

Using of biological diatom Indices (IBD) for ecological status of the Cauvery River, India

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In this study, diatom indices such as the Biological Diatom Index (BDI), Shannon Index, Berger-Parker Index, diatom assemblages and trophic condition were analyzed and discussed. Results of the present study cautions the indiscriminate dumping and release of pollutants into rivers which might lead to serious environmental deterioration which could be considered as a potential source of threat to the biotic life.

[Key words: Diatom, IBD, Ecology, Cauvery river]

Introduction

Diatom-based indices might be particularly valuable in assessing rivers because a one-time assay of species composition of diatom assemblages within the system could provide better characterizations regarding physicochemical conditions than one time measurement of those conditions^{1,2-21}. This scrupulous guide gives a means with regard to identification of the entire diatom taxa utilized in the Biological Diatom Index (BDI) created for use within national river quality assessment networks in France²². Developed a comparable guide for that identification involving common benthic diatoms in Great Britain²³. Work on the usage of diatoms seeing that bioindicators has in reality proceeded to such an extent that in some cases diatom indices include replaced invertebrate indices because the biomonitoring methods of choice²⁴. Diatom-based indices possibly will be mainly very useful for monitoring habitats in which it is able to be difficult or inappropriate to utilize other sorts of monitoring tools.

Materials and Methods

The Cauvery River is one of the major rivers of South India originate in the Western Ghats and flows in eastward direction passing through the states of Karnataka, Tamil Nadu, Kerala and Pondicherry before it drains into Bay of Bengal. 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 41.1 sq. km (Fig. 1).

Macrophytes, epilithic and water samples were collected from the Cauvery river during 2011 to 2013. We usually started our sampling from Mettur Dam to Bhavani with the Global Position System (GPS) and location of all the sampling points were noted down. All the macrophytes and epilithic samples were packed for different laboratory analysis appropriately in well-insulated zip-lock polythene cover added with formaldehyde (4%) for preservation. Different the methods mentioned in this studied used for sampling diatoms from different habitats for environmental studies in the Cauvery river. Epiphytic diatoms grow attached to macrophytes and large algae. Phytoplankton

samples were collected ideally by manual collection. The attached microalgae, of which diatoms are a dominant component, were collected by scraping natural substrates in river, streams and lake. Floating filamentous algae and plant materials are often full of loosely attached diatoms.

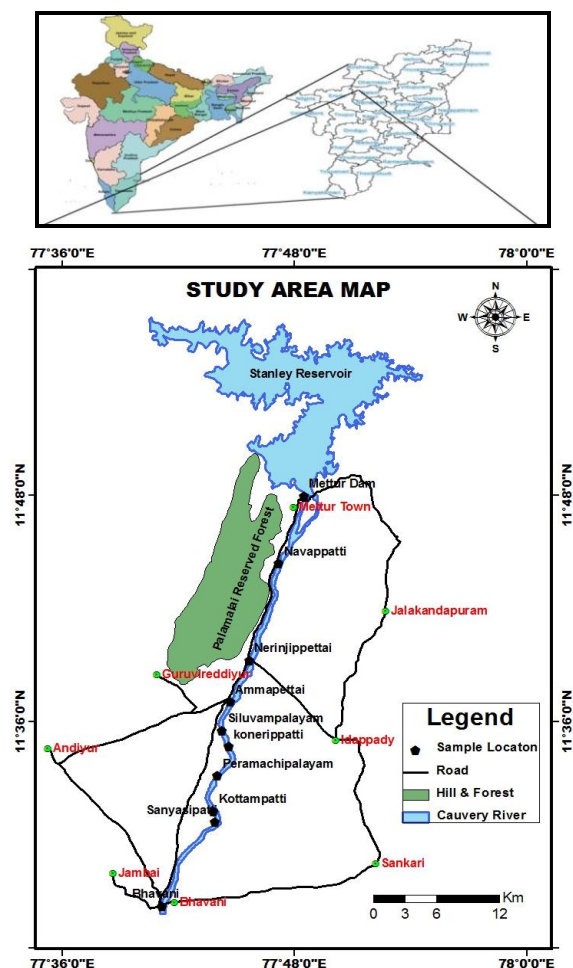


Fig. 1. Location of the Study area

Concentrated diatom samples were boiled in 50-60% nitric acid to oxidize the organic materials and then the acid was washed off with demineralised water by settling or centrifugation. The final 'cleared' diatom samples, an ash colored material was mounted in a mounting medium Naphrax with a refractive index close to 1.7 and placed on a hotplate until the solvent in the medium evaporates. The slide was cooled immediately, by removing from the hotplate. The diatom slide thus obtained is permanent. The diatoms cleaned cells in permanent slides were observed under X 40 and photographed using black and white for best results or by digital photography.

In the present study, the systematic classification of Diatoms by "The Diatoms, Biology & Morphology of the Genera" is followed²⁵. In addition, the work of on "Diatoms in the Swan River Estuary, Western Australia"²⁶: Taxonomy and Ecology" and ²⁷"An Illustrated Guide to Common Diatom of Peninsular India" widely used along with the published literatures for comparison of taxa.

Biological Diatom Index (BDI) index indicates general ecological status of rivers²⁸. This practical index is a good compromise between reliability and efficiency. It is based on some hundreds of most common diatom taxa. The scale runs from 1 to 20 (Table 1 and Table 2).

Table 1 Index score and Ecological status of BDI

Index score	Ecological State
17.0 to 20.0	Very good
13.0 to 17.0	Good
09.0 to 13.0	Moderate
05.0 to 09.0	Low
01.0 to 05.0	Very low

Table 2 Class limit values for Diatom indices (Eloranta & Soininen, 2002)

Index score	Class	Trophy
>17	High quality	Oligotrophy
15 to 17	Good quality	Oligo-mesotrophy
12 to 15	Moderate quality	Mesotrophy
9 to 12	Poor quality	meso-eutrophy
<9	Bad quality	Eutrophy

Ecological diversity was calculated for each sample using diversity indices, Shannon Weiner's (H'), Simpson's D and Berger-Parker.

Shannon - Wiener Diversity index was employed to determine species diversity (H')^{29,30,31}.

$$H' = - \sum_{i=1}^S p_i \ln p_i \dots \dots \dots (2)$$

where

P_i: proportion of individuals of ith species

Remarks: The value ranges between 1.5 and 3.5 and rarely surpasses 4.5

$$d = \frac{N_{max}}{N} \dots \dots \dots (3)$$

where N_{max} is the number of individuals in the most abundant species and N is the total number of individuals in the sample. Remarks: The number of individuals in the dominant taxon relative to n, where n is the total number of species³².

Result and Discussion

Distributions of diatoms

In ten different stations in aquatic systems of Cauvery river showed rich and diverse diatom taxa population. 102 (One hundred and two) diatom taxa belong to 3 Classes, 5 Subclasses, 16 Orders, 24 Families and 35 genera recorded in the study area were as follows: *Cyclotella atomus*, *Cyclotella catenata*, *Cyclotella meneghiniana*, *Cyclotella stelligera*, *Cyclotella striata*, *Melosira granulata*, *Melosira moniliformis*, *Melosira varians*, *Aulacoseira distans*, *Aulacoseira granulata*, *Terpsinoe musica*, *Pleurosira indica*, *Pleurosira laevis*, *Ctenophora pulchella*, *Fragilaria intermedia*, *Fragilaria tenera*, *Fragilaria ulna*, *Fragilaria rumpens*, *Meridion circulare*, *Synedra rumpens*, *Synedra ulna*, *Tabellaria flocculosa*, *Tabellaria ventricosa*, *Eunotia bilunaris*, *Eunotia fallax*, *Eunotia pectinalis*, *Cymbella aspera*, *Cymbella cymbiformis*, *Cymbella ehrenbergii*, *Cymbella helvetica*, *Cymbella lanceolata*, *Cymbella microcephala*, *Cymbella tumida*, *Cymbella turgidula*, *Encyonema minutum*, *Achnanthes brevipes*, *Achnanthidium eutrophilum*, *Achnanthidium exiguum*, *Achnanthidium latecephalum*, *Achnanthidium minutissima*, *Cocconeis pediculus*, *Cocconeis placentula*, *Anomoeoneis sphaerophala*, *Gomphonema affine*, *Gomphonema clavatum*, *Gomphonema augur*, *Gomphonema gracile*, *Gomphonema lanceolatum*, *Gomphonema olivaceum*, *Gomphonema parvulum*, *Gomphonema truncatum*, *Neidium affine*, *Neidium productum*, *Diadesmic confervacea*, *Frustulia rhomboids*, *Gyrosigma acuminatum*, *Pinnularia acrosphaeria*, *Pinnularia maior*, *Pinnularia gibba*, *Sellaphora pulchra*, *Stauroneis phoenicenteron*, *Caloneis silicula*, *Navicula atomus*, *Navicula cryptocephala*, *Navicula elginensis*, *Navicula mutica*, *Navicula radiosa*, *Navicula subrhynchocephala*, *Navicula salinarum*, *Navicula symmetrica*, *Navicula tripunctata*, *Navicula viridula*, *Craticula cuspidata*, *Stauroneis anceps*, *Pleurosigma angulatum*, *Pleurosigma elongum*, *Pleurosigma angulatum*, *Pleurosigma salinarum*, *Mastogloia braunii*, *Amphora holsatica*, *Amphora veneta*, *Amphora ovalis*, *Tryblionella apiculata*, *Tryblionella debilis*, *Tryblionella levidensis*, *Bacillaria paxillifer*, *Nitzschia acicularis*, *Nitzschia angustata*, *Nitzschia dissipata*, *Nitzschia heufferiana*, *Nitzschia linearis*,

Nitzschia lorenziana, *Nitzschia microcephala*, *Nitzschia palea*, *Nitzschia pseudofonticola*, *Nitzschia recta*, *Nitzschia sigma*, *Surirella angusta*, *Surirella linearis*, *Surirella ovalis*, *Surirella robusta*, *Surirella splendida* and *Surirella tenera* recorded from Cauvery River.

Biological Diatom Index

Mettur Dam

In most dominant species, taxa were recorded such as *Achnanthes brevipes* (5.1%), *Cymbella aspera* (5.4%), *Cocconeis placentula* (7.6%), *Craticula cuspidata* (5.8%) and *Navicula cryptocephala* (5.4%) in Mettur dam. The IBD values in Mettur dam (14.4) indicated good ecological status in 2011 due to the inflow of water to Mettur dam changing the water quality as oligo-mesotrophy i.e. good quality.³³ The similar result was reported in Dari Stream, Isparta Turkey with good water quality were associated with such species as *Cocconeis pediculus* and *C. placentula*. In most dominant species, taxa were recorded such as *Achnanthidium minutissima* (9.7%), *Amphora ovalis* (6.1%), *Cymbella microcephala* (6.7%), *Caloneis silicula* (6.1%), *Cymbella tumida* (9.7%), *Gomphonema olivaceum* (5.5%) and *Navicula viridula* (9.7%). The IBD values in Mettur dam (14.2) indicated good ecological status in 2012. In most dominant species taxa were recorded such as *Aulacoseira granulata* (11.7%), *Cymbella cymbiformis* (12.9%), *Navicula elginensis* (9%), *Nitzschia obtusa* (8.9%), *Navicula subrhynchocephala* (6.3%), and *Synedra rumpens* (7.4%). The IBD values in Mettur dam (16.5) indicated good ecological status in 2013. The similar result reported in with good water quality were associated with such species as *Achnanthidium minutissimum* Kalyoncu 2013 in Dari Stream, Isparta Turkey and Bertalot (1978) and Barlas (1988) say that *A. minutissimum* is an organism of moderate quality. Finally in present study Mettur Dam was water quality is as oligo-mesotrophy condition therefore good quality in ecological status in table 3 to 5.

Navappatti

In most dominant species taxa were recorded such as *Amphora veneta* (5.4%), *Aulacoseira distans* (9.7%), *Cyclotella atomus* (8.6%), *Craticula cuspidata* (8.6%), *Diadesmic confervacea* (1.4%), *Fragilaria rumpens* (5.4%), *Gomphonema gracile* (8.6%) and *Synedra ulna*

(6.5%). The IBD values in Navappatti (14.2) indicated good ecological status in 2011. In most dominant species taxa were recorded such as *Achnantheidium minutissima* (6.8%), *Amphora veneta* (8.4%), *Aulacoseira granulata* (9.1%), *Cymbella turgidula* (6.8%), *Cymbella tumida* (6.8%), *Melosira granulata* (9.8%), *Nitzschia lorenziana* (6.8%), *Navicula subrhynchocephala* (6.8%), *Nitzschia microcephala* (6.8%), *Surirella ovalis* (9.1%) and *Surirella robusta* (6.8%). The IBD values in Navappatti (13.3) indicated good ecological status in 2012. In most dominant species taxa were recorded such as *Achnantheidium eutrophilum* (6.8%), *Anomoeoneis sphaerophora* (6%), *Cymbella microcephala* (8.3%), *Ctenophora pulchella* (6.8%), *Fragilaria rumpens* (5.8%), *Neidium productum* (4.6%), *Nitzschia obtusa* (6.8%), *Surirella ovalis* (6.8%) and *Tryblionella victoriae* (6.8%). The IBD values in Navappatti (16.5) indicated good ecological status in 2013. In present study Navappatti there is no change for ecological status this area good ecological status in during 2011-2013.

Nerinjipettai

In present study most dominant species taxa were recorded such as *Cymbella aspera* (4.9%), *Cocconeis placentula* (4.9%), *Neidium productum* (4.9%) and *Nitzschia palea* (8.9%). The IBD values in Nerinjipettai (11.29) indicated moderate ecological status in 2011.³³ The similar result reported by in with moderate to bad water quality were associated with such species as *Nitzschia palea* taxa determined in tolerant of pollution in Dari Stream, Isparta Turkey. It was described study, however, this species had high relative abundance at alfamosaprobic critically polluted water quality, an indication that it is tolerant of high pollution. In this study IBD values in Nerinjipettai (11.29) indicated moderate ecological status due to sewage influences in this area. In present study most dominant species taxa were recorded such as *Amphora holsatica* (5.6%), *Amphora veneta* (9.5%), *Amphora ovalis* (4.8%), *Aulacoseira granulata* (9.3%), *Cymbella tumida* (4%), *Encyonema minutum* (5.6%), *Gomphonema lanceolatum* (5.6%), *Gyrosigma acuminatum* (5.6%) and *Surirella angusta* (5.6%). The IBD values in Nerinjipettai (13.6) indicated moderate ecological status in 2012. In present study most dominant species taxa were recorded such as *Cymbella tumida*

(5.1%), *Frustulia rhomboids* (4.3%), *Nitzschia acicularis* (5.1%), *Navicula elginensis* (9%), *Nitzschia obtusa* (8.9%), *Navicula subrhynchocephala* (6.3%), *Synedra rumpens* (7.4%) and *Synedra ulna* (5.1%). The IBD values in Nerinjipettai (10.3) indicated poor ecological status in 2013. In similarly, was reported the diatoms indicating anthropogenic pollution were *Amphora ovalis*, *Synedra ulna*, *Cymbella tumida*, *Gomphonema olivaceum*, *Navicula subrhynchocephala* in Doddakere lake of Mysore city³⁴. In present study, Nerinjipettai was affected in anthropogenic pollution and sewages IBD values of (10.3) were indicating ecological states in poor quality.

Ammapettai

In present study most dominant species taxa were recorded such as *Cyclotella striata* (58%), *Diadesmis confervacea* (5.8%), *Gomphonema gracile* (5.8%), *Neidium affine* (5.8%) and *Pinnularia gibba* (5.8%). The IBD values in Ammapettai (12.52) indicated moderate ecological status in 2011. In similar study, Hosmani was reported the diatoms indicating anthropogenic pollution were *Pinnularia gibba* in Dadadahally Lake, Doddakere lake of Mysore city³⁴. In present study, Ammapettai was slightly polluted due to sewage and anthropogenic activity. In present study most dominant species taxa were recorded such as *Achnantheidium minutissima* (5.2%), *Amphora veneta* (9.7%), *Amphora ovalis* (5.8%), *Cymbella microcephala* (5.2%), *Caloneis silicula* (5.2%), *Cymbella tumidula* (8.4%), *Gomphonema parvulum* (7.7%), *Navicula elginensis* (9.7%) and *Synedra ulna* (5.2%). The IBD values in Ammapettai (11.4) indicated moderate ecological status in 2012. Hosmani 2012 was reported the most common indicators of organic pollution were *Nitzschia intermedia*, *Cyclotella meneghiniana*, *Navicula cryptocephala*, *Cyclotella atomus*, *Melosira varians* in Dadadahally Lake, Doddakere lake of Mysore city. In present study most dominant species taxa were recorded such as *Achnantheidium eutrophilum* (6.8%), *Anomoeoneis sphaerophora* (6%), *Cymbella microcephala* (8.3%), *Ctenophora pulchella* (6.8%), *Fragilaria rumpens* (5.8%), *Neidium productum* (4.6%), *Nitzschia obtusa* (6.8%), *Surirella ovalis* (6.8%) and *Tryblionella victoriae* (6.8%). The IBD values in Ammapettai (14.4) indicated good ecological status in 2013.

Siluvampalayam

In present study most dominant species taxa were recorded such as *Achnanthes eutrophilum* (4%), *Amphora ovalis* (4%), *Anomoeoneis sphaerophora* (2.4%), *Cyclotella atomus* (4.8%), *Ctenophora pulchella* (4%), *Cymbella ventricosa* (6.4%), *Gomphonema gracile* (4.8%), *Gomphonema olivaceum* (4%), *Meridion circulare* (4%), *Navicula viridula* (6.4%), *Synedra rumpens* (6.4%) and *Surirella splendida* (4%). The IBD values in Siluvampalayam (13.5) indicated good ecological status in 2011. The similar result reported Kalyoncu 2013 by in with mean moderate water quality were associated with such species as *Melosira circulare*, *Gomphonema olivaceum* represents excellent quality class, *Gomphonema olivaceum*, good quality class taxa determined in tolerant of pollution in Dari Stream, Isparta Turkey. In study, Siluvampalaiyam was IBD score (13.5) indicated in good ecological status. In present study most dominant species taxa were recorded such as *Achnanthes brevipes* (53%), *Bacillaria paxillifer* (6.1%), *Cymbella turgidula* (3.0%), *Cymbella ventricosa* (6.1%), *Fragilaria ulna* (5.3%), *Gomphonema gracile* (9.1%), *Gomphonema parvulum* (8.6%), *Gomphonema lanceolatum* (7.6%) and *Nitzschia palea* (9.1%). The IBD values in Siluvampalayam (11.1) indicated moderate ecological status in 2012. Hosmani 2012 was reported the most common indicators of organic pollution were diatoms indicating anthropogenic pollution were *Gomphonema parvulum* in Doddakere lake of Mysore city.

In present study most dominant species taxa were recorded such as *Aulacoseira granulata* (4.9%), *Cymbella microcephala* (5.6%), *Frustulia rhomboids* (5.6%), *Gomphonema affine* (6.8%), *Meridion circulare* (7.2%), *Neidium affine* (8.5%), *Nitzschia recta* (6.2%), *Synedra ulna* (9.3%), *Tabellaria ventricosa* (1.2%), *Tryblionella victoriae* (4.9%), *Fragilaria intermedia* (1.6%), *Navicula festiva* (1.3%), *Pleurosigma angulatum* (1.4%) and *Pleurosira indica* (2.6%). The IBD values in Siluvampalayam (14.5) indicated good ecological status in 2013.

Koneripatti

In present study most dominant species taxa were recorded such as *Achnanthes brevipes* (5.1%), *Amphora veneta* (4.7%), *Amphora*

ovalis (4.3%), *Cymbella aspera* (5.4%), *Cocconeis placentula* (7.6%), *Craticula cuspidata* (5.8%), *Navicula cryptocephala* (5.4%) and *Neidium affine* (4.3%) in Koneripatti. The IBD values in Koneripatti (10.4) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Aulacoseira granulata* (4.1%), *Cymbella microcephala* (5.4%), *Cocconeis pediculus* (4.1%), *Diadescmic confervacea* (9.4%), *Gomphonema lanceolatum* (8.8%), *Gomphonema olivaceum* (8.2%), *Navicula viridula* (9.4%) and *Surirella robusta* (5.4%). The IBD values in Koneripatti (10.4) indicated moderate ecological status in 2012. In present study most dominant species taxa were recorded such as *Aulacoseira granulata* (7.3%), *Caloneis silicula* (6.1%), *Diadescmis confervacea* (6.1%), *Navicula cryptocephala* (6.1%), *Nitzschia linearis* (6.1%), *Surirella robusta* (6.1%), *Synedra rumpens* (9.8%), *Synedra ulna* (7.8%) and *Tabellaria flocculosa* (7.9%). The IBD values in Koneripatti (10.4) indicated moderate ecological status in 2013.

Peramachipalayam

In present study most dominant species taxa were recorded such as *Achnanthes eutrophilum* (9.4%), *Amphora veneta* (6.8%), *Cymbella cymbiformis* (7.9%), *Cocconeis placentula* (7.3%), *Cyclotella striata* (6.3%), *Cymbella ventricosa* (5.8%), *Fragilaria rumpens* (6.3%), *Navicula elginensis* (8.9%), *Navicula viridula* (7.9%) and *Pinnularia acrospheria* (8.4%). The IBD values in Peramachipalayam (13.5) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Achnanthes minutissima* (3.9%), *Amphora veneta* (8.4%), *Cymbella tumida* (7.1%), *Gomphonema affine* (5.8%), *Navicula elginensis* (5.8%), *Navicula salinarum* (5.8%), *Surirella linearis* (4.5%) and *Synedra ulna* (5.2%). The IBD values in Peramachipalayam (10.1) indicated moderate ecological status in 2012. In present study most dominant species taxa were recorded such as *Achnanthes minutissima* (9.6%), *Anomoeoneis sphaerophora* (9.6%), *Eunotia fallax* (9.6%), *Nitzschia acicularis* (8.4%), *Nitzschia microcephala* (8.4%) and *Synedra ulna* (8.4%). The IBD values in Peramachipalayam (11.4) indicated moderate ecological status in 2013.

Kottampatty

In present study most dominant species taxa were recorded such as *Amphora veneta* (6.6%), *Cyclotella atomus* (6.6%), *Cymbella aspera* (5.7%), *Cymbella cymbiformis* (6.6%), *Craticula cuspidata* (6.6%), *Cyclotella striata* (9%), *Encyonema minutum* (1.6%), *Fragilaria rumpens* (9.8%), *Gomphonema gracile* (6.6%) and *Synedra ulna* (9.8%). The IBD values in Kottampatty (12.6) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Amphora veneta* (9.3%), *Cocconeis pediculus* (5%), *Ctenophora pulchella* (8.7%), *Surirella linearis* (6.8%), *Surirella robusta* (6.8%), *Gomphonema affine* (6.8%) and *Synedra ulna* (9.8%). The IBD values in Kottampatty (13.2) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Anomoeoneis sphaerophora* (9.2%), *Cyclotella atomus* (7.6%), *Cymbella cymbiformis* (8.6%), *Cocconeis pediculus* (9.8%), *Nitzschia microcephala* (9%), *Nitzschia recta* (8%) and *Synedra rumpens* (6.1%). The IBD values in Kottampatty (10.3) indicated moderate ecological status in 2013.

Sanyasipatti

In present study most dominant species taxa were recorded such as *Cyclotella atomus* (7.1%), *Ctenophora pulchella* (7.1%), *Gomphonema*

parvulum (7.1%), *Gomphonema olivaceum* (1.8%), *Surirella tenera* (8.8%) and *Nitzschia palea* (8.8%). The IBD values in Sanyasipatti (11.9) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Amphora veneta* (5%), *Encyonema minutum* (8.4%), *Fragilaria rumpens* (5.7%), *Gomphonema olivaceum* (6.5%), *Gomphonema parvulum* (9.2%), *Melosira granulata* (5.7%), *Nitzschia obtusa* (8.5%), *Navicula salinarum* (5.7%) and *Navicula viridula* (8.5%). The IBD values in Sanyasipatti (11.5) indicated moderate ecological status in 2011. In present study most dominant species taxa were recorded such as *Cocconeis placentula* (9.6%), *Diademsis confervacea* (3.9%), *Gomphonema parvulum* (6.1%), *Nitzschia dissipata* (3.9%), *Navicula mutica* (5%), *Surirella ovalis* (4%) and *Synedra ulna* (9.8%). The IBD values in Sanyasipatti (8.8) indicated moderate ecological status in 2013. In similar reported, was reported the most common indicators of organic pollution were *Gomphonema parvulum* (6.1%), *Synedra ulna* (9.8%) in Dadadahally Lake, Doddakere Lake of Mysore city³⁴. In present study, Sanyasipatti was affected in organic pollution due to dying factory effluent and sewages. So Sanyasipatti was IBD values of 8.8 indicated moderate ecological statuses.

Table 3 Diversity of Diatom taxa in 2011

Diversity Indices	1	2	3	4	5	6	7	8	9	10
Dominance D	0.04	0.07	0.03	0.04	0.04	0.03	0.07	0.06	0.08	0.15
Shannon H	3.37	2.94	3.56	3.35	3.26	3.54	2.92	3.08	2.86	2.53
Berger Parker	0.06	0.11	0.05	0.05	0.10	0.05	0.12	0.13	0.16	0.30

Table 4 Diversity of Diatom taxa in 2012

Diversity Indices	1	2	3	4	5	6	7	8	9	10
Dominance D	0.05	0.08	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.09
Shannon H	3.27	2.87	3.29	3.35	3.23	3.18	3.19	3.07	2.97	2.93
Berger Parker	0.11	0.15	0.08	0.072	0.08	0.13	0.08	0.12	0.11	0.23

Table 5 Diversity of Diatom taxa in 2013

Diversity Indices	1	2	3	4	5	6	7	8	9	10
Dominance D	0.09	0.07	0.12	0.16	0.07	0.06	0.04	0.09	0.10	0.07
Shannon H	2.7	2.68	2.46	2.36	2.72	2.81	3.32	2.60	2.63	2.89
Berger Parker	0.22	0.11	0.27	0.35	0.12	0.09	0.08	0.19	0.19	0.13

Bhavani

In present study most dominant taxa were recorded such as *Achnanthes eutrophilum* (3.8%), *Amphora ovalis* (4.8%), *Cymbella lanceolata* (4.8%), *Cymbella turgidula* (1.9%), *Ctenophora pulchella* (4.8%), *Fragilaria rumpens* (38%), *Gomphonema parvulum* (8.3%), *Gomphonema olivaceum* (3.8%), *Navicula viridula* (3.8%), *Pinnularia acrospheria* (3.8%), *Synedra rumpens* (3.8%), *Surirella splendida* (3.8%), *Nitzschia palea* (8.3%), *Tryblionella levidensis* (5.7%). The IBD values in Bhavani (10.22) indicated moderate ecological status in 2011. In similarly reported³⁵ described *Nitzschia palea* as a medium pollution-tolerant species and *G. parvulum* is a relatively abundant species at downstream eutrophic sites with high organic pollution as alfamesosaprobic from lotic systems in southern Brazil. This taxon represented quality class was moderate to poor quality. In similarly result *Nitzschia palea* (8.3%) was most dominant taxa in this area. In present study most dominant species taxa were recorded such as *Amphora ovalis* (3%), *Gomphonema gracile* (9%), *Gomphonema lanceolatum* (9%), *Gomphonema olivaceum* (7.2%), *Gomphonema parvulum* (9.8%), *Navicula viridula* (7.8%) and *Nitzschia palea* (8.9%). The IBD values in Bhavani (11) indicated moderate ecological status in 2012. In similarly reported Lobo et al. 2004 described *Nitzschia palea* as a medium pollution-tolerant species and *Gomphonema parvulum* is a relatively abundant species at downstream eutrophic sites with high organic pollution as alfamesosaprobic from lotic systems in southern Brazil. This taxon represented quality class was moderate to poor quality. In present study, *Gomphonema parvulum* (9.8%) and *Synedra ulna* (8.9%) were most dominant in this area affected to sewages and dying factories. In present study most dominant species taxa were recorded such as *Amphora veneta* (4.4%), *Cymbella cymbiformis* (4.4%), *Cocconeis pediculus* (9.6%), *Cyclotella stelligera* (9.4%), *Ctenophora pulchella* (4.4%), *Eunotia bilunaris* (4.4%), *Frustulia rhomboids* (4.4%), *Gomphonema truncatum*, (8%), *Gomphonema parvulum* (9.8%), *Nitzschia acicularis* (7.9%), *Navicula subrhynchocephala* (4.4%), *Pinnularia acrospheria* (4.4%), *Surirella angusta* (7.9%), *Nitzschia palea* (9.6%) and *Synedra rumpens* (7.9%). The IBD values in Bhavani (7.7) indicated moderate ecological status in 2013. In similar result of was studied both taxa richness

and diversity declined due to a mixture of waste water to stream³³. All of the taxa determined in this site are tolerant of pollution. These taxa are *N. palea*, *G. parvulum* and *Navicula cryptocephala* in Dari Stream, Isparta Turkey and however, this species had high relative abundance at alfamesosaprobic with critically polluted water quality, an indication that it is tolerant of high pollution. In present study during 2011-2013 was determined to moderate in ecology status due to In present study, Bhavani in receives untreated domestic and industrial wastewaters from Bhavani region, The pollution in the river is due to the merger of sewages and industrial pollution. The industry in this area seems to discharge effluents in the river without treating it posing danger to human health and animal habitat. Cauvery river is grossly polluted due to the discharge of untreated sewage disposal and industrial effluents directly into the river. Results of the present study cautions the indiscriminate dumping and release of pollutants into rivers which might lead to serious environmental deterioration which could be considered as a potential source of threat to the biotic life.

Shannon index

Shannon diversity index (H') computed as per equation 2 takes into account the number of individuals as well as number of taxa. This varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. Low H' was recorded in Sanyasipatti (2.86), *Surirella tenera* and *Synedra ulna*, representing (8.8%) in 2011 (Table 4). Low H' was recorded in Navappatti (2.87), *Aulacoseira distans* representing (9.7%) in 2012 (Table 5). Low H' was recorded in Ammapettai (2.36), *Cymbella microcephala* representing (8.3%) in 2013.

Berger-Parker Index

Berger-Parker index was calculated (equation 3) from the number of individuals in the dominant taxon relative to the total number of species. *Synedra ulna* and *Tryblionella levidensis* are the dominant species (with 8.3% abundance) showing a high index value in Bhavani during 2011. *Synedra ulna* and *Tryblionella levidensis* are the dominant species (with 8.3% abundance) showing a high index value in Bhavani during 2012. In Bhavani *Navicula viridula* (9%), *Nitzschia palea* (8.9%) of the population from a macrophytes habitat.

Cyclotella atomus (5.8%), *Cyclotella striata* (5.8%), *Diadlesmis confervacea* (5.8%), *Gomphonema gracile* (5.8%), *Neidium affine* (5.8%) in Ammapettai 2013.

Dominance

Dominance is the total of a particular species with respect to different species in an ecological community predominate, ranging from 0 (all taxa are equally present) to 1 (a taxon dominates the community completely). The dominance analysis shows that the Bhavani locality in Cauvery river has species with *Synedra ulna* (8.3%) and *Tryblionella levidensis* (8.3%) as dominant species (dominance: 0.15), while *Surirella tenera* (8.8%) and *Synedra ulna* (8.8%) are dominated in Sanyasipatti, (dominance 0.08), and *Achnanthidium eutrophilum* (9.4%), and *Cyclotella atomus* (6.2%) in Peramachipalayam (dominance 0.07), Navappatti (dominance 0.07). Remaining sites showed dominance index value between 0.1- 0.4 (Table 4) in 2011. The dominance analysis shows that the Bhavani locality in Cauvery river has species with *Navicula viridula* (9% as dominant species (dominance: 0.09), while *Melosira granulata* (9.8%) dominated Navappatti (dominance 0.08) and Kottampatti and Sanyasipatti (dominance 0.06) *Nitzschia palea* (9.8%), *Navicula viridula* (8.5%) dominance respectively. The dominance analysis shows that the Mettur dam, Siluvampalaiyam, Koneripatti, Peramachipalayam has the dominances of 0.05. Remaining Nerinjipettai and Ammapettai sites showed dominance index value 0.4 (Table 4) in 2012. The Dominance analysis shows that the Ammapettai locality in Cauvery river has species with *Cymbella microcephala* (8.3%), as dominant species (dominance: 0.16), while

Nitzschia palea (9.8%), dominated Sanyasipatti (dominance 0.16) in 2013.

Diatom assemblages and trophic condition

In present study, most dominant species taxa were recorded such as *Cyclotella atomus* (7.1%), *Gomphonema gracile* (7.1%), *Surirella tenera* (8.8%) and *Synedra ulna* (8.8%), *Encyonema minutum* (8.4%), *Gomphonema parvulum* (9.2%), *Melosira granulata* (5.7%), *Nitzschia obtusa* (8.5%), *Cocconeis placentula* (9.6%), *Diadlesmis confervacea* (3.9%), *Synedra ulna* (9.8%) which are more tolerant to high levels of pollutions in Sanyasipatti (Fig. 2 and 3).

In Bhavani, cosmopolitan extreme pollution resistant species *Synedra ulna* (8.3%), *Tryblionella levidensis* (8.3%), *Gomphonema gracile* (9%), *Gomphonema lanceolatum* (9%), *Gomphonema olivaceum* (7.2%), *Gomphonema parvulum* (7.8%), *Cocconeis pediculus* (9.6%), *Cyclotella stelligera* (9.4%), *Surirella robusta* (9.6%) and *Synedra rumpens* (7.9%) were dominant species highlighting eutrophic status of water with higher electrolyte. Xiang Tan (2013) reported to Biological Diatom Index (IBD) and diatom based eutrophication/pollution index (EPI-D) were strongly related to trophic status and ionic content were related to organic pollution and conductivity. Yet, the diatom indices showed weak relationships with physical and chemical variables during the wet season in Han River in the Yangtze River basin is the water source area of China. It is concluded that IBD have strong correlations with some water quality variables in subtropical rivers in China, especially in the dry season, despite differences in taxonomy, geographic setting (e.g., climate, geology) and the nature of the pollutant gradient.

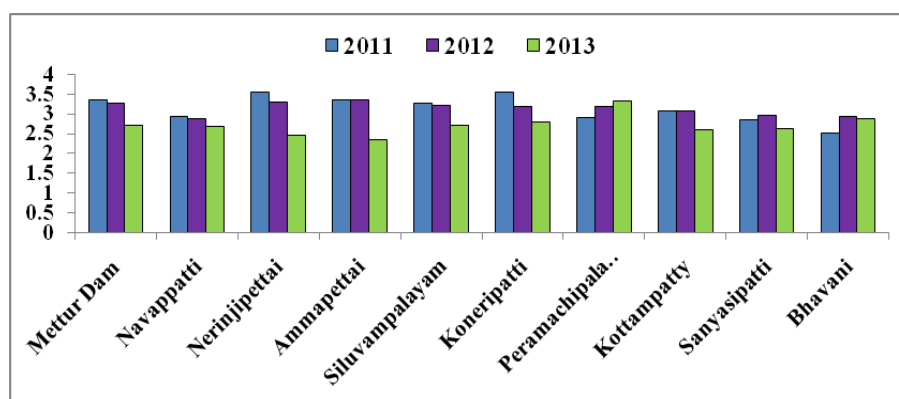


Fig.2. Shannon diversity Index in different areas under study

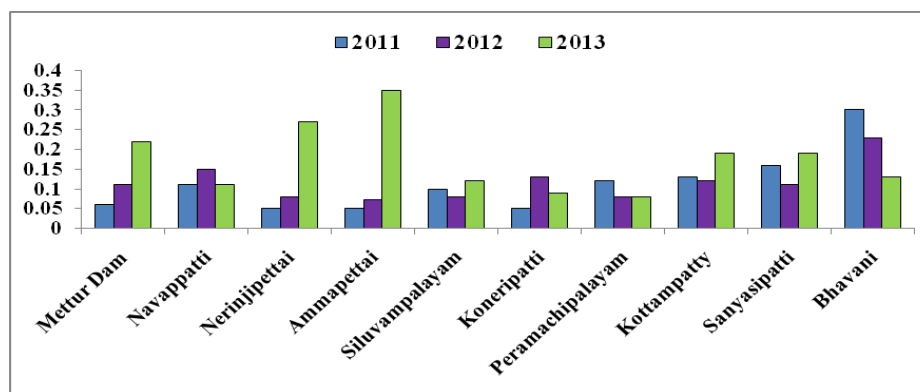


Fig.3. Berger-Parker Index in different areas under study

Mettur dam was IBD (14.2), mesotrophy indicated to moderate quality in 2011, IBD (14.2), mesotrophy indicated to moderate quality in 2012 and IBD (16.5), oligo-mesotrophy indicated to good quality in 2013 due to the inflow of water to Mettur dam changing the water quality as oligo-mesotrophy i.e. good quality. Finally, Mettur Dam was water quality is as oligo-mesotrophy condition therefore good quality in ecological status. Navappatti was IBD (14.2), mesotrophy- indicate to moderate quality in 2011, IBD (13.3), mesotrophy indicate to moderate quality in 2012 and IBD (16.5), oligo-mesotrophy indicates to good quality in 2013.

In Navappatti there is no change for ecological status this area good ecological status in during 2011-2013. Nerinjipettai was IBD (11.29), meso-eutrophy indicates to poor quality in 2011, IBD (13.6), mesotrophy indicate to moderate quality in 2012 and IBD (10.3), meso-eutrophy indicated to poor quality in 2013. Nerinjipettai was affected in anthropogenic pollution and sewages IBD values of (10.3) were indicating ecological states in poor quality. Ammapettai was IBD (12.52), mesotrophy indicate to moderate quality in 2011, IBD (11.4), meso-eutrophy indicates to poor quality in 2012 and IBD (14.4), Mesotrophy- Moderate quality in 2013. Ammapettai was slightly polluted due to sewage and anthropogenic activity. Siluvampalayam was IBD (13.5), mesotrophy indicated to moderate quality in 2011, IBD (11.1) meso-eutrophy indicates to poor quality in 2012 and IBD (14.5) Mesotrophy indicates to moderate quality in 2013. Siluvampalayam was affected in organic pollution, anthropogenic pollution and sewages.

Koneripatti was IBD (12.1) mesotrophy indicate to moderate quality in 2011, IBD (11.5)

meso-eutrophy indicates to poor quality in 2012 and IBD (13.7) mesotrophy indicates to moderate quality in 2013. In Koneripatti was affected in discharge of effluents and untreated sewage into the river by dying units from Koneripatti. Peramachipalayam was IBD (13.5) mesotrophy indicate to moderate quality in 2011, IBD (10.1) meso-eutrophy indicates to poor quality in 2012 and IBD (11.4) meso-eutrophy indicates to poor quality in 2013. In during 2011-2013, Peramachipalayam was affected in sewage, industrial effluent and dying factory. Kottampatti was IBD (12.6) mesotrophy indicate to moderate quality in 2011, IBD (13.2) mesotrophy indicate to moderate quality in 2012 and IBD (10.3) meso-eutrophy indicated to poor quality in 2013. Kottampatti study area affected to sewages and dying factories. Sanyasipatti was IBD (11.9) meso-eutrophy indicated to poor quality in 2011, IBD (11.5) meso-eutrophy indicates to poor quality in 2012 and IBD (8.8) eutrophy indicates to bad quality in 2013. Sanyasipatti was affected in organic pollution due to dying factory effluent and sewages. Bhavani was IBD (10.22), meso-eutrophy indicates to poor quality in 2011, IBD (11) meso-eutrophy indicates to poor quality in 2012 and IBD (7.7), eutrophy indicates to bad quality in 2013.

Conclusion

The studies on Diatoms indices reveal that water qualities of the Cauvery River are good quality (oligo-mesotrophy) at Mettur where as it is heavily polluted (eutrophic) at Bhavani sites. Bhavani areas of Cauvery River are grossly polluted due to the discharge of untreated sewage disposal and industrial effluents directly into the river.

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