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Abundance and Composition of Mesophytoplanktonic Community in the Coastal Shelf, Arabian Sea, Karnataka

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ABSTRACT: Coastal ecosystems are among the most productive and dynamic ecosystems on the planet. Phytoplankton biomass is considered as one of the most primary indicators of coastal ecosystem health because of its vital function in the food web. The rapid adaptation capability of phytoplankton makes them a critical component in the any aquatic ecosystem and a sensitive indicator of changes in the system concerned. A shift in phytoplankton abundance can alter the food web and impact fisheries production. Therefore, to maintain a healthy coastal ecosystem, it is important to understand the dynamics of phytoplankton communities. A total of 45 genera of mesophytoplankton were recorded from these coastal shelf waters. Of these, Chrysophyta was represented by thirty four (34) genera, Pyrrophyta by eight (8) genera, Cyanophyta and Chlorophyta by two (2) & one (1) genera, respectively. The results showed that chrysophytes predominated the phytoplankton community among these, Centrales (82.36% to 95.74% at S1; 69.22% to 96.81%) seemed to be the dominant Chrysophytes at both the stations over that of pennate (4.26% to 17.64% at S1; 3.19% to 30.78% at S2) diatoms.

Keywords: Phytoplankton, Coastal continental shelf, Salinity, Chlorophyll.

INTRODUCTION

With the rapid development of coastal cities, increasing pressure is being placed on many coastal ecosystems. Coastal waters are complex, dynamic, and sensitive, and any change in the system impacts the marine environment and life. Coastal environments are generally dominated by microphytoplankton due to their competitive advantage in highly fluctuating nutrient environments (Kitchen *et al.*, 1975; Malone, 1980). Plankton is excellent indicators of ecosystem status and fisheries because of their pivotal role in food webs and their core values in the integrated ecosystem assessment (IEA). By forming the basis of the food chain and hence, the pathways for carbon and energy fluxes (Ryther, 1969), they play an important role in marine ecosystems. Some general understanding of the consequences of shifting nutrient regimes can be derived from the detailed investigation of the phytoplankton community and its diversity. Hence, monitoring plankton is essential to understand their dynamics and underlying processes. Present work is carried out in the coastal shelf waters of Arabian Sea, off Mangalore.

MATERIALS AND METHODS

Surface water samples (composite samples) were collected from two selected sampling stations (Station 1 (S1) & Station 2 (S2)) in the coastal shelf of Arabian Sea, off Mangalore, at monthly intervals for a period of 12 months, covering two consequent post-monsoon seasons with pre-monsoon in between (Here after the study period will be expressed as EPOM (Early Post-Monsoon), PRM (Pre-monsoon) and LPOM (Later Post-monsoon) to analyze salinity and chlorophyll-*a* content of water. Sampling couldn't be carried out during monsoon, due to rough weather conditions.

Description of sampling stations:
S1: Lat. 12° 50' 699" N Long. 74° 48' 940" E Mean depth: 7m
S2: Lat. 12° 50' 605" N Long. 74° 47' 948" E Mean depth: 10m

Salinity of water was estimated in the laboratory by following Mohr's method (Strickland and Parsons, 1972) and the results are expressed in psu. Water samples collected for the estimation of chlorophyll-*a* were filtered through 198 µm nylon bolting silk net to remove the grazers. Then a known volume (1000 mL) was filtered immediately through a Millipore membrane filter of 47 mm diameter, having a pore size of 0.45µm by adding two drops of magnesium carbonate suspension during filtration. Particulate matter on the filter paper was extracted with 10 mL of 90% v/v acetone under dark, at low temperatures by keeping over night with periodic shaking. Then the extract was centrifuged for 20 minutes at 2000 rpm. The supernatant was decanted into 1cm path length cuvette, to measure the extinction at different wave lengths *i.e.*, 630, 647, 664 and 750 nm against an acetone blank.

Chlorophyll-*a* concentration was then calculated by using the equation, recommended by Parsons *et al*. (1989) and the values are expressed in terms of µg/L. The absorbance was measured colorimetrically using Spectrophotometer (Systronics UV-VIS Spectrophotometer 119).

Standard Plankton net was used to collect plankton samples. In the laboratory, the plankton samples were again filtered through a 198 µm nylon bolting silk cloth to remove the zooplankton trapped, if any. The filtrate along with the phytoplankton was made up to a known volume (100 mL) and was preserved in Lugol's solution. The 'net phytoplankton' (includes phytoplankton retained after filtration *i.e*., in the size range of 60 µm - 198 µm) present in quadruple aliquots of 1mL from a subsample (25% of total sample) was analyzed both qualitatively, based on morphology following standard keys (Davis, 1955; Bellinger and Sigee, 2010) and quantitatively using Sedgwick Rafter cell and plankton abundance was expressed in number/m3. OLYMPUS - CKX41 (Inverted microscope) and OLYMPUS - CX 21 microscopes were used in the qualitative and quantitative analysis of phytoplankton. Alpha diversity indices of plankton were estimated using Primer Software.

RESULTS AND DISCUSSION

Salinity: Salinity is a dynamic indicator of the nature of the exchange system. Next to light, temperature and nutrients, it is one of the major abiotic factors affecting algal growth and distribution in various habitats. Salinity varied from 9.12 ppt (at station 1) from 19.99 ppt (at station 2) to 34.36 ppt. This observed low salinity at S1 was due to intense precipitation with consequent monsoon driven runoff, due to its close proximity to estuarine mouth region. Except at one instance during the onset of LPOM at S1, much of the study period, coastal shelf waters experienced euhaline nature. The mean salinity at S1 seemed to be 26.04 ppt, while at S2, it was 30.46 ppt. Satpathy *et al*. (2010) reported salinity in the range of 23.38 to 35.97 ppt and Sahu *et al.* (2012) documented salinity ranging from 24.9 to 35.9 for coastal waters of Kalpakkam. Jha *et al.* (2022) reported a mean salinity (31.73 ± 1.52 ppt for coastal waters of Tamil Nadu at Ramanathapuram.

Spatio-temporal variations in the salinity of water are presented in Fig. 1.

Chlorophyll-*a*: One of the most widely accepted methods of expressing biomass of phytoplankton is by way of Chlorophyll-*a* concentration. In studies related to food chains or trophic dynamics, an estimate of standing crop of phytoplankton becomes a prerequisite than that of carbon assimilation, and the chlorophyll indicates the total plant material available in the water at the primary stages of the food chain (Qasim, 1978). In the present study it varied from 1.72 to 5.96 µg/L, with a mean of 3.03 µg/L and from 1.85 to 4.24 µg/L, with a mean of 2.95 µg/L at S1 and S2, respectively. Spatio-temporal variations in chlorophyll-*a* content was represented in Fig. 2**.** Compared to pre-monsoon season, higher values were noticed during post-monsoon season (especially during LPOM), indicating monsoon impact due to land runoff and river fluxes, so only, comparatively higher value was observed at S1, than at S2, because of the closer proximity of the former to estuarine mouth region. Similar trend of monsoonal/post-monsoonal highs and summer (pre-monsoon) lows were reported by Sarangi *et al*. (2008). Satpathy *et al*. (2010) reported chlorophyll *a* ranging from 0.28 to 8.29 µg/L, while Sahu *et al.* (2012) reported it in the range of 1.42 to 7.51 µg/L for coastal waters of Kalpakkam.

The relationship between chlorophyll-*a* and total plankton count is represented through (Linear regression) Fig. 3. The obtained R^2 values revealed that 84% and 57% of the variability in the total plankton count can be explained by the chlorophyll-*a* level, at S1 and S2, respectively.

Phytoplankton dynamics: While the measurement of chlorophyll-*a* is important, it may not necessarily draw out the relationships between primary producers and other organisms higher up the food chain. Changes in community structure and diversity, for example, may alter the food value even though the productivity of the system may remain the same. One method to provide greater insight into food web dynamics is to measure the dynamics of the plankton community. In the coastal shelf waters of Arabian sea, off Mangalore, mesophytoplankton abundance varied from 127600 to 4097800 cells/m^3 and from 168920 to 2086200 cells/m^3 at selected stations S1 and S2, respectively. Their community structure composed of Chrysophyta (45.8% to 95.83% at S1; 55.05% to 95% at S2), Cyanophyta (0% to 32.05% at S1; 0% to 19.67% at S2), Chlorophyta (0% to 2.07% at S1; 0% to 2.77% at S2), Pyrrophyta (4.15% to 23.18% at S1; 4.71% to 41.69% at S2). At both stations, across the seasons the overall abundance of phytoplankton was in the order of Chrysophyta > Pyrrophyta > Cyanophyta > Chlorophyta. A total of 45 genera of mesophytoplankton were recorded from these coastal shelf waters. Of these, Chrysophyta was represented by thirty four (34) genera, Pyrrophyta by eight (8) genera, Cyanophyta and Chlorophyta by two (2) & one (1) genera, respectively.

Top ten phytoplankton genera (based on regularity & dominance) found in these coastal shelf waters include *Chaetoceros, Ceratium, Coscinodiscus, Biddulphia, Ditylum, Helicotheca, Leptocylindrus, Asterionella,* and *Rhizosolenia* spp. at both the stations, besides these nine genera, *Fragilaria* at S1 and *Thalassionema* spp. at S2. Ramesha *et al.* (1992) along the coast of Mangalore also observed the dominance of the *Coscinodiscus* and *Chaetoceros* spp among the centrales and *Pleurosigma* and *Asterionella* spp. among the pennales. Gouda and Panigrahy (1996) also reported the abundance of *Biddulphia*, *Coscinodiscus* and *Chaetoceros* spp in the near shore waters of Gopalapur, Odisha.

Genera wise dynamics of different planktonic groups in the order of S1 and S2 are as follows: Centrales were represented by – the regular/dominant forms of *Biddulphia* (2800 to 215000 cells/m^3 & 3100 to 53800 cells/m^3), *Chaetoceros* (24400 to 2536000 cells/m^3 & 21600 to 757200 cells/m^3), *Coscinodiscus* (4400 to

126000 cells/m^3 & 5400 to 56000 cells/m^3), *Cyclotella* (0 to 7200 cells/m^3 & 0 to 3200 cells/m^3), *Ditylum* (0 to 290000 cells/m^3 & 0 to 138000 cells/m^3), *Helicotheca* (0 to 192000 cells/m^3 & 0 to 250000 cells/m^3), *Leptocylindrus* (0 to 160000 cells/m^3 & 0 to 162000 cells/m^3), *Planktoniella* (0 to 5000 cells/m^3 & 0 to 6400 cells/m^3), *Rhizosolenia* (3800 to 50000 cells/m^3 & 3000 to 84200 cells/m^3), *Triceratium* (0 to 7200 cells/m^3 & 0 to 5800 cells/m^3), *Bacteriastrum* (rare form at S1 & 0 to 8800 cells/m^3), *Lampriscus* (rare form at S1 & 0 to 19200), *Melosira* (rare form at S1 & 0 to 32200 cells/m3), *Skeletonema* (rare form at S1 & 0 to 49200 cells/m3), and rare forms like *Campylodiscus, Climacodium, Eucampia, Guinardia, Hemiaulus, Lauderia, Proboscia, Pseudosolenia, Stephanopyxis* spp. Pennate diatoms were represented by - the regular/dominant forms like *Asterionella* (0-122400 cells/m^3 & 0-140400 cells/m^3), *Fragilaria* (0 to 122000 cells/m^3 & rare form at S2), *Pleurosigma* (1000 to 15200 cells/m^3 & rare form at S2), *Nitzschia* (0 to 3600 cells/m^3 & rare form at S2), *Thalassionema* (0 to 90000 cells/m^3 & 0 to 9800 cells/m^3), Gyrosigma (rare form at S1 & 0 to 9000 cells/m^3), *Nitzschia* (rare form at S1 & 0 to 5000 cells/m^3), *Thalassionema* (rare form at S1 & 0 to 135000 cells/m^3), and rare forms like, *Bacillaria, Pseudonitzschia, Navicula and Tabellaria* spp. Chlorophyta was represented by a single genera *Pediastrum* spp. with rare occurrence at both the stations. At both the stations, Cyanophyta was represented by the dominant form *Trichodesmium* (0 to 6600 cells/m^3 & 0 to 6800 cells/m^3) and a rare form *Merismopedia* spp. Pyrrophyta was represented by the regular/dominant forms like *Ceratium* (12200 to 104000 cells/m^3 & 18700 to 82900 cells/m^3), *Noctiluca* (0-12000 cells/m^3 & 0-6400 cells/m^3), *Preperidinium* (0-6400 cells/m^3 & 0-14400 cells/m^3), *Protoperidinium* (0 to 60000 cells/m^3 & 0 to 19000 cells/m^3), and rare forms like *Akashiwo, Cladopyxis, Dinophysis and Lingulodinium* spp.

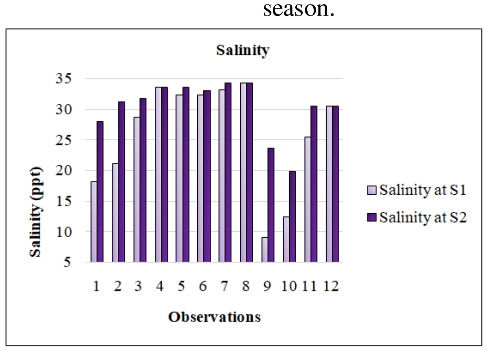
All the coastal species observed in this present study were present in S1. Among the different plankton observed in the present study, *Biddulphia mobiliensis*, *B. sinensis*, *Rhizosolenia imbricata* and *Coscinodiscus spp.* were present continuously throughout the study period. Besides these, *Chaetoceros coarctatus*, *C. decipiens*, *Ceratium fusus, and Pleurosigma* spp. were also present continuously throughout the study period in the Station 1.

Spatio-temporal variability in different planktonic groups based on abundance (as % contribution) is shown in Fig. 4 and plankton community structure at selected stations is shown through Fig. 5.

The phytoplankton community was dominated by chrysophyta followed by pyrophyta. Centrales (82.36% to 95.74% at S1; 69.22% to 96.81%) seemed to be the dominant Chrysophytes at both the stations over that of pennate (4.26% to 17.64% at S1; 3.19% to 30.78% at S2) diatoms. Diatoms (Chrysophyta) are the preferred food of many grazers and organisms in the upper trophic levels and thus form the basis for many of our productive fisheries. The higher relative abundance of diatoms (Chrysophytes) throughout the sampling period could be a consequence of the relatively high silicate concentrations that have been poured into the coastal waters through runoff during monsoon, so only, their abundance seemed to be more during EPOM and LPOM than PRE, besides no competition for this nutrient (silicate) by other counterparts of the plankton community and also could be due to the generally faster growth rate of diatoms. One of the reasons may be due to lower half saturation values of diatoms for nitrates and ammonia uptake, the major limiting nutrient (nitrate) in estuarine and marine waters, thereby they have better ability to utilize low nitrogenous nutrient levels. Other reason may be, high chlorophyll content of diatoms, thereby, high photosynthetic capacity (Langdon, 1988) which resulted in high inherent growth rate. Naik *et al.* (1990); Ramesha *et al.* (1992); Sawant and Madhuprathap (1996); De'Souza (2001); Katti *et al.* (2002) also have recorded the dominance of diatoms (Chrysophytes) along the west coast of India.

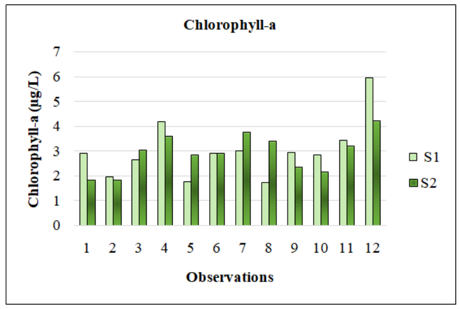
In the present investigation, Cyanophyta of coastal waters was represented by *Trichodesmium erythreum* and *Merismopedia* spp. Among these, *Trichodesmium erythreum* is a marine form, which was observed in all seasons, but *Merismopedia* spp was observed only during post-monsoon season suggesting its passive transport, thereby could have got entered in to the coastal waters through river run-off during monsoon season.

In the present investigation, Chlorophyta of coastal waters was represented by a single species, *Pediastrum duplex* and that to it was observed only during post-monsoon season, which might have advected in to the coastal waters through river run-off during monsoon season.



Observations **1 to 4** represents **EPOM**, **5 to 8** represents **PRM**, **9 to 12** represents **LPOM**

Fig. 1. Spatio-temporal variations in the salinity of water.



Observations **1 to 4** represents **EPOM**, **5 to 8** represents **PRM**, **9 to 12** represents **LPOM**

Fig. 2. Spatio-temporal variations in *chlo-a* content of water.

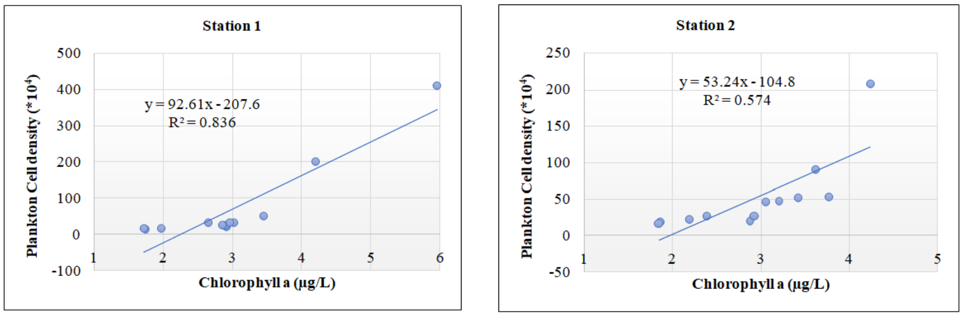
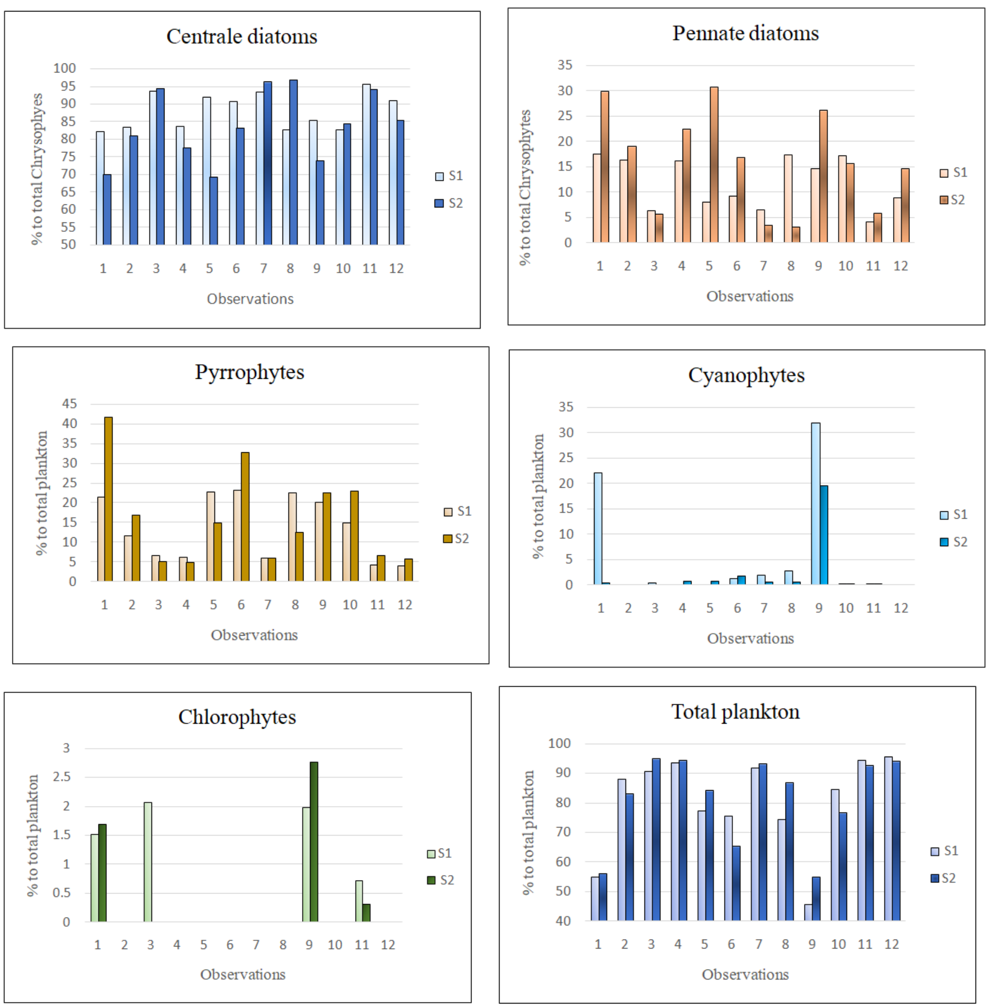
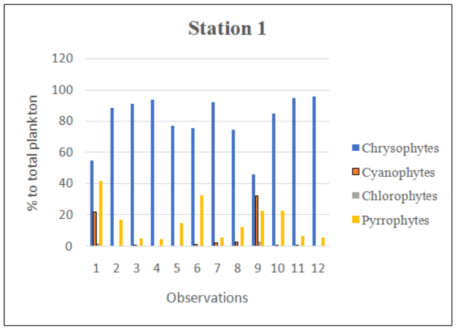


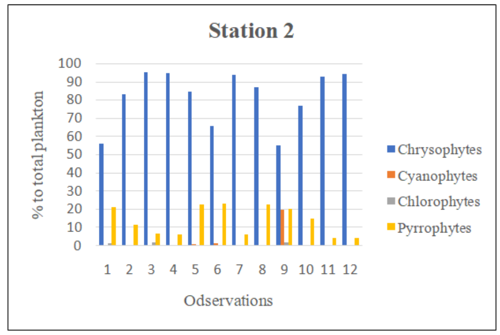
Fig. 3. Linear regression between chlorophyll *a* and total plankton count (as No.*10^4).



Observations **1 to 4** represents **EPOM**, **5 to 8** represents **PRM**, **9 to 12** represents **LPOM**

Fig. 4. Dynamics of different planktonic groups in the coastal shelf waters (Arabian Sea, off Mangalore)





Observations **1 to 4** represents **EPOM**, **5 to 8** represents **PRM**, **9 to 12** represents **LPOM**

Fig. 5. Phytoplankton community structure at selected stations.

CONCLUSIONS

The current study provides valuable insights into the seasonal dynamics and community structure of mesophytoplankton in the coastal shelf waters of the Arabian Sea off Mangalore. The dominance of Chrysophyta throughout the study period, emphasizes the significant role of diatoms in these coastal shelf waters. The observed fluctuations in Cyanophyta and Chlorophyta highlight the influence of freshwater influx on phytoplankton composition. These findings underscore the importance of continuous monitoring of phytoplankton communities as indicators of coastal water quality and ecosystem health. Understanding these dynamics is crucial for managing and conserving the productivity of coastal fisheries, which are directly linked to the health of the phytoplankton populations that form the base of the food web, the present study also will contribute to the valuable information data set on the coastal waters of the west coast of India, for broader understanding of these valuable ecosystems in the face of environmental changes.

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