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Seasonal distribution of phytoplankton in Nethravathi estuary, Mangalore

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Abstract

The variations of phytoplanton with reference to abundance and distribution have been studied in relation to temperature, salinity and nutrients in the Nethravathi estuary. Trimodal distribution pattern of phytoplankton was observed with higher production during May, June July and Nov. - Dec. The phytoplankton biomass varied between 1132 and 65514 cells/m³ . Diatoms were the major components of phytoplankton followed by green algae, dinoflagellates, blue green algae and silicoflagellates. Green algae were more abundant during the periods of low temperature and salinity while diatoms, dinoflagellates and blue green algae were relatively higher during higher temperature conditions and salinity.

Introduction

Phytoplankton form the prime component in the food chain of an aquatic ecosystem. Species of phytoplankton vary in their dominance and diversity due to changing physicochemical and biological factors. Information on phytoplankton composition, distribution, spatiotemporal variations, abundance and succession from the estuaries of India are available (Gopinathan, 1972, 1975; Joseph and Pillai, 1975; Santhanam, 1976; Thangaraj, 1984; Jayalakshmi *et.al.*, 1986; Edward and Ayyakkannu, 1991; Murugan and Ayyakkanu, 1993; Mishra and Panigrahy, 1995; Tiwari and Nair, 1998). Information of the hydrography and nutrient dynamics of Nethravathi estuary is available (Bhat, 1979; Reddy. *et. al.*, 1979; Sahu, 1981; Reddy *et. al.*, 1991 and Reddy and Hariharan, 1995), but the information on phytoplankton abundance and distribution is rather meagre. Hence the present investigation was undertaken to study the seasonal variation, distribution, species composition and abundance of phytoplankton and the influence of selected physico-chemical parameters in the Nethravathi estuary.

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Meterial and methods

Nethravathi river takes birth in the western ghats and flows westerly, joins Gurupur river before draining into the Arabian Sea near Old Mangalore Port (12° 50 'N and 74° 50 'E). It has an intrusion length of 19 km with an average depth of 2m except at the confluence where a depth of 7 m during high tide has been reported. Estuary receives large quantity of freshwater laden with high volume of suspended materials during south west monsoon season. The estuary is characterized by mixed type of diurnal tides (Reddy, *et.al.*, 1979) and on the basis of salinity fluctuation and the circulation pattern, the estuary is grouped as a well mixed type.

The area investigated includes the lower part of the estuary, which is navigable, extending between the confluence at the Light House at old Bunder and Bajal towards upper stretch of the estuary (Fig.1). Monthly samples were collected from the fixed stations during high tide using a dinghy with outboard engine for 16 months from Feb. 1993 to May 1994. Net phytoplankton samples were collected (horizontal) by using Heron - Tranter net (64μm mesh size). The samples were preserved in 4% formalin. Phytoplankton were identified to their species level and counted using inverted microscope. Environmental parameters - temperature, salinity and nutrients - nitrate-N and phosphate-P were determined by following standard methods (Strickland and Parsons, 1972 and Parsons *et.al.*,1989).

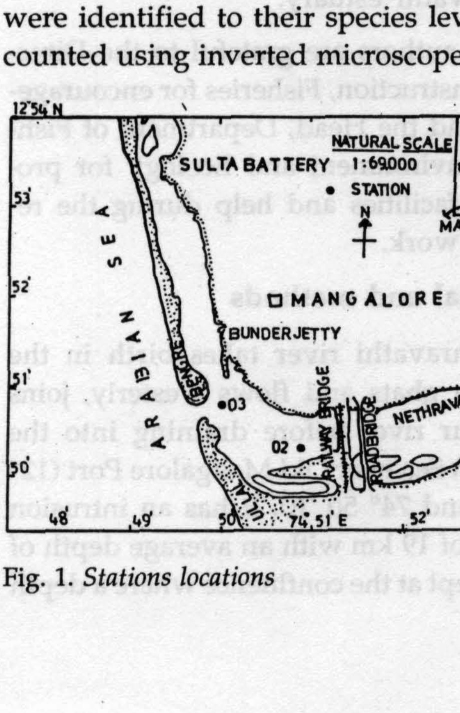

Fig. 1. *Stations locations*

Results

Seasonal and spatial variation of phytoplankton cell counts are presented in the Fig. 2. The phytoplankton density varied between 1132 and 65514 cells/m^3. The distribution of phytoplankton showed a trimodal pattern with higher biomass during May, June - July and Nov - Dec in the Nethravathi estuary. While, lower numbers were recorded during Sept - Oct and March - April.

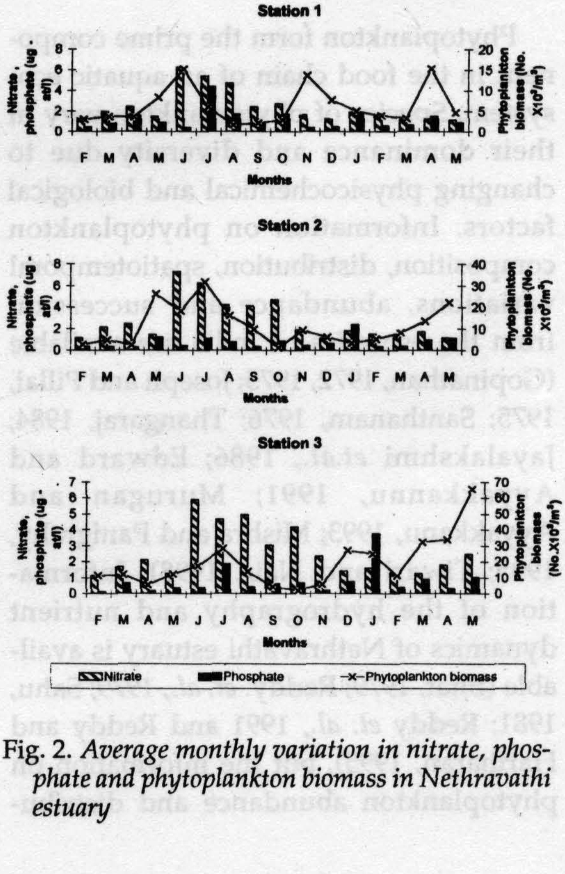

Fig. 2. *Average monthly variation in nitrate, phosphate and phytoplankton biomass in Nethravathi estuary*

Phytoplankton crop was mainly contributed by 5 important groups. viz. diatoms, dinoflagellates, green algae, blue green algae, and silicoflagellates (Fig. 3). Qualitative composition of phytoplankton indicated a total of 58 species of which 35 were diatoms, 9 dinoflagellates, 8 green algae, 5 blue green algae and 1 silicoflagellate in the Nethravathi estuary (Table 1). Diatoms were the major components of the total phytoplankton and their population ranged between 324 - 33147 cells/m^3 and their biomass was high during pre-and postmonsoon seasons and low during monsoon period. Blooms of diatoms were observed during April to June and Nov. in the estuary. Species of *Ceratulina bergonii, Nitzschia sigma, N. closterium, Chaetoceros loranzianus, C. curvisetus, Rhizosolenia styliformis* and *Streptotheca indica* were common during April - May. *Thallassionema nitzchioides* during June - July and *Nitzschia seriata, Chaetoceros curvisetus, C. indicus, C. loranzianus* and *Ceratulina bergonii* in Nov. - Dec.

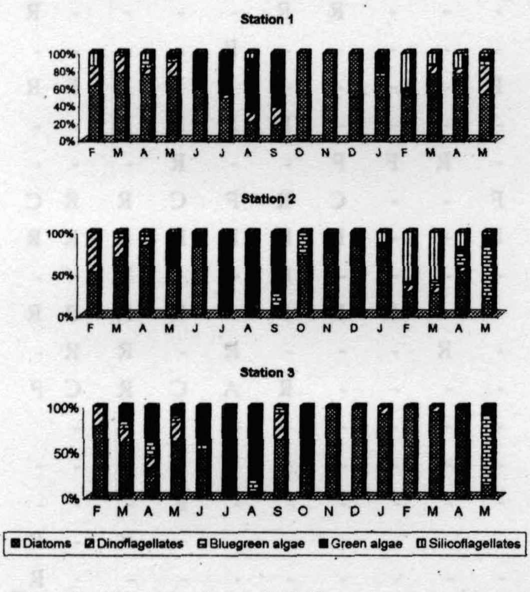

Fig. 3. *Distribution of different groups of phytoplankton at different stations in Nethravathi estuary*

The green algae were important groups and were dominant only during monsoon and early postmonsoon periods. Their population varied between 128 - 30277 cell/m^3.The blooms of green algae were observed during June - July, mainly contributed by species of *Mougoetia, Spirogyra, Ulothrix* and *Zygnema*.

The blue green algal population fluctuated between 52 and 50500 cells/m^3.They were dominant during premonsoon and absent or less conspicuous during monsoon and postmonsoon periods. They formed blooms during the month of April - May by *Oscillatoria* sp.

The dinoflagellates varied between 112 - 2551 cells/m^3. Their population was high and consistent during premonsoon season and blooms formed during March and May by species of *Ceratium furca, C.fusus* and *Peridinium depressum*.

Silicoflagellates were high during Feb., March and April mainly contributed by *Dictoyocha fibula*. Their population varied between 92 to 4621 cells/m^3.

Only few species of phytoplankters ocurred during most part of the year. The relative abundance of 11 most common form of diatom are presented in Table 2. Species of *Ceratulina bergonii, Chaetoceros curvisetus, Biddulphia mobiliensis, Rhizosolenia styliformis* and *Ceratium fusus* were

Table 1. *Species composition of phytoplankters in Nethravathi estuary.*

Phytoplankton	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
BACILLARIOPHYCEAE																
1. *Amphiprora gigantea*	-	-	R	R	R	R	R	R	R	R	-	-	R	R	R	-
2. *Asterionella japonica*	R	-	-	-	-	-	-	-	-	-	R	-	-	-	R	C
3. *Bacillaria paradoxa*	-	-	-	-	-	-	-	-	-	R	R	-	-	-	-	
4. *Bellerochea malleus*	-	R	-	R	R	R	-	-	-	R	R	-	-	-	-	-
5. *Bacteriastrum hyalinum*	R	-	R	-	R	-	-	-	-	-	-	-	-	R	-	-
6. *Biddulphia mobiliensis*	R	C	R	C	-	-	-	-	-	-	-	R	R	R	R	A
7. *Ceratulina bergonii*	C	R	R	R	-	-	-	-	-	C	A	C	C	A	A	A
8. *Chaetoceros curvisetus*	-	R	C	F	-	-	-	-	-	A	A	C	F	A	C	F
9. *C. decipens*	R	R	F	F	-	-	R	R	-	-	-	-	R	R	-	R
10.*C. lorenzianus*	-	-	-	C	-	-	-	-	-	C	C	R	R	C	R	R
11.*C. indicus*	-	-	-	-	-	-	-	-	-	C	C	R	-	C	-	-
12.*Coscinocira polychorda*	R	R	R	-	-	-	-	-	-	-	-	-	R	R	R	R
13.*Coscinodiscus occculus - iridis*	C	F	C	C	F	-	-	C	A	R	R	C	R	F	C	R
14.*C. marginatus*	C	R	R	R	R	-	-	R	-	-	R	R	-	-		
15.*C. granii*	R	R	R	F	R	F	R	-	F	-	-	-	R	R	-	-
16.*C. perioratus*	R	R	-	R	F	-	R	-	-	-	F	-	R	R	-	R
17.*Fragillaria intermedia*	-	-	-	F	R	-	R	-	-	-	R	-	-	R	-	R
18. *Hemidiscus hardmannianus*	-	-	R	R	-	-	-	-	-	R	R	-	-	-	-	R
19.*Leptocylindricus danicus*	-	-	R	R	R	-	-	-	-	-	-	R	-	-	-	-
20.*Navicula membranacea*	-	-	-	-	-	-	R	-	-	-	-	-	-	R	F	R
21.*Nitzchia closterium*	R	R	-	-	-	-	-	-	-	-	R	R	R	R	-	-
22.*N. longissima*	R	F	R	-	-	-	-	R	F	F	-	-	R	-	-	-
23.*N. seriata*	-	-	-	R	R	R	F	-	-	C	R	F	C	R	R	C
24.*N. sigma var indica*	-	-	-	R	R	-	R	-	-	R	R	R	F	R	R	R
25.*Pleurosigma directum*	R	R	-	F	F	R	-	-	-	-	R	-	-	R	-	-
26.*P. elongatum*	-	R	R	R	F	C	-	-	R	R	-	-	R	R	R	R
27.*Rhizosolenia alata*	-	R	-	R	-	-	-	R	-	-	-	R	-	R	R	-
28.*R. styliformis*	R	C	R	R	-	-	-	-	-	-	R	A	C	R	C	F
29.*Skeletonema costatum*	-	-	-	R	-	-	-	-	-	-	-	-	R	-	-	
30.*Streptotheca indica*	-	-	-	R	R	-	-	-	-	-	-	-	-	-	-	-
31.*Synedra formosa*	R	-	-	-	-	R	-	-	-	-	-	-	R	-	-	-
32.*Thallasosiosira decipens*	-	-	-	R	F	-	-	-	-	-	-	-	-	R	-	R
33.*T. subtilis*	-	-	R	R	R	-	-	-	-	-	-	-	-	-	-	R
34.*Thallassionema nitzschiodes*	R	R	R	R	C	-	-	-	-	-	-	C	F	R	R	F
35.*Thallassiothrix longissima*	-	-	-	R	R	R	-	-	-	-	R	-	-	-	-	-

DINOPHYCEAE																
1. *Ceratium furca*	R	R	F	C	-	-	R	R	-	-	R	R	-	R	F	F
2. *C.tripos*	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. *C.fusus*	F	F	R	F	-	-	-	-	-	-	-	C	R	F	R	F
4. *C. macroceros*	-	-	-	R	R	R	-	-	-	-	-	-	-	-	-	R
5. *Dinophysis miles*	-	R	F	R	-	-	-	-	-	R	R	-	-	-	R	-
6. *D caudata*	-	R	-	R	R	F	-	R	-	R	-	-	-	R	-	-
7. *Peridiniuim depressum*	R	F	R	-	-	-	C	F	R	-	-	-	R	R	R	-
MYXOPHYCEAE																
1. *Anabaena* spp.	-	-	R	R	-	-	-	-	-	-	-	R	-	-	-	-
2. *Nostoc* spp.	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R	-
3. *Oscillatoria* sp.	-	R	R	R	R	-	F	F	-	R	-	-	-	R	-	C
4. *Trichodesmium theibautii*	F	R	-	R	-	-	-	-	-	-	-	-	-	R	-	R
5. *Spirulina major*	-	-	-	-	-	-	-	-	-	-	R	-	R	-	-	-
CHLOROPHYCEAE																
1. *Cylindrocytis* sp.	-	-	-	-	-	R	-	-	-	-	-	R	R	-	-	R
2. *Cylindrocytis* sp.	-	-	-	C	-	R	-	-	-	-	-	-	-	-	-	-
3. *Microspora* sp.	-	-	-	-	-	-	-	C	-	-	-	R	-	-	-	F
4. *Mougoetia* sp.	-	-	-	-	R	C	R	R	R	-	-	R	-	-	-	-
5. *Netrium* sp.	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R
6. *Spirogyra* sp.	-	-	-	-	R	C	-	R	R	F	R	-	-	-	-	-
7. *Ulothrix* sp.	-	-	-	R	C	A	F	-	-	-	-	R	-	-	-	C
8. *Zygema* sp.	-	-	-	R	-	C	-	-	-	-	-	R	-	-	-	-
SILICOFLAGELLATES																
Dictyocha fibula	R	R	-	R	-	R	R	-	-	-	-	-	C	C	C	-

A-Abundant > 5000 cells/m³ C-Common > 1000 cells/m³

F - Few >500 cells / m³ R - Rare < 500 cells/m³ - Absent

more dominant during premonsoon period while *Coscinodiscus occulus iridis*, *Ceratium furca* and *Peridinium depressum* were present throughout the year in the Nethravathi estuary.

The relationship between phytoplankton biomass and essential plant nutrients - nitrate and phosphate are presented in Fig. 2. Water temperature varied between 24.2 and 31.8°C (Fig.4). During the period of peak phytoplankton biomass, temperatures recorded were 31.6 - 32.1°C (May), 25.4 - 27.1°C (June - July) and 26.4 - 27.9° C (Nov. - Dec.). During the same corresponding period salinity values were observed to be 26.3 - 31.6 ‰ (May), 0.5 - 2.4‰ (June - July) and 3.4 - 21.9 ‰ (Nov. - Dec.) respectively. Salinity values fluctuated between 0.5 to 31.6‰ in Nethravathi estuary.

Nitrate-nitrogen varied between 1.1 and and 7.28 µg - at/l and higher concentrations were recorded during monsoon and lower during April - May and Nov. - Dec.

Table 2: *Seasonal variation in most common phytoplankters (cells/m³)*

Months	*Ceratulina bergonii*	*Coscino-discus*	*Chaetoceros curvisetus occulus-iridis*	*Biddulphia mobiliensis*	*Nizschia seriata*	*Rhizo-solenia styliformis*	*Pleuro-sigma elongatum*	*Thallassio-nema nitzschioides*	*Ceratium furca*	*C.fusus*	*Peridinium depressum*
Feb, 1993	2066	1276	-	128	-	339	-	416	122	984	314
Mar	405	782	328	1148	-	1553	304	375	378	608	560
April	432	1200	1431	193	-	355	50	162	511	210	152
May	378	1200	608	1243	324	91	353	365	3327	674	-
June	-	602	-	-	189	-	945	4306	-	-	-
July	-	-	-	-	281	-	2410	-	-	-	-
Aug	-	-	-	-	689	-	-	-	454	-	1458
Sept	-	1166	-	-	-	-	-	-	450	-	526
Oct	-	6221	-	-	-	-	315	-	-	-	129
Nov	1028	71	8481	-	1281	-	315	-	-	-	-
Dec	47205	334	24301	-	352	310	-	-	122	-	-
Jan,1994	3274	3812	2695	120	1841	5100	-	2460	120	1140	-
Feb	3066	486	729	182	1692	1378	365	778	718	115	160
Mar	11238	513	13762	401	54	459	118	229	918	504	429
April	123510	1054	3328	323	388	1488	217	378	528	232	189
May	68371	446	581	5670	1188	815	144	603	830	804	

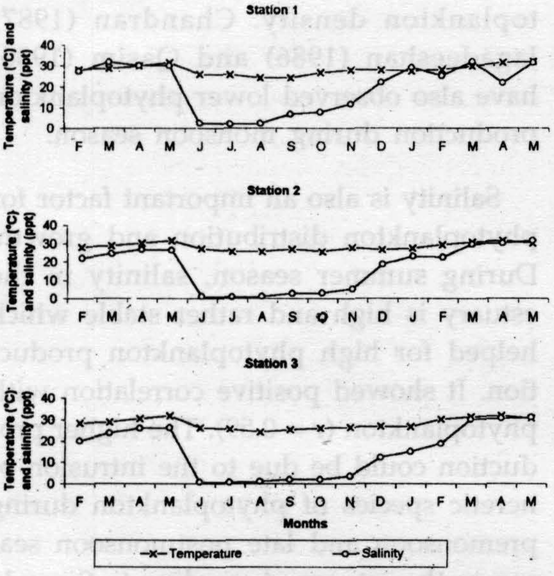

Fig. 4. *Average monthly variation in temperature and salinity in Nethravathi estuary*

coinciding with higher production of phytoplankton. Phosphate-phosphorus was always lower than nitrate-nitrogen and varied between 0.10 - 4.32 µg-at/1. Higher concentration was recorded during monsoon and postmonsoon period. Lower values coincided with the period of peak production of phytoplankton.

Discussion

Phytoplankton are the dominant primary producers, mainly composed of diatoms, green algae, blue green algae, dinoflagellates and silicoflagellates. Phytoplankton population was more during pre - and postmonsoon seasons and lower during monsoon period. However, some peaks observed during monsoon were due to green algae. Similar observations were made in Cochin backwaters by Gopinathan (1972), Devassy and Bhattathiri (1974), in Mulki estuary, by Edward and Ayyakkannu (1991). The higher density during pre-and post-monsoon is attributed to stability of water, less turbidity and improved light condition.

High species diversity was observed during pre-and postmonsoon seasons. In Vellar estuary, Perumal *et.al.*, (1999) and in Kollidam estuary, Edwards and Ayyakkannu (1991) have made similar observations. Dominance of diatoms, dinoflagellagtes, blue green algae and silicoflagellates during pre- and postmonsoon periods and dominance of green algae only during monsoon period was observed. The dominance of diatoms, dinoflagellates and silicoflagellates during pre- and postmonsoon was common in the estuaries of India (Devassy and Bhattathiri, 1974; Joseph and Pillai, 1975; Jagadeeshan, 1986; Jayalakshmi *et. al.*, 1986; Murugan and Ayyakkanu, 1993; Mishra and Panigrahy, 1995 and Tiwari and Nair, 1998). Dominance of green algae was observed during monsoon period indicating the freshwater algae are present only in the low saline waters (Devassy and Bhattathiri, 1974; Joseph and Pillai, 1975; Patnaik and Sarkar, 1976 and Reddy and Gupta, 1988).

The fluctuations in the phytoplankton densities was due to changes in temperature, salinity, light, turbidity and nutrients (Dehadrai, 1970; Thangaraj, 1984; Chandran, 1987; Roden *et al.*, 1987; De *et. al.*, 1991; Tiwari and Nair, 1998). The high density of phytoplankton during postmonsoon was due to the great adaptability of phytoplankton to utilize the dissolved nutrients, temperature and light conditions. The peak phytoplankton biomass coincided with the periods of temperature and light conditions. The peak phytoplankton biomass coincided with the periods of low nutrient concentration. Qasim (1980), Murugan and Ayyakkannu (1993) and Jagadeeshan (1986) have observed similar phenomena in Cochin backwaters, Cuddalore, Uppanan backwater and Coleroon estuary and attributed the lowering of concentration due to utilization by phytoplankton. The lower phytoplankton production coincided with higher concentration of nitrate-nitrogen. Owens *et al.*, (1986) opined that light and nutrient availability are fundamental variables responsible for phytoplankton growth. On the contrary, Ketchum (1947) showed that the nutrients do not have direct bearing on phytoplankton density as nutrients could not be replaced due to regeneration and exchange from bottom waters to surface waters. In the present study, nitrate and phosphate did not show total depletion at any time. Therefore, nutrients did not act as limiting factors for phytoplankton production.

The variation in temperature showed a positive correlation with phytoplankton density (r = 0.59). The higher temperature during pre- and postmonsoon coincided with high density of phytoplankton and *vice versa* during monsoon season. The same relationship was observed by Thangaraj (1984) Jagadeeshan (1986) and Qasim (1980). The lower temperature during monsoon due to cloudy sky and rainfall were responsible for lower phytoplankton density. Chandran (1987) Jagadeeshan (1986) and Qasim (1980) have also observed lower phytoplankton production during monsoon season.

Salinity is also an important factor for phytoplankton distribution and growth. During summer season, salinity in the estuary is high and rather stable which helped for high phytoplankton production. It showed positive correlation with phytoplankton (r = 0.59). The higher production could be due to the intrusion of neretic species of phytoplankton during premonsoon and late postmonsoon season in the estuary. According to Smayda (1970) high salinity favours phytoplankton abundance. The lower population during monsoon season was due to inflow of large quantity of freshwater into the estuary with higher turbidity. However, some species of diatoms, green and blue green algae such as species of *Oscillatoria, Spirogyra, Anabaena, Maugoetia, Ulothrix, Cylindrocystis, Zygnema, Amphipora, Coscinodiscus, Pleurosigma* and *Thallassionema* were present during the monsoon period. Dominance of freshwater species was also observed by Joseph and Pillai (1975), Edward and Ayyakkannu (1992) and Murugan and Ayyakkannu (1993).

It can be concluded that species diversity of phytoplankton biomass was maximum during pre-and postmonsoon period and minimum during monsoon period in the estuary. The phytoplankton distribution, species composition and dominance are closely associated with the prevailing hydrographic parameters and nutrients.

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