# Microhabitat influence on diatom distributional pattern in diverse ecosystems

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## Abstract

Macrophytes provide microhabitat for diatoms and also aid as biological filters as they uptake nutrients. We examined diatom community from submerged macrophytes in restored (Ulsoor and Kothanur) and unaltered (Ramasandra and Yelahanka) lakes of Bangalore urban region. We also collected diatoms from rock scrapings aiming to determine the importance of macrophytes for abundant species growth. Water samples were collected concurrently to analyze diatom environment relationship. Diatom taxa belonging to genus *Nitzschia*, *Fragilaria*, *Staurosirella*, *Gomphonema, Cymbella, Cyclotella and Achnanthidium* were recorded during the study period. *Ulnaria ulna* (Nitzsch) Lange-Bertalot dominated in Ulsoor lake while *Staurosirella pinnata* and *Cyclotella meneghiniana* structured diatom community of Yelahanka lake. Kommaghatta lake showed high species diversity (27 species) on macrophytes before restoration and low species diversity (13 species) in post-restoration sample due to lack in macrophyte availability in later sample. Even though, epiphyte (*Eichornia crassipes*) covered Yelahanka lake, diatom community structure revealed polluted water condition. This highlights diatom-habitat relationship with respect to water conditions. However, appropriate species of macrophytes are to be chosen while deciding management and restoration of lakes.

**Keywords**: Bangalore lakes, Biomonitoring, Restoration, Macrophytes

## 1.0 Introduction

Microhabitats with complex interactions in the aquatic environment and influenced by physical and chemical factors (such as water depth, light availability and nutrients load), support diverse flora and fauna. Symbiotic association of submerged macrophytes with bacteria, blue green algae and diatoms provide heterogeneous habitats for microbial diversity (Tundisi & Matsumura-Tundisi, 2011). Spatio-temporal factors such as catchment land use, water inflow level, nutrients, ionic concentration, organic content, etc. influence macrophyte. Also, the habitat complexity and heterogeneity of an aquatic environment is influenced by macrophytes (Thomas & Cunha, 2010). Scheffer, 2004 compares the attached/littoral zone macrophyte floral diversity to aquatic forest whereas free floating/pelagic zone floral diversity as barren sand dune. Biomass production in macrophytes serves as food sources for grazing and detritivorous invertebrates (Esteves, 1998). Diatoms constitute a vital freshwater component, considering its function as primary food source for zooplanktons, macroinvertebrates and amphibians (Welsh and Ollivier, 1998; Skelly et al., 2002). They occupy submerged habitats of lakes and also grow on rocks in rivers and streams (Stenger-Kovács et al., 2007; Karthick et al., 2010; Uedeme-Naa et al., 2011). Diatom species preferences for particular substrata and microhabitats like stones (epilithic), sediments (epipelic, epipsammic), submerged plants (epiphytic) and fish guts hav been reported (Round, 1991; Rothfritz et al., 1997; Shirey et al., 2008; Alakananda et al., 2011). *Synedra* sp., *Lemnicola* sp. *Cocconeis* sp. and *Cymbella* sp. (epiphytic diatoms) favor growing on macrophytes like *Wolffia* sp., *Lemna* sp. and other submerged plants (Round, 1991; Hameed, 2003; Buczko 2007) due to the availability of higher concentrations of organic matter. Epiphytic diatoms and its abundance depend on microhabitats for the optimal growth of species (Muylaert et al., 2006*)* and hence are used as potential biological indicators of trophic status in several temperate streams (Kelly et al., 1998). Organic content, nutrient availability and ions influence the distribution pattern of diatoms (Negro and Hoyos, 2005; Cantonati et al., 2009), but the role of macrophyte as microhabitat has not been explored in diatom ecological studies (Leira and Cantonati, 2008). Diatoms attached to macrophytes indicate the extent of urban stress such as nutrient run off, invasive species, etc. (King and Buckney, 2000). The investigation of epiphytic diatoms is indispensable for improvement of water quality and also to define urban stress in lakes (Uedeme-Naa et al., 2011). Macrophytes perform an important ecological function of water purification by removing nutrients. Still their role is least understood by policy makers evident from the removal of shoreline aquatic plants, submerged macrophytes and wetlands while restoring urban lakes. The current study focuses on the vital associations of epiphytic diatoms and macrophytes in urban lakes of Bangalore region. The study provides restoration guidelines for Bangalore lakes.

## 2.0 Study area and Methods

Bangalore is located at 12.95º N and 77.57º E with an altitude of 920 metres a.m.s.l. The annual precipitation is 924m and temperature varying from ~15 °C during winter months (January) to ~36 °C in hot summer months (April/May). Bangalore is delineated into four watersheds, namely the Hebbal, Koramangala, Challaghatta and Vrishabhavathi valleys with more than 70 interconnected lakes. During the last decade, lakes located at Ulsoor, Hebbal, Lalbhag were restored, but eutrophication persists. Five lakes viz., Ulsoor, Kothanur, Ramasandra, Kommaghatta and Yelahanka were studied considering different habitats and also water quality. Water and diatoms from submerged plants were sampled simultaneously for 6 months (December 2010-

March 2011). Kommaghatta lake was sampled during pre and post restoration to study the effects of restoration on lake biodiversity. Lists of lakes along with the code used in the text are mentioned in Table 1. Analysis of pH, Electric Conductivity, Total Dissolved Solids, Dissolved Oxygen and water temperature was performed onsite. Biological oxygen demand, Chemical oxygen demand and chlorides were analyzed following APHA (1985) in Aquatic ecology laboratory at Centre for Ecological Sciences, Indian Institute of Science, Bangalore. Diatom samples were collected, cleaned, process in acid and slides were prepared following standard protocol (Karthick et al., 2010) and identified following standard diatom literatures. Statistical analysis was performed using PAST 2.16 (Hammer et al., 2001).

## 3.0 Results

Seventy six species from thirty seven genera within all habitats, and twenty four taxa common on both epiphytic and epilithic habitats were recorded. Diatom species such as *Achnanthidium exiguum* (Grunow) Czarnecki, *Amphora veneta* Kützing, *Aulocoseira granulata* (Ehrenberg) Simonsen, *Cyclotella meneghiniana* Kützing, *Diploneis oblongella* (Naegeli) Cleve-Euler, *Gyrosigma rautenbachiae* Cholnoky and *Nitzschia palea* (Kützing) W.M. Smith, dominated representing epiphytic habitat and *Ulnaria ulna v. acus* (Kützing) Lange-Bertalot characterized epilithic habitat. These epiphytic and epilithic species reached up to 50% of total abundances in sampled lakes. Taxa belonging to genus *Achnanthidium* sp. were confined to stone and plant habitats and are indifferent to alterations in water flow induced forces. Table 2 lists the diversity indices, which reflected the highly variable species richness among samples with taxa ranging from 2- 27 at respective sampling sites. Shannon diversity illustrated in Figure 1, ranges from 0.29 (Ulsoor) - 2.62 (Kommaghatta). Overall, dominance ranged from 0.1-0.83 where, taxa were 80% dominant at Ulsoor lake. Dissimilarity and decline in taxa were observed in pre and post restoration period of Kommaghatta lake.

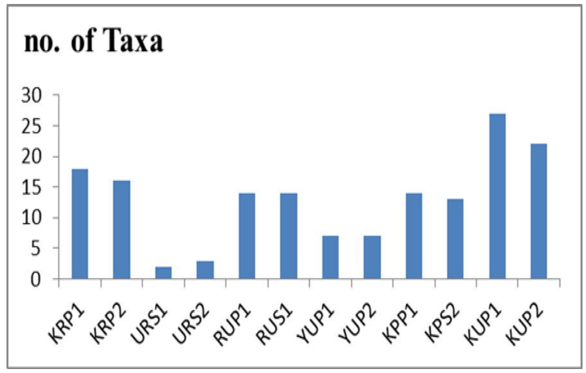


Figure 1: Number of taxa recorded across sampling sites (Refer table 1 for sampling sites and its codes)

Species richness of taxa collected from 2 different habitats, were plotted to study the highest preferred habitat for benthic diatoms and represented in Figure 2. Highest number of taxa was found on epiphytic/submerged habitat followed by epilithic/ stones. The adherence and accumulation of diatom growth was observed to be reliant on the type of macrophytes available and water conditions (Figure 3). Highest species occupancy was observed on macrophyte *Alternanthera* sp. with water conductivity value of 651±39 $\mu Scm^{-1}$ at Kommaghatta (before restoration). Moderate species richness of 1.93±0.09 and 2±0.07 (*Pistia* sp. and *Typha* sp.) were noticed and conductivity recorded are 773±9 $\mu Scm^{-1}$ and 490±22 $\mu Scm^{-1}$. Lowest species richness on *Eichornia* sp. with highest water conductivity of 1285±65 $\mu Scm^{-1}$. Dissolved oxygen, Biological oxygen demand and chemical oxygen demand classified Kothanur, Ulsoor and Yelahanka lakes (Table 1) as most polluted from that of moderately polluted lakes (Ramsandra and Kommaghatta). Nitrates and phosphates were within the surface water standards, ranging from 0.039-0.27 ppm and 0.001-2.01 ppm, although pollution was evident from organic concentration levels.

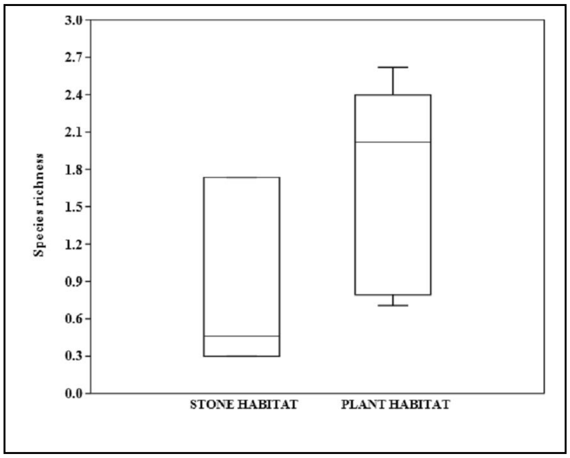


Figure 2: Species richness of diatoms on Stone (epilithic) and Plant (epiphytic) habitat

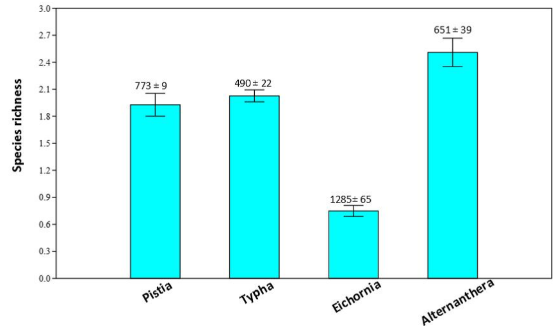


Figure 3: Diatom distribution on four different macrophytic habitats in Bangalore lakes. Number on top of each bar represents corresponding conductivity values

Table 1 List of sampling sites along with codes used in analysis and water quality data

| **sampling sites** | **Code** | **pH** | **EC ($\mu Scm^{-1}$)** | **DO ($mgL^{-1}$)** | **BOD ($mgL^{-1}$)** | **COD ($mgL^{-1}$)** | **N (ppm)** | **P (ppm)** |
|---|---|---|---|---|---|---|---|---|
| Kommaghatta post restoration plant 1 | KPP1 | 9.01 | 782 | 4.55 | 25.30 | 44.00 | 0.056 | 0.02 |
| Kommaghatta post restoration stone 2 | KPS2 | 8.98 | 764.5 | 6.14 | 13.71 | 78.00 | 0.066 | 0.02 |
| Kommaghatta unaltered plant 1 | KUP1 | 8.50 | 690 | 7.48 | 7.30 | 36.50 | 0.04 | 0.03 |
| Kommaghatta unaltered plant 2 | KUP2 | 8.10 | 612 | 8.94 | 4.71 | 23.55 | 0.17 | 0.05 |
| Kothanur restored plant 1 | KRP1 | 7.20 | 1110 | 0.97 | 14.50 | 72.50 | 0.079 | 0.30 |
| Kothanur restored plant 2 | KRP2 | 7.14 | 968 | 2.19 | 13.33 | 66.65 | 0.15 | 0.37 |
| Ulsoor resotred stone 1 | URS1 | 9.48 | 705 | 1.63 | 16.98 | 43.96 | 0.27 | 1.89 |
| Ulsoor restored stone 2 | URS2 | 9.38 | 609 | 4.07 | 15.96 | 41.92 | 0.18 | 2.01 |
| Yelahanka unaltered plant 1 | YUP1 | 9.06 | 1220 | 4.63 | 21.94 | 53.88 | 0.19 | 1.34 |
| Yelahanka ulatered plant 2 | YUP2 | 9.33 | 1350 | 2.76 | 26.385 | 62.77 | 0.26 | 1.61 |
| Ramasandra unaltered plant 1 | RUP1 | 8.85 | 490 | 6.67 | 7 | 30.99 | 0.051 | 0.001 |
| Ramasandra unaltered stone 1 | RUS1 | 8.60 | 496 | 7.06 | 6.00 | 30.67 | 0.039 | 0.020 |
| BIS surface water standards | BIS | 6.5-9 | 1200 | >3 | <5 | <30 | - | - |

**Table 2: Diversity indices**

| **CODE** | **no. of Taxa** | **Dominance** | **Shannon** | **Evenness** |
|---|---|---|---|---|
| KPP1 | 14 | 0.1628 | 2.088 | 0.5762 |
| KPS2 | 13 | 0.4587 | 1.316 | 0.2869 |
| KUP1 | 27 | 0.1084 | 2.621 | 0.5092 |
| KUP2 | 22 | 0.1319 | 2.398 | 0.5001 |
| KRP1 | 18 | 0.2122 | 2.018 | 0.4178 |
| KRP2 | 16 | 0.2112 | 1.838 | 0.3927 |
| URS1 | 2 | 0.8385 | 0.2993 | 0.6744 |
| URS2 | 3 | 0.7709 | 0.4614 | 0.5288 |
| YUP1 | 7 | 0.6885 | 0.7057 | 0.2893 |
| YUP2 | 7 | 0.6161 | 0.7923 | 0.3155 |
| RUP1 | 14 | 0.1607 | 2.074 | 0.5685 |
| RUS1 | 14 | 0.3166 | 1.735 | 0.4048 |

## 4.0 **Discussion**

The analysis of diatom distribution is not restricted to water quality monitoring studies but also done for characterization of micro habitats and ecological significance in a defined section of ecosystems (Weilhoefer and Pan, 2007). This study reveals macrophytes as one of the necessary habitats for benthic diatom assemblages. Habitat specific diatoms and its accumulation on different macrophytes were well noticed through species richness, which is probably the widely used diversity indices (Maguran, 2004). *Typha* sp., the commonly spread macrophyte at Ramasandra lake is known to reduce biological oxygen demand and thereby increase dissolved oxygen in water body. Thus, Ramasandra showed a moderate BOD/COD range. But, the burgeoning growth of *Eichornia* covered the entire water surface at Yelahanka lake, hindering light penetration and hence low species richness.

Earlier reports indicate that diatom assemblage is significantly different under varying nutrient, ionic concentrations and host macrophytes (Soininen et al., 2004; Cejudo-Figueiras et al., 2010). In the current study, we documented more species assemblage from macrophytes compared to stone habitat. In earlier studies, subsequent lower species richness and diatom diversity has been observed on hard substrata (rocks and wood) than on soft substrata (Kitner and Poulícková, 2003). Further, application of epiphytic diatoms might be useful for computing water quality indices as it is likely to reveal more precise information about water quality in south Indian lakes than epilithic samples. Besse-Lototskaya et al. (2006) and Yallop et al., 2009 observed that the Trophic diatom index (TDI) and other diatom indices are influenced by choice of substrate and are accurate on using macrophytes attached diatom assemblages.

Pollution tolerant species *Staurosirella pinnata* (Ehrenberg) Williams & Round and *Cyclotella meneghiniana* Kützing were dominant diatom community of Yelahanka lake while *Achnanthidium exiguum* (Grunow) Czarnecki was abundant at Ramsandra lake. Ulsoor a restored lake with no macrophytes showed high conductivity values with low species richness and dominance of *Ulnaria ulna* var. *acus*. Kommaghatta lake showed high species diversity (27 species) on epiphytic habitat macrophytes before restoration and low species diversity (14 species) in post-restoration samples due to lack of suitable habitats. This also has decreased aquatic insects and molluscan diversity, leading to imbalance in the food chain and microbial activity (Masseret et al., 1998). Most conservation studies particularly anurans and fish diversity reported epiphytic diatoms as important tool in understanding interrelationship within trophic food chain of complex aquatic ecosystems (de Sousa Filho et al., 2007). This conform that benthic diatom species, its preference and patterning are important to study and are determined by macrophyte availability and consequent water quality.

Due to improper management strategies, most restoration practices disregard the importance of shoreline aquatic plants which has led to the decline in aquatic biodiversity particularly in degraded urban region (Ramachandra and Kumar, 2008). Urban lakes need robust water monitoring regulations, taking into account microhabitat availability and prominent pollution load. Excessive growth of invasive weeds such as *Eichornia* sp. hinder navigation, choking in irrigation channels and lakes, impede drainage and increase silt deposition. Thus, restoration and pollution prevention measurement needs to implement macrophytes management, removal of excessive weed growth and retain nominal aquatic plants for colonization of macro invertebrates, tadpoles and microbial activities. Wetland region is a vital component of the lake ecosystem, to be maintained at inflow region for substantial microbial community, in particular to diatom distribution and macro habitat that function in lake purification, colonization and for sustained ecosystem health.

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