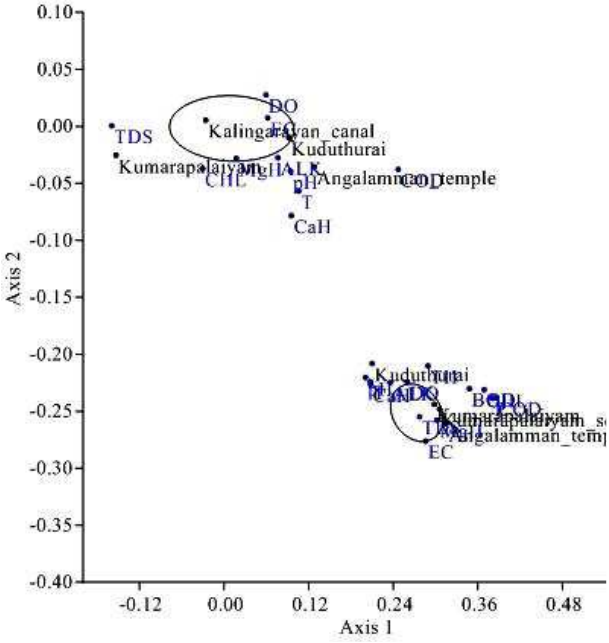

Fig. 5 Detrended correspondence analysis for species distribution across the river

Segment II (Bhavani)

The study represents a total of 36 species are like that *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 pseudofonticola, Nitzschia recta, Nitzschia sigma, Nitzschia thermalis, Melosira granulata, Pinnularia acrosphaeria, Pleurosira indica, Pleurosigma salinarum, Stauroneis anceps, Surirella linearis, Surirella robusta, Surirella splendida, Surirella tenera, Synedra rumpens, Synedra ulna* belonging to 17 genera with wide range of community composition and species distribution across the river. Among all

species (relative abundance >40% of all sites), *Achnanthes minutissima* Kutz, *Cyclotella catenata* Brun*, Cymbella tumida* (Breb) Van Heurck, *Cymbella turgida* (Greg) Cleve, *Cymbella ventricosa* Kutz, *Fragilaria intermedia* Grun *var. robusta, Gomponema lanceolatum* Ehr, *Nitzschia sigma* (Kutz) W Smith*, Nitzschia thermalis* Kutz v minor Hilse*, Pleurosigma salinarum* Grun, *Synedra ulna* (Nitzsch) Ehr were the most abundance species occurred. *Cyclotella meneghiniana* Kützing*, 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 palae* with environmental characteristics of highly tolerant to nutrients and ions was abundant at Kuduthurai, which is having the highest Electrical conductivity and ionic concentrations. However Kalingarayan canal, unlike from rest of the river (low ionic level) was dominated by *Achnanthes minutissiuma* Kutz species which occurs in slightly too moderate waters.

3.3 Principal Component Analysis (PCA) analysis

Segment I (Mettur)

Principal Component Analysis (PCA) analysis reveals that considerable movement away in water chemistry transversely river explaining 79.50% and 20.99% of the variance from 1st and 2nd axis respectively (Fig.2). All samples are within potable limit with respect to WHO 1995 standard. PCA formed 2 groups of unpolluted among sampling sites. Sampling sites Mettur dam and Bridge were grouped to the right side along the component 1, characterized by higher concentrations of study area but within preventive value of World Health Consumption water temperature, Biological oxygen demand (BOD), Chemical oxygen demand (COD), Phosphate and Calcium. Bridge west site, four roads and four roads towards west side were grouped along the component 2 with minimum influence of water chemistry. These were grouped separately showed pH, Electrical conductivity, dissolved oxygen and magnesium effects of can be said as slightly polluted among sampling sites.

Segment II (Bhavani)

Principal Component Analysis (PCA) analysis

Principal Component Analysis (PCA) indicated considerable movement away in water chemistry transversely river explaining 56.691% and 37.209% of the variance from 1st and 2nd axis respectively (Fig.3). Principal Component Analysis (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, characterized by higher concentrations of water temperature, Biological oxygen demond (BOD), Carbon oxygen demond (COD), Phosphate and Calcium. Kalingarayan canal and Kuduthurai were grouped the component 2 with minimum influence of water chemistry. These were grouped separately showed pH, Electrical conductivity, dissolved oxygen and magnesium effects of can be said as moderately or slightly polluted among sampling sites.

3.4 Detrended correspondence analysis (DCA) analysis

Segment I (Mettur)

The Detrended Correspondence Analysis (DCA) for diatom data indicated that communities differed clearly between the sampling stations (Fig.4). This plot shows diatom community composition and its relationship with environmental variables across sampling sites. The Eigen values of the first two axes for diatom DCA analysis were 0.01839 and 0.0139. The first DCA axis summarized the distribution of the diatom communities throughout the conductivity and nutrient gradient of the moderately pollutes sites at the bottom of the plot. The unpolluted sites were clustered on the right side of the axis with dominant tolerant taxi. Diatom taxi showing maximum abundance in these samples were *Eunotia curvata, Cymbella tumida* and *Tabellaria floccules* indicate unpolluted Sites.

Segment II (Bhavani)

The Detrended Correspondence Analysis (DCA) analysis for diatom data shows that communities differed clearly between the sampling stations (Fig.5). This plot shows diatom community composition and its relationship with varying environmental variables across sampling sites. The Eigen values of the first two axes for diatom DCA analysis were 0.0175 and 0.01066. The first DCA axis summarized the distribution of the diatom communities throughout the conductivity and nutrient gradient of the moderately pollutes sites at the bottom of the plot. The Highly polluted sites were clustered on the right

side of the axis with dominant taxa and corresponded to those sites located in highly industrialized (dyes factories) areas (Angalamman temple, Kumarapalaiyam, Kumarapalaiyam South). Diatom taxa showing maximum abundance in of species *C. meneghiniana, G. lanceolatum,* and *S. ulna* in these samples. Sites on the upper left side of the axis 2 corresponded to communities in moderate pollution, Kalingarayan canal (Fig.3), in this locations the most abundant species are *Cyclotella catenata* and *Cymbella tumida*.

4.0 Conclusion:

The environmental distinguishing of every diatom taxi in occurrence and distribution as community composition was significant at every sampling location in segment-I and segment-II. The significance of water quality difference among the sampling sites is expressed in PCA gradient. The highly polluted sites are clearly separated from rest of the data. PCA and DCA analysis demonstrate that sampling sites segment-I locations are not occurred and segment-II Angalamman temple, Kumarapalaiyam and south Kumarapalaiyam were grouped to the right side along the component 1, characterized by highly polluted water that locations present the diatom species like *C. meneghiniana, G. lanceolatum,* and *S. ulna,* pollution due to densely populated and highly industrialized (dyes factories). Segment-I all sides and Segment-II Kalingarayan canal and Kuduthurai were grouped along the component 2 with minimum influence of water chemistry. These were grouped separately showed pH, Electrical conductivity, dissolved oxygen and magnesium effects of can be said as moderately or slightly polluted among sampling sites. DCA analysis demonstrate that sampling sites Segment-I samples is not occur and segment-II Angalamman temple, Kumarapalaiyam and south Kumarapalaiyam sides were grouped to the component 1, characterized by highly polluted water that locations present the diatom species like *C. meneghiniana, G. lanceolatum,* and *S. ulna,* pollution due to densely populated and highly industrialized (dyes factories). Segment-I all sides and segment-II Kalingarayan canal and Kuduthurai sides were grouped along the component 2 with slightly polluted water that locations present the species like *Cyclotella catenata* and *Cymbella tumida* among sampling sites.

5.0 Acknowledgement:

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