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Phytoplankton Community Assemblage of Upper Stretches of Nethravati Estuary Dakshina Kannada, Karnataka

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ABSTRACT: To gain a more comprehensive understanding of ecosystem health, it is necessary to assess the diversity and density of its phytoplankton communities, considering changes due to freshwater discharge and tidal influx, since phytoplankton community is highly sensitive and more susceptible to disturbances compared to other organisms, thereby serves as an excellent indicator, hence the present study. Surface water samples and plankton (meso/net plankton) were collected at monthly intervals from upper stretch of Nethravati limb of Nethravati-Gurupur estuary, for a period of 16 months covering post-monsoon, pre-monsoon, monsoon and ensuing post-monsoon. Phytoplankton abundance was in the order of Cyanophyta (0.16% to 93.51%) > Chrysophyta (2.79% to 79.92%) > Chlorophyta (0% to 67.19%) > Pyrophyta (0% to 0.23%). While, generic diversity was in the order of Chrysophyta (24) > Chlorophyta (22) > Cyanophyta (18) > Rhodophyta (1) Pyrophyta (0). Alpha diversity indices of plankton were estimated using Primer software and are as follows: Maegalef's Richness Index (0.47 to 2.15); Pielou's Evenness Index (0.30 to 0.64); Shannon's Diversity Index (0.62 to 2.27). Salinity varied over a wide range from 0.04 psu (monsoon) to 25.62 psu (pre-monsoon), being limnetic during monsoon and early post-monsoon seasons. Chlorophyll-*a*, the main molecule in charge of photosynthesis, varied between 2.95µg/L and 6.86µg/L, thereby indicated the mesotrophic nature of the water.

Keywords: Phytoplankton, Nethravati estuary, salinity, chlorophyll, plankton indices.

INTRODUCTION

Estuaries are transition zones linking freshwater and marine systems, and are therefore characterized by gradients of chemical, physical and biological components in the water column. These gradients strongly influence the spatial and temporal distribution and abundance of phytoplankton in estuaries. Estuaries in India are influenced by monsoonal rainfall, hence they are called monsoonal estuaries (Sarma *et al*., 2014; Ranjith *et al.,* 2017), where clarity of the water plays a major role than nutrients in deciding plankton productivity. They receive land driven nutrients through rivers and these nutrients support rich phytoplankton production in estuaries (Neill, 2005; Chalapathi *et al.,* 2018). The magnitude of river discharge controls the water column stability, residence time, salinity and nutrient composition. Due to these changes, river discharge not only affect phytoplankton biomass but also functional groups of phytoplankton community. The species composition, biomass, relative abundance and their spatial and temporal distribution of this aquatic biota are an expression of the environmental health or biological integrity of a particular water body (Ekwu and Sikoki 2006; Dattatreya *et al.,* 2018). Phytoplankton biomass and community composition are highly dynamic at the land-sea interface where diverse human actions and climate variability intersect to drive complex patterns of change over time (Cloern and Jassby 2008), thereby serve as a key element in assessing the ecological quality status in these transitional waters.

The present investigation was carried out in Nethravati limb of Nethravathi-Gurupur estuary, which is formed by the confluence of the Netravathi and Gurupur river, located in coastal urbanized city Mangalore, India.

MATERIALS AND METHODS

Composite samples were collected from surface waters at monthly intervals for a period of 16 months from the upper stretch of Nethravati estuary at Adyar, covering pre-monsoon, monsoon and post-monsoon seasons to analyze salinity and chlorophyll-*a* content of water. 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).

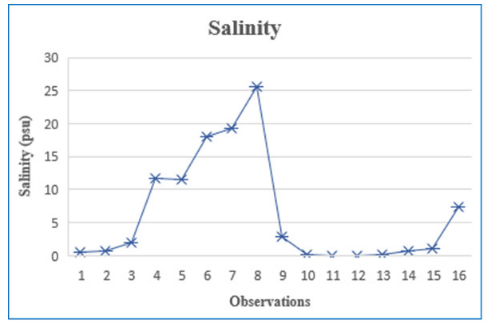
Standard Plankton net was used to collect plankton samples. In the laboratory, the plankton samples were again filtered through a 198 µm nylon bolting silk cloth to remove the zooplankton trapped, if any. The filtrate along with the phytoplankton was made up to a known volume (100 mL) and was preserved 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/m^3. 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: In estuaries where salinity often variable due to tides and river runoff, salinity is one of the key parameters along with nutrients for regulation of phytoplankton abundance and species assemblages.

In the present investigation, majority of the period during monsoon and early post-monsoon seasons, study area witnessed strictly limnetic (<0.5 psu) conditions, indicating almost total flushing of the estuarine water during this period, thereby making the estuary, nearly a freshwater system. Salinity showed a wide variation (25.58 psu) ranging from 0.04 psu (in the monsoon) to 25.62 psu (in the pre-monsoon). Similar type of observations was made by Tripathi (2002) in the waters of Nethravati-Gurupur estuary (1.75 to 32.25 psu), Kumary *et al*. (2007) in Adimalathura estuarine waters (0.007 to 36.27 psu), Martin *et al*. (2008) from Cochin estuary ('0' to 30 psu), Kumar *et al*. (2009) in Tapi estuarine waters (0.11 to 32 psu). In the present investigation, salinity acted as a significant explanatory variable for the observed temporal variability in plankton abundance.

Temporal variations in the salinity of water are presented in Fig. 1.

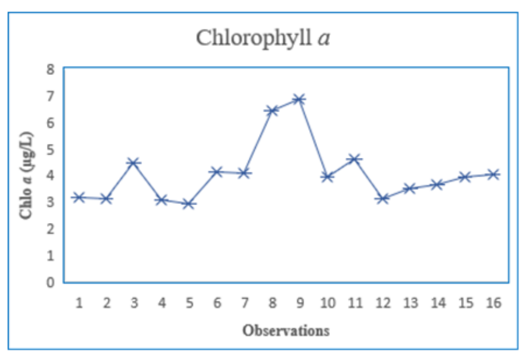


Observations **1 to 4** represents **post-monsoon, 5 to 8** represents **pre-monsoon, 9 to 12** represents **monsoon** and **13 to 16** represents **post-monsoon** seasons respectively.

Fig. 1. Temporal variations in the salinity of water.

Chlorophyll-*a*: Chlorophyll-*a* is an important biochemical component in the molecular apparatus of microalgae that is responsible for photosynthesis. It serves a dual role in oxygenic photosynthesis, *i.e*., in light harvesting as well as in converting energy of absorbed photons to chemical energy. This photosynthetic pigment is present in all species of phytoplankton, including eukaryothic (algae) and prokaryotic organisms (cyanobacteria) and thus it is a reliable and commonly used proxy for total phytoplankton biomass, thereby gives a clue about the trophic status of the water body concerned.

Temporal variations in the Chlorophyll-*a* content were presented in Fig. 2. In the present study it fluctuated between 2.95µg/L and 6.86µg/L, thereby indicated mesotrophic nature, in accordance with Mineeva (2000). Some earlier works that are in line with the present study includes, Chlorophyll-*a* content of Sunderban mangrove estuary, Bangladesh, is 3.09µg/L (Rahaman *et al*., 2013); and that of Godavari mangrove estuary, India, is 12.49µg/L (Tripathy *et al*., 2005). These observed spatio-temporal variations could be conveniently ascribed to a combination of varying light availability and grazing pressure.



Observations **1 to 4** represents **post-monsoon, 5 to 8** represents **pre-monsoon, 9 to 12** represents **monsoon** and **13 to 16** represents **post-monsoon** seasons respectively.

Fig. 2. Temporal variations in chlo-a content of water.

The temporal variations in Chlorophyll-*a* content, coincided by and large, with the respective trend in plankton abundance. The relationship between chlorophyll-*a* and total plankton count is represented through Fig. 3.

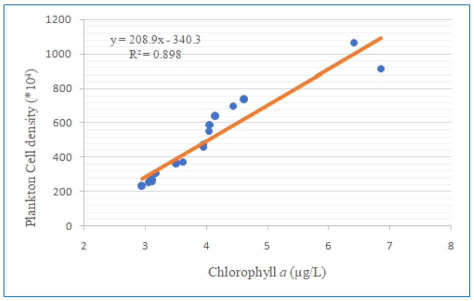


Fig. 3. Linear regression between chlorophyll a and total plankton count (as No.*104).

Phytoplankton community structure. Communities are recognized as recurrent organized systems of organisms responding to changes in the environment and any disturbance in the environment produces changes in many growth variables of an individual, which ultimately leads the community to become reorganized (Smayda, 1963). Phytoplankton community composition is important in establishing ecosystem structure and function. Of the many abiotic factors that influence the growth of phytoplankton community of an estuarine ecosystem, the monsoonal runoff and tidal activity being the major contributors (Cloern, 1996; Sin *et al*., 1999). Higher phytoplankton diversity was observed in the south Indian estuaries than north Indian estuaries due to the long water residence time in the former (Bharathi and Sarma 2019). In the present study, 65 phytoplankton genera were contributed to community structure, and the generic diversity was in the order of Chrysophyta (24) > Chlorophyta (22) > Cyanophyta (18) > Rhodophyta (1) Pyrophyta (0). Phytoplankton biomass in estuaries is controlled by complex biological and chemical processes that control growth and mortality, and physical processes that control transport and dilution. Phytoplankton abundance was in the order of Cyanophyta > Chrysophyta > Chlorophta > Rhodophyta, with complete absence of Pyrophyta.

Top ten phytoplankton genera (based on regularity & dominance) found at this station are *Merismopedia, Hydrodictyon, Aphanizomenon, Coscinodiscus, Desmidium, Spirogyra, Melosira, Pediastrum, Tabellaria and Gomphosphaeria* spp. Among the observed plankton during the present investigation, *Coscinodiscus*, *Tabellaria* spp. were present continuously throughout the study period.

In the present study, **Centrales** were represented by regular/dominant forms like *Campylodiscus* (0 to 48000 cells/m^3), *Coscinodiscus* (6000 to 1980000 cells/m^3), *Melosira* (0 to 1430000 cells/m^3), and by rare forms like *Chaetoceros*, *Cyclotella, Triceratium* spp. While, **Pennales** were represented by the regular /dominant forms like *Bacillaria* (0 to 180000 cells/m^3), *Gyrosigma* (0-44000 cells/m^3), *Nitzschia* (0-12000 cells/m^3), *Pleurosigma* (0 to 18000 cells/m^3), *Tabellaria* (4000 to 290000 cells/m^3), and rare forms like *Asterionella, Fragilaria, Gomphonema, Navicula, Pinnularia, Surirella, Synedra, Thalassionema and Thalassiothrix* spp. **Cyanophyta** was represented by the regular/dominant forms like *Aphanizomenon* (0 to 1280000 cells/m^3), *Gomphosphaeria* (0 to 576000 cells/m^3), *Lyngbya* (0 to 24000 cells/m^3), *Merismopedia* (0 to 7680000 cells/m^3), *Oscillatoria* (0 to 14000 cells/m^3), *Phormidium* (0 to 62000 cells/m^3), *Spirulina* (0 to 16000 cells/m^3), *Stigonema* (0 to 96000 cells/m^3) and rare forms like *Anabaena, Aphanocapsa, Aphanotheca, Coelosphaerium, Gleocapsa, Heterohormogonium, Marssoniella, Microcystis, Nostoc, Trichodesmium* spp. **Chlorophyta** was represented by the regular/dominant forms like *Basicladia* (0 to 36000 cells/m^3), *Closterium* (0 to 40000 cells/m^3), *Desmidium* (0 to 1000000 cells/m^3), *Dichotomosiphon* (0 to 24000 cells/m^3), *Hydrodictyon* (0 to 2000000 cells/m^3), *Mougoetia* (0 to 110000 cells/m^3), *Pediastrum* (0 to 448000 cells/m^3), *Spirogyra* (0 to 864000 cells/m^3) and rare forms like *Actinastrum, Cladophora, Kirchneriella, Microthamnion, Pandorina, Pleurotaenium, Prasinocladus, Scenedesmus, Sirogonium, Sphaerocystis, Spitotaenia, Stigeoclonium, Triploceros, Ulothrix and Zygnema* spp. **Rhodophyta** was represented by single genera *Lemanea* spp (0 to 12000 cells/m^3).

Seasonal variations in the plankton community structure based on abundance was shown in Fig. 4**.** and temporal variations in abundance of plankton taxonomic groups were represented through Table 1, while, Indices worked out on the basis of plankton dynamics were presented in Table 2.

With respect to relative abundance, present investigation revealed that, Cyanophytes overwhelmingly dominated (74.23%) its competent counterparts, *i.e*., Chlorophytes (19.93%) in organizing the plankton community structure during pre-monsoon. Predominance of blue–green algae during this period might be due to the existence of brackish water and stagnant water conditions due to less discharge as opined by Bharathi and Sarma (2019). With change in season from pre-monsoon to monsoon, with respect to cell density, a remarkable decrease in case of cyanophytes (from 74.23% to 56.62%) and increase in case of chlorophytes (from 19.93% to 37.38%) was noticed. Post-monsoon season witnessed a notable increase in chrysophyte abundance (18.58%), whose abundance was only less than 6% during the rest of the seasons. Rhodophytes contribution to total standing crop of plankton was very meagre, *i.e.,* not even contributed to 0.5%, across the seasons.

A stressed environment typically has low diversity and greater representatives from the existing taxa (Gao and Song 2005). As the study area witnessed strictly limnetic conditions (<0.5 ppt salinity) during monsoon and early post-monsoon seasons, thereby transition to ensuing pre-monsoon has created a stressful environment, hence early pre-monsoon witnessed a bloom of *Coscinodiscus* spp., while alone had contributed to 78.26% of total phytoplankton.

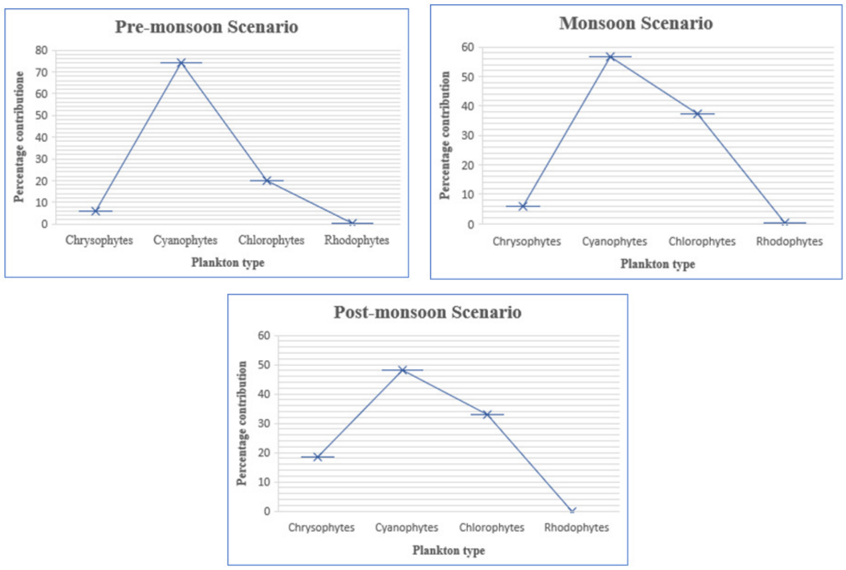


Fig. 4. Seasonal variations in the plankton community structure.

Table 1: Temporal variability in the phytoplankton dynamics (Cells/m^3) of water.

Plankton Taxonomic group / Observation	Centrales	Pennales	Total chrysophytes	Cyanophytes	Chlorophytes	Rhodophytes	Total phytoplankton
1	38000	144000	182000	1896000	954000	4000	3036000
2	140000	12000	152000	1276000	1268000	2000	2698000
3	892000	44000	936000	5888000	130000	0	6954000
4	2004000	18000	2022000	4000	504000	0	2530000
5	96000	54000	150000	2160000	0	0	2310000
6	124000	144000	308000	5442000	632000	4000	6386000
7	408000	90000	558000	2796000	2508000	10000	5872000
8	300000	72000	432000	8310000	1884000	10000	10636000
9	102000	180000	382000	6044000	2684000	12000	9122000
10	50000	110000	300000	2638000	1606000	6000	4550000
11	140000	352000	632000	3028000	3688000	4000	7352000
12	42000	30000	72000	1658000	848000	6000	2584000
13	12000	118000	130000	1964000	1518000	6000	3618000
14	6000	122000	128000	1084000	2482000	0	3694000
15	36000	408000	564000	1724000	2446000	0	4734000
16	1568000	406000	1974000	1980000	1532000	0	5486000

Observations 1 to 4 represents **post-monsoon**, 5 to 8 represents **pre-monsoon**, 9 to 12 represents **monsoon** and 13 to 16 represents post-monsoon seasons respectively.

Table 2: Temporal variations observed in the plankton indices of water (upper stretch of Nethravati estuary).

Observations / Plankton indices	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Margalef's Richness Index	2.01	1.08	1.46	0.47	1.16	1.79	1.80	1.85	1.50	1.89	2.15	1.49	1.59	1.12	1.43	1.55
Pielou's Evenness Index	0.53	0.60	0.40	0.30	0.53	0.35	0.57	0.35	0.50	0.55	0.64	0.61	0.57	0.57	0.61	0.63
Shannon's Diversity Index	1.83	1.71	1.27	0.62	1.54	1.18	1.90	1.21	1.61	1.86	2.27	1.91	1.85	1.65	1.91	2.04

Observations 1 to 4 represents post-monsoon, 5 to 8 represents pre-monsoon, 9 to 12 represents monsoon and 13 to 16 represents post-monsoon seasons respectively.

CONCLUSIONS

Salinity played a pivotal role in shaping the temporal variability and distribution of phytoplankton populations, as this estuarine system exhibited distinct seasonal patterns, with a marked influence of monsoonal runoff and tidal activity on phytoplankton community structure. Cyanophytes, Chrysophytes, and Chlorophytes were the dominant groups, with Cyanophytes overwhelmingly dominating during pre-monsoon. The observed mesotrophic nature of the water, indicated by Chlorophyll-*a* concentrations, suggests that the estuary maintains moderate productivity levels. This finding is significant as it indicates that the estuary is not undergoing eutrophication, instead, it appears to be balanced, with nutrient inputs being moderated by tidal exchanges and monsoonal flushing. But, season's transition from post-monsoon to pre-monsoon witnessed stressful conditions, indicated by the bloom of *Coscinodiscus* spp., contributing to 78.26% of total phytoplankton.

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