Seasonal variation in diatoms in response to physico-chemical characteristics of coastal waters of Uttara Kannada district, West Coast of India

Sushanth V.R, Rajashekhar M
Department of Biosciences, Mangalore University, Mangalagangothri – 574 199
profmrajashekhar@yahoo.co.in
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ABSTRACT

The present study was undertaken to know the diatom distribution in different seasons in response to physico-chemical properties of Arabian Sea water in the Uttara Kannada District, Karnataka over a period of one year from November 2009-October 2010. The study revealed the presence of 55 species of diatoms, highest number was recorded in post-monsoon and the least in monsoon season. The major genera belong to Amphora, Chaetoceros, Coscinodiscus, Navicula, Pleurosigma, Achnanthes, Cymbella, Mastogloia, Nitzschia, Biddulphia, Diploneis and Licmophora. Bloom of Asterionella japonica was observed during early monsoon season. The physico-chemical parameters studied showed noticeable seasonal variations, which may be attributed to the local climatic conditions and water exchange mechanisms. The physico-chemical parameters like temperature, salinity, conductivity and nutrients were found to influence the occurrence of diatoms.

Keywords: Diatoms, Physico-chemical properties, Seasonal variations, Arabian Sea, Uttara Kannada District.

1. Introduction

There are few reports on the occurrence of diatoms in the coastal waters of India (Ramamurthy, 1965; Dehadrai and Bhargava, 1972; Sarvanane et al., 2000; Madhupratap et al., 2001). They constitute one of the important components of phytoplankton and hence contribute for primary productivity. Some studies have been carried out to evaluate the seasonal behavior and abundance of diatoms in relation to physico-chemical parameters of sea water (Koster and Pienitz, 2006). The distribution of nutrients in the sea water exhibit some variations depending on the local conditions like rainfall, fresh water inflow, tidal incursion and also biological activities. The nutrients determine the concentration of phytoplankton in an area and therefore it is important to gather information about their distribution and behavior in different coastal ecosystems (Harvey, 1960).

Diatoms are used in the environmental assessment and monitoring with the water parameters like pH, salinity, nutrient concentrations, suspended sediment, flow regime, elevation and different types of human disturbances (Laskar and Gupta, 2009). The extent to which diatoms can tolerate the levels of these parameters makes them potential indicator organisms. The systematic study on the availability of nutrients in relation to physico-chemical parameters of water (nitrate, phosphate, silicate and sulphate) is scarce. In this view a study was undertaken to know the seasonal variation in nutrient content and to relate the effect of nutrients on their abundance with reference to changes in physico-chemical parameters of water of Arabian Sea,
Uttara Kannada District of Karnataka and also to create a baseline data on the occurrence of diatoms in the West Coast of India.

2. Materials and Methods

2.1 Description of study areas

Uttara Kannada has a coastal line of 144 kms, extending from Majali on the north to Gorte in Bhatkal Taluk on south. It lies between 13°55’ and 15°31’ North latitude and 74°9’ and 75°10’ East longitude (Figure 1). For the study, four sampling stations were selected, Bhatkal, Kumta, Gokarna and Majalli along Uttara Kannada coast.

![Figure 1: Map showing the sampling stations along Uttara Kannada Coast](image)

2.2 Sampling and Collection of water samples

Surface water samples for physical and chemical parameters determination were collected in screw capped plastic containers seasonally (Pre-monsoon – February to May, Monsoon – June to September and Post-monsoon – October to January) from the three sites of each sampling stations for the period of one year (November 2009-October 2010) and stored in a refrigerator prior to the analysis.

2.3 Physico-chemical parameter analysis

Surface water temperature was measured using mercury-in-glass thermometer. pH, salinity and conductivity were analyzed in situ using Systronics water analyzer. Dissolved oxygen
was determined by Winkler’s method. The dissolved nutrients such as nitrate, phosphate, silicate and sulphate were estimated by spectrophotometric methods (APHA, 1992). The data obtained were computed and presented as mean ± standard deviation.

2.4 Collection, preservation and analysis of diatom samples

The diatom samples were collected by filtering 50 liters of surface seawater samples through a plankton net cloth of 20 µm pore size and preserved in 4% formaldehyde. The samples were analyzed for their species composition using phase contrast microscope and identified by referring standard books and monographs (Prescott, 1975; Desikachary, 1987). Quantitative estimation of diatoms was carried out with the help of Haemocytometer.

3. Results and discussion

The physico-chemical parameters showed noticeable seasonal variations (Figure a-i), which may be attributed to the local climatic conditions and water exchange mechanism. When the river water mixes with sea water, some changes take place, which may influence the water quality (Prasanna and Ranjan, 2010). Variations in nutrient contents and other physico-chemical characteristics of study stations depend on several factors such as days of sampling, time of sampling and nature of effluents discharged to the sampling stations before or during the sampling.
Figure 2: Seasonal variation in physico-chemical parameters of the study areas (1.Bhatkal, 2.Kumta, 3.Gokarna, 4.Majali) during the sampling period.

The pH values showed no marked fluctuations. It remained alkaline (7.9-8.5) throughout the study period in all the stations. Highest and lowest values were observed during pre-monsoon and monsoon seasons, respectively. The higher value of pH during pre-monsoon was due to the uptake of CO2 by photosynthesizing organisms. The low pH was observed during the monsoon season may be due to the influence of fresh water influx, dilution of sea water, low temperature and organic matter decomposition (Soundarapandian et al., 2009).
The temperature is one of the important factor in the coastal ecosystem, which may influence the distribution and abundance of flora and fauna. The water temperature values varied from 28.7 – 30.3°C. The highest and lowest values were observed during pre-monsoon and monsoon seasons, respectively. In general, all the sampling stations showed similar temperature variations. Higher temperature values recorded in the dry season may be because of heat raising temperature of surface water. Low temperature in monsoon season was due to cloudy sky and rainfall brought down the temperature to the minimum (Kannan and Kannan, 1996).

The observed salinity values ranged from 26.5 - 31.8 ppt. The highest values were noticed during pre-monsoon and post-monsoon seasons. In the present study, the lower salinity was recorded during monsoon season which may be due to heavy rainfall and large quantity of freshwater inflow resulting in the dilution of water and hence causes reduction in salinity (Nirmal et al., 2009). The salinity was higher in dry season due to low rainfall, decreased fresh water inflow and rise in temperature.

The conductivity values were ranged from 43.3-54.1mS and it was high during pre-monsoon season. In most practical oceanographic applications, the change of conductivity is dominated by temperature.

In aquatic systems, oxygenation is the result of an imbalance between the process of photosynthesis, degradation of organic matter, re-aeration (Granier et al., 2000) and physico-chemical properties of water (Aston, 1980). The dissolved oxygen content varied from 5.30 – 6.90 mg/l. The increase in DO observed in monsoon season could be attributed to the input of DO-rich fresh water during the monsoon period.

According to Satpathy et al. (2010), the distribution and behavior of nutrients in the coastal environment exhibit considerable variations due to rainfall, quantum of fresh water inflow, tidal incursion and also biological activities. The concentration of nitrates ranged from 2.2–18.6 mg/l. High nitrate content was recorded in sampling stations 2 (Kumta). Variations in nitrate and its reduced inorganic compounds are predominantly the results of biologically activated reactions. Higher values of nitrate were observed during the pre-monsoon period than the other times of the year. This could be attributed to rapid replenishment of nitrate from microbial activities. Increase in temperature and rapid mixing of sub-surface and surface water during pre-monsoon season might have favored the nitrate replenishment mechanism. Wolfhard and Reinhard (1998) concluded that nitrates are usually built up during dry season and high levels of nitrates are only observed during early rainy seasons. This is because initial rains flush out deposited nitrate from near-surface soils and nitrate level reduces drastically as rainy season progresses.

The phosphate values varied from 0.47- 5.51 mg/l. High phosphate values were recorded during post-monsoon season and it was low during monsoon. Phosphate is considered to be the most significant among the nutrients responsible for eutrophication. High phosphate content was found in the sampling station 4 (Majali). Phosphate concentration in the coastal waters depends upon its concentration in the fresh water that mixed with the seawater within the land-sea interaction zone, phytoplankton uptake, addition through localized upwelling, and replenishment as a result of microbial decomposition of organic matter (Satpathy et al., 2010).

The silicate values varied from 0.01–16.10 mg/l. Highest values were recorded during monsoon seasons and lowest during post-monsoon season, respectively. Silicate was found to
be more in the sampling station 4 (Majali). The variation of silicate in coastal water is influenced by several factors like physical mixing of seawater with fresh water (Purushothaman and Venugopalan, 1972), adsorption of reactive silicate into suspended sedimentary particles (Lal, 1978), chemical interaction with clay minerals (Aston, 1980; Gouda and Panigrahy, 1992), coprecipitation with humic compounds and iron (Stephns and Oppenheime, 1972) and biological removal by phytoplankton, especially by diatoms and silicoflagellates (Liss and Spencer, 1970; Aston, 1980). During monsoon period, more dissolved silicate in the fresh water was discharged into the coastal water could be the reason for the observed higher values during monsoon period.

Sulphate is a major ion in sea water. Sulphate values varied from 471 – 711 mg/l and therefore variation in sulphate concentration due to biological processes is not significant.

Table 1: Seasonal variation of diatoms in the Arabian Sea of Uttara Kannada District, Karnataka

| Study areas | Bhatkal | Kunta | Gokarna | Majali |
|-------------|--------|-------|---------|--------|
| Species     | I   | II   | III | I   | II | III | I | II | III |
| Achnanthes brevipes | + | - | - | + | - | - | + | + | - |
| A. citronella | + | - | + | - | - | + | + | - | + |
| A. compacta | - | - | - | + | + | - | - | + | + |
| Amphora capensis | - | - | + | - | + | - | - | - | - |
| A. coffeaeformis | - | + | - | + | - | + | - | + | - |
| A. costata | - | - | + | - | - | - | + | + | - |
| A. Laevis | - | - | - | + | - | + | - | - | - |
| A. marina | + | - | + | - | + | + | - | - | - |
| A. ovalis | - | - | - | + | - | + | - | - | - |
| Asterionella glacialis | - | - | + | - | - | - | - | - | + |
| Aulacodiscus orientalis | + | - | - | + | - | - | - | - | + |
| Azpeita nodulifera | - | + | - | - | - | - | - | - | - |
| Biddulphia aurifera | - | + | - | - | - | + | - | - | - |
| B. longicruris | + | - | - | - | - | - | - | - | + |
| Caloneis crassa | - | - | + | - | - | - | - | - | - |
| Chaetoceros bacteriostroides | - | + | - | - | + | - | - | + | - |
| C. coarctatus | + | - | - | - | + | - | - | - | - |
| C. curvicetus | - | - | + | - | - | + | - | - | - |
| C. eibeni | - | - | - | - | - | - | - | - | - |
| C. lorenzianus | - | - | + | - | - | - | - | + | + |
| C. paradoxus | - | - | + | - | - | + | - | + | + |
| Cocconeis scutellum | + | - | - | - | + | - | - | - | + |
| Coscinodiscus asteromphalus | - | + | - | - | + | - | - | + | - |
| C. radiates | - | - | + | - | - | - | - | - | - |
| C. subrtilis | - | + | - | - | - | - | - | - | - |
| Coscinodiscus sp. | - | - | + | - | - | - | - | - | - |
| Cymbella aspera | - | - | - | - | - | - | - | - | - |
| C. cistula | - | - | - | - | - | - | - | - | - |
| C. yarrensis | - | - | - | - | - | - | - | - | - |
| C. paradoxa | - | - | + | - | - | - | - | - | - |
| C. radiates | - | - | + | - | - | - | - | - | - |
| C. subrtilis | - | + | - | - | - | - | - | - | - |
| Coscinodiscus sp. | - | - | + | - | - | - | - | - | - |
| Cymbella aspera | - | - | - | - | - | - | - | - | - |
| C. cistula | - | - | - | - | - | - | - | - | - |
| C. yarrensis | - | - | - | - | - | - | - | - | - |
| Frugillaria intermedia | - | - | + | - | - | - | - | - | - |
| Diploneis crabro | - | - | - | - | - | - | - | - | - |
| D. weissflogii | - | - | - | - | - | - | - | - | - |
| Gyrosigma balticum | - | - | - | - | - | - | - | - | - |
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| Licmophora abbreviata | - | + | + | - | + | + | - | + | - | - | - |
| L. bharadwajai | - | - | - | + | - | + | - | - | + | - | + |
| Mastogloia angulata | - | - | - | - | - | + | - | - | + | - | - |
| M. lineata | + | - | + | - | - | - | - | + | + | - | + |
| M. ovata | - | + | - | - | - | + | - | + | - | - | + |
| Melosira moniliformis | - | - | - | + | - | - | - | + | - | - | - |
| Navicula cuspidata | - | - | + | - | - | + | - | + | - | - | + |
| N. peregrine | - | - | - | - | + | - | - | + | - | - | - |
| N. distans | + | - | - | - | - | + | - | - | + | - | + |
| N. monilifera | - | - | - | - | - | - | - | + | - | - | + |
| Nitzschia longissima | - | - | + | - | + | - | - | - | + | - | + |
| N. spectabilis | + | + | - | - | - | + | - | + | + | + | - |
| N. sigmoidea | - | + | + | - | - | - | + | - | - | - | + |
| Pleurosigma aestuarii | - | - | - | + | - | - | - | - | - | - | - |
| P. falx | - | - | - | - | + | + | - | - | - | - | + |
| P. formosum | - | - | - | - | + | + | - | - | - | - | + |
| P. normanii | + | - | + | - | - | + | - | + | + | + | - |
| Proboscia alata | + | - | - | - | - | - | - | + | - | - | - |
| Skeletonema costatum | - | - | + | - | - | - | + | - | - | + | + |
| Synedra hennedyana | + | + | - | - | - | + | - | + | + | - | - |
| Thalassionema nitzschioides | - | - | - | - | - | + | - | + | - | - | + |
| Thalassiothrix longissima | + | - | - | - | - | - | - | - | - | - | - |

| Total No. of diatoms | 15 | 12 | 25 | 17 | 12 | 23 | 21 | 17 | 23 | 21 | 19 | 25 |

I – Pre-monsoon; II – Monsoon; III – Post-monsoon

Figure 3: Seasonal distribution of diatoms during the study period in the sampling stations (1. Bhatkal, 2. Kumta, 3. Gokarna and 4. Majali).

A total of 55 species of diatoms were recorded in the study stations during sampling period. The highest number of diatoms in post-monsoon, followed by pre-monsoon and least was recorded in monsoon season. The total number of diatoms ranged from $59 \times 10^4$/L (Station 1) - $73 \times 10^4$/L (Station 4) during post-monsoon season. Variation in total number of diatoms during pre-monsoon season was $50 \times 10^4$/L (Station 2) - $56 \times 10^4$/L (Station 4). During monsoon period, the total diatom cell number varied from $22 \times 10^4$/L (Station 1) - $30 \times 10^4$/L (Station 4). The major genera in terms of frequency and abundance were *Amphora* (6), *Chaetoceros* (6), *Coscinodiscus* (4), *Navicula* (4), *Pleurosigma* (4), *Achnanthes* (3), *Navicula* (4), *Pleurosigma* (4), *Achnanthes* (3),...
Cymbella (3), Mastogloia (3), Nitzschia (3), Biddulphia (2), Diploneis (2), Licmophora (2) and single species of Asterionella, Aulacodiscus, Azpeita, Caloneis, Cocconeis, Fragillaria, Gyrosigma, Melosira, Proboscia, Skeletonema, Synedra, Thalassionema and Thalassiothrix.

Water temperature affects the abundance of diatoms. Most diatoms are suited to cold water, but if the temperature is too low, it will suppress the growth (Wim and Koen, 1995). It was observed that salinity influenced the abundance of diatoms and low number of diatoms were recorded during monsoon when salinity was low and high numbers during increased salinities i.e. during post-monsoon and pre-monsoon seasons (Redekar and Wagh, 2000). Conductivity is also one of the important factor in explaining diatom distribution. Changes in conductivity is naturally occurring process; however they are being accelerated by human activities and increase in conductivity result in reductions in biodiversity (Daveis et al., 2002; John et al., 2007). The concentration of nutrients is important in the determination of dominant diatom species through its influence on other environmental factors acting on diatoms (Gligora et al., 2007). Phytoplankton growth is promoted by the presence of nutrients such as nitrates, phosphates, silicates in the seawater. Relatively lower values of silicate were observed during the post-monsoon period, which could be due to uptake of phytoplankton.

Several alterations in physico-chemical characteristics of water can lead to various ecological consequences like changes in species composition, blooms of phytoplankton and decrease of oxygen concentrations (Kumar et al., 2005). In many estuaries and inshore areas of the west coast of India, diatom blooms are observed in upwelled waters rich in nutrients during the monsoon and post monsoon months. During the course of study, diatom bloom was observed at Majali station in the month of June, 2010 (early monsoon) dominated by Asterionella japonica (94%). It was in the form of a brownish patch. Other species of diatoms found in the bloom sample was Diploneis crabro, Cymbella aspera, Chaetoceros lorenzianus, and Navicula sp. Introduction of nutrients during summer and monsoon periods through river run off and coastal upwelling are major factors influencing the algal blooms. In many inshore areas of the west coast of India, diatom blooms were observed during the monsoon and post-monsoon seasons.

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