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# Freshwater Diatoms As Indicators Of River Water Quality

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ABSTRACT

*Systematic studies on diatoms are abundant, but studies on the use of diatoms as indicators of river water quality are lacking. A study on diatoms as ecological indicators of river Kabini of Southern India has been done. Specific methods of collection, preservation, identification and enumeration of diatoms have been described. A total of 21 species of diatoms were recorded during a two year study from 2008 to 2010.Sampling was carried out seasonally .Cyclotella meneghiniana and Navicula mutica were indicators of organic pollution while Synedra ulna, Synedra acus, Stauroneis anceps and Navicula rhynchocephala were indicators of moderate anthropogenic eutrophication. Degradation and saprobity of the river water was also moderate, while Nitrogen autotrophic taxa tolerating high levels of organically bound nitrogen were predominant. Diatoms can be used as excellent river water quality indicators. The software OMNIDA facilitates easy analysis of data.*

Keywords : Diatoms, Indicators, River, Kabini, Ecological, OMNIDA

**Introduction**

Systematic studies on diatoms in India were done by Detoni(1891-94), Cleve(1878) and Leudger-Fortmorel(1893). Prediction of environmental changes using diatom assemblages were done by Gopinath and Quasim(1971), and Juttner *et al*.(2003) who established relationship between diatoms and the water chemistry variables . Ecological indicators have widespread applications in environmental monitoring. The fluctuation of diatom species to various environmental changes can be an early warning towards freshwater ecological problems. Their sensitivity to small changes in water quality makes them powerful indicators. Kolbe(1932), Van Der Werff and Huls(1957-1974), Dixit *et al*.(1992) and Van Dam *et al*.(1993) have studied the interrelationships of diatoms to water chemistry. Van Dam *et al*. (1994) has prepared an exclusive list of fresh water diatoms that play an important role as ecological indicators. The design of OMNIDA Software for computation of diatom indices has facilitated the use of diatom based bio monitoring (Leconite *et al*., 1993). The soft ware has an inbuilt ecological data for 13000 diatom species and is a comprehensive data base. The present study discusses diatoms as indicators of water quality of River Kibini in Southern India. The OMNIDA software has been used to derive the ecological values.

**Materials and methods**

The methods for collection, preservation, identification and enumeration of diatom species are same as described by Taylor *et al*. (2007) and Basavaraju *et al*. (2011). Taxonomic guides consulted include Gandhi (1998), Sarode and Kamath(1984), Schomen and Archibald(1976-1980), Archibald(1983), Gasse(1986), Kramer and Lange Bertalot(1978-1981) and Karthick *et al*.(2010). The analysis of Kabini river water samples were carried out seasonally for a period of two years from 2008 to 2010.

Kabini or Kapila is a river of Southern India. It originates in Wayanad district of Kerala State, from the confluence of Panama ram River and Mananthavady River and flows eastward to join the Kaveri River at Tirumalakuda Narsipur in Karnataka, which empties into the Bay of Bengal. Kabini River is 80 Km from Mysore and it forms a huge reservoir which is 2284 feet(696 m) in height with gross storage of 19.5 tmc ft. It is situated between villages Beechanahalli and Bidarhalli which are the main contributors of organic load into the river. A wild life sanctuary situated on the banks of the river features a large quaint lake surrounded by verdant landscape of over 55 acres and is a popular tourist spot.

**Results and Discussions**

The occurrence of epilithic diatoms and their acronyms occurring in the river is presented in Table 1.The classification of the ecological indicators values of Van Dam *et al*.(1994) are presented in Table 3.. The indicator values for diatom taxa have been derived from Hustedt(1938). The salinity classification is according to Vander Werff and Huls (1957-1974) and is based on the concentration of chloride in water. The nitrogen uptake metabolism is based on Cholonoky(1968) and Van Dam(1975) where diatoms are capable of assimilating organic nitrogen compounds. Classification of oxygen requirements is based on Hustedt(1938) which indicate saturation levels of oxygen in water. The saprobity system combines indicator properties for the presence of biodegradable organic matter and oxygen concentrations. The term meta-eutrophic indicates indifferent species present in both oligotrophic and eutrophic waters (Leentvaar, 1958).

During the present study a total of 21 species belong to 14 genera were recorded. Two species each of *Cymbella* and *Fragillaria* were recorded, while the remaining 7 were represented by single species each. The ecological values for river Kabini are presented in Table 2. The river water is alkaline during all seasons but remains neutral only during the rainy season of the first year. According to the salinity values the water is considered as fresh/brackish with chloride levels always less than 500mg$^{-1}$ and the salinity values are less than 0.9. The river water supports nitrogen autotrophic diatoms that tolerate elevated levels of organically bound nitrogen. Oxygen requirements of diatoms quite often vary from season to season.

It is fairly high (above 75%saturation) during the rainy and winter of the first year of study, but later becomes continuously high (above 100% saturation) during summer and winter of the second year. Beta-mesosaprobic conditions prevail, where the water class becomes II, oxygen saturation reaches 70-85%, and BOD levels become 4 mg/$l^{-1}$.All diatom species occurring in the river are strictly moisture tolerant. Although organic pollution in the river ranges between nonexistent to moderate, the indicator species of organic pollution are *Cyclotella meneghinian* and *Navicula mutica* and the percentage of organic pollution ranges between a minimum of 3.48 during summer and 20.5 during monsoon. Four species, *Synedra acus*, *Synedra ulna* and *Stauroneis anceps and Navicula rhynchocephala* are the prime indicators of anthropogenic eutrophication. *Synedra acus* is the commonest indicator.

The number of diatom species is high during summer and least during winter, evenness of species with small variations is predominant. Schoeman (1973) studying the ecology of diatoms in relation to water quality concluded that many waters were alkaline and oxygen rich which were confirmed by the use of diatoms. Pollution due to nitrogenous compounds was very high. These observations are also true to the present study. The main reason for this is the settlement of many villages with huge livestock rearing along the river basin of Karnataka. These settlements add enormous organic matter that flows into the river mainly during monsoon and during heavy rainfall. This in turn considerably increases the Total Daily Maximum Load increasing the trophic state of the river. Louis-Laclerq (2008) developed an index IDSE/5 for saprobity and eutrophication into five grades. According to this index, degradation in the river is moderate. The study stresses upon the use of diatom assemblages as powerful ecological indicators of water quality.

**Conclusion**

Kabini river water is alkaline throughout the period of study with high levels of Chloride. The diatom species occurring in the river are nitrogen autotrophic taxa tolerating high levels of organically bound nitrogen. Oxygen requirements range from moderate to fairly high levels. Oxygen saturation is very high (85%) with low BOD and the water is considered as Beta mesosaprobic to eutrophic. Two species indicate organic pollution while three others indicate anthropogenic eutrophication which may be attributed to the pollution load by mushrooming of villages on the banks of the river. Degradation and saprobity are moderate. Fresh water diatoms can serve as excellent indicators of river water quality.

Table1: Distribution of Diatom species in Kabani dam of Mysore district (2008 to 2010) values expressed as O/L (Organisms/Litre)

| No. | Acronym | Species | Summer | Rainy | Winter | Summer | Rainy | Winter |
|---|---|---|---|---|---|---|---|---|
| 1 | CPER | ***Cymbella perpusiela* A. Cleve** | 960 | 0 | 480 | 0 | 0 | 480 |
| 2 | CPLA | ***Cocconeis placentula* Ehrenberg** | 1440 | 960 | 1920 | 1440 | 1920 | 480 |
| 3 | CMEN | ***Cyclotella meneghiniana* Kutzing** | 480 | 1920 | 960 | 3360 | 1920 | 3360 |
| 4 | CLEP | ***Cymbella leptoceros* (Ehrenberg)Kutzing** | 1440 | 480 | 960 | 1440 | 480 | 1920 |
| 5 | FCAP | ***Fragilaria capucina* Desmazieres** | 1440 | 960 | 1920 | 960 | 0 | 480 |
| 6 | FPIN | ***Fragilaria pinnata* Ehrenberg** | 1440 | 960 | 2880 | 2400 | 960 | 1920 |
| 7 | GYAT | ***Gyrosigma atenuatum*(Kutzing)Rabenhorst** | 1440 | 1920 | 480 | 960 | 960 | 1440 |
| 8 | MSMI | ***Mastogleoia smithii* Thwaites** | 960 | 0 | 1440 | 480 | 480 | 960 |
| 9 | MISL | ***Melosira islandica* O. Muller** | 3840 | 2880 | 2400 | 1440 | 960 | 3360 |
| 10 | NRHY | ***Navicula rhynchocephala* Kuetzing** | 960 | 0 | 1440 | 480 | 480 | 960 |
| 11 | NMUT | ***Navicula mutica* Kutzing** | 1920 | 1440 | 960 | 1440 | 1440 | 1920 |
| 12 | NOBT | ***Nitzschia obtuse* W.M. Smith** | 1440 | 960 | 480 | 1440 | 480 | 1920 |
| 13 | NSCA | ***Nitzschia scalaris*(Ehr.) W.M. Smith** | 2400 | 1440 | 1920 | 1920 | 480 | 960 |
| 14 | PDIV | ***Pinnularia divergens* W.M. Smith** | 1440 | 960 | 1920 | 2400 | 480 | 1440 |
| 15 | PGRA | ***Pinnularia gracillima* Gregory** | 480 | 1440 | 0 | 960 | 1920 | 480 |
| 16 | GHIP | ***Gyrosig,a hippocampus*(Ehr.) Hassel** | 3360 | 1460 | 1920 | 2880 | 2400 | 3360 |
| 17 | STAN | ***Stauroneis anceps* Ehrenberg** | 2400 | 960 | 960 | 480 | 0 | 960 |
| 18 | SURO | ***Surirella robusta* Ehrenberg** | 960 | 0 | 1440 | 480 | 480 | 960 |
| 19 | SOVA | ***Surirella ovate* Kutzing** | 1460 | 960 | 1920 | 480 | 0 | 0 |
| 20 | SACU | ***Synedra acus* Kutzing** | 3360 | 1440 | 2440 | 2880 | 480 | 1920 |
| 21 | SULN | ***Synedra ulna*(Nitzsch.)Ehr** | 11520 | 6720 | 12480 | 12480 | 7200 | 12000 |

Table 2: Diatoms as Ecological indicators of water quality, Kabani River (2008 to 2010)(OMNIDA: Lecointe et al.2003)

| Ecological Values | Summer | Rainy | Winter | Summer | Rainy | Winter |
|---|---|---|---|---|---|---|
| pH(R) | Alkaliphilic | Neutrophilic | Alkalipilic | Alkaliphilic | Alkaliphilic | Alkaliphilic |
| Salinity(H) | Fresh water/ Brackish, $Cl^{-1}$ < 500 $mg^{-1}$, Salinity < 0.9 | | | | | |
| Nitrogen uptake Metabolism(N) | Nitrogen autotrophic taxa tolerating elevated levels of organically bound nitrogen | | | | | |
| Oxygen Requirements(O) | Moderate (above 50%) | Fairly high (above 75%) | Fairly high (above 75%) | Continuously high (above 100% saturation) | Moderate (above 50%) | Continuously high (above 100% saturation) |
| Saprobity(S) | Beta –mesosaprobic, Water Class II, Oxygen saturation 70-85%, BOD 2 to 4 mg/$l^{-1,}$ five days @ $20^0$C | | | | | |
| Trophic state(T) | Hypoeutrophic | Eutrophic | Hypoeutrophic | Eutrophic | Eutrophic | Eutrophic |
| Moisture tolerance(M) | All species strictly aquatic, sometimes occurring on wet places and can survive under slightly dry conditions | | | | | |
| Indicators of Organic pollution | Nonexistent (CMEN,NMUT) | Low(CMEN, NMUT) | Nonexistent (CMEN, NMUT) | Low(CMEN,NMUT) | Moderate (CMEN, NMUT) | Low(CMEN, NMUT) |
| % Organic Pollution | 3.48 | 16.35 | 6.9 | 16.95 | 20.5 | 17.19 |
| Indicators of Anthropogenic Eutrophication | Moderate(NRHY,SACU, STAN,SULN) | Low(SACU, STAN) | Low(NRHY, SACU, STAN) | Low(NRHY,SACU, STAN) | Low(NRHY, SACU) | Low(NRHY, SACU) |
| %Anthropogenic Eutrophication | 42.68 | 11.68 | 17.2 | 13.58 | 5.88 | 12.50 |
| IDSE/5 Index | 3.48 | 3.63 | 3.72 | 3.52 | 3.5 | 3.52 |
| No. of species | 20 | 16 | 18 | 19 | 16 | 19 |
| Total population | 42740 | 20552 | 27840 | 28320 | 16320 | 30720 |
| Diversity | 3.79 | 3.91 | 4.01 | 3.99 | 3.72 | 4.02 |
| Evenness | 0.88 | 0.98 | 0.96 | 0.94 | 0.93 | 0.95 |
| No. of genera | 13 | 12 | 13 | 13 | 12 | 12 |
| Trophic state tolerance | All species are highly tolerant to the trophic state of water | | | | | |

CMEN:Cyclotella meneghiniana,NMUT: Navicula mutica; NRHY:Navicula rhynchocephala, SACU:Synedra acus,STAN: Stauroneis anceps,SULN:Synedra ulna

**Table 3: Ecological Indicator values (VanDam et al.1994)**

**(R) pH(1-6)**
1. Acidobiontic Optional Occurrence at pH< 5.5
2. Acidophilous Mainly occurring at pH < 7
3. Circumneutral Mainly occurring at pH 7
4. Alkaliphilous Mainly occurring at Ph > 7
5. Alkalibiontic Exclusively occurring at pH>7
6. Indifferent No apparent optimum

**(M Moisture(1-5)**
1. Never or only very rarely occurring outside water bodies
2. Mainly occurring in water bodies, sometimes on wet places
3. Mainly occurring in wet places rather regularly on wet and moist places
4. Mainly on wet places, temporarily on moist or dry places
5. Nearly exclusively occurring outside water bodies

**(N)Nitrogen uptake metabolism (1-4)**
1. Nitrogen autotrophic taxa tolerating very small concentrations of organically bound nitrogen
2. Nitrogen autotrophic taxa tolerating elevated levels of organically bound nitrogen
3. Facultatively bound nitrogen-heterotrophic taxa needing periodically elevated concentrations of organically bound nitrogen
4. Obligately nitrogen-heterotrophic taxa needing continuously elevated concentrations of organically bound nitrogen

**(O) Oxygen requirements (1-5)**
1. Continuously high (about 100% saturation)
2. Fairly high (above 75% saturation)
3. Moderate (above 50% saturation)
4. Low (above 30% saturation)
5. Very low (about 10% saturation)

**(T) Trophic State(1-7)**
1. Oligotrophentic
2. Oligo-mesotrophentic
3. Mesotrophentic
4. Meso-eutrophentic
5. Eutrophentic
6. Hypereutrophentic
7. Oligo to eutrophentic(Hypoeutrophentic)

**(S) Saprobity(1-5)**

| | Water quality Class | Oxygen saturation (%) | $BOD^5@20^0C$ |
|---|---|---|---|
| 1. Oligosaprobous | II | > 85 | 2 |
| 2. Beta -mesosaprobous | II | 70-85 | 2-4 |
| 3. α meso-saprobous | III | 25-70 | 4-13 |
| 4. α-meso-polysaprobous | III-IV | 10-25 | 13-22 |
| 5. Polysaprobous | IV | <10 | 22 |

**(H) Salanity(1-4)**

| | Cl-($mgl^{-1}$) | Salinity |
|---|---|---|
| 1. Fresh | < 100 | <0.2 |
| 2. Fresh brakish | <500 | <0.9 |
| 3. Brakish fresh | 500-1000 | 0.9-1.8 |
| 4. Brakish | 1000-5000 | 1.8-9.0 |

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