

Ecology of phytoplankton from Dharamtar creek, west coast of India

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Phytoplankton pigment, cell count and species diversity were studied at five locations in Dharamtar creek during September 1984 to November 1985. Chemical parameters indicated a healthy system free of any environmental stress. The water was vertically mixed except during the monsoon period and nutrients never became a limiting factor for phytoplankton production. Concentration of chlorophyll *a* and phaeophytin were fairly high, (av. 1.94 and 1.89 mg m⁻³ respectively). A total of 58 genera of phytoplankton comprising 46 diatoms, 6 dinoflagellates and 6 other algae were recorded from the area. *Thalassiosira* dominated the phytoplankton community. In the interior part of the creek blooms of *Skeletonema* and *Peridinium* were respectively observed during October-November and December. Correlation between chlorophyll *a* and cell count was significant while there was no correlation between phytoplankton and different physico-chemical parameters. Margalef's diversity index *D* varied from 1.14 to 4.93 with higher diversity towards the outer than the interior zone. In general the creek sustained a rich and diverse phytoplankton community.

Information on phytoplankton around the coast of Bombay is meagre. Variation in seasonal composition of plankton for the Bombay harbour was reported¹ while primary productivity study of the area was done by Krishnamurthy & Vishwanathan². The study of phytoplankton from polluted and unpolluted environments³ included a few locations off Bombay. Later Lodh⁴ carried out extensive studies on phytoplankton from Bombay harbour – Thana – Bassein system. However, there is no information on phytoplankton from Dharamtar creek, a major estuaries system adjoining the Bombay harbour. The contribution of the creek system in terms of phytoplankton to the bioproductivity potential of the nearshore waters of Bombay is significant. The present study, in addition to rendering information on ecological characteristics of phytoplankton communities will also help in providing baseline information for future monitoring of the system considering the industrial growth around the creek.

Materials and Methods

Five stations were selected within a stretch of about 30 km from Bombay harbour to Dharamtar

located between lat. 18°42'11" - 18°51'52" N and long. 72°51'29" - 73°01'42" E (Fig. 1). This covers the segments where influence of rain water is negligible (sts 1, 2) as well as the mid-interior estuarine area (sts 3-5) predominantly influenced by the tide. Depth in the area varied from 2.5 to 14 m. Based on the water quality characteristics, sts 1 and 2 were denoted as outer zone and sts 3-5 as interior zone. Water samples for selected physico-chemical parameters, phytoplankton and pigments were

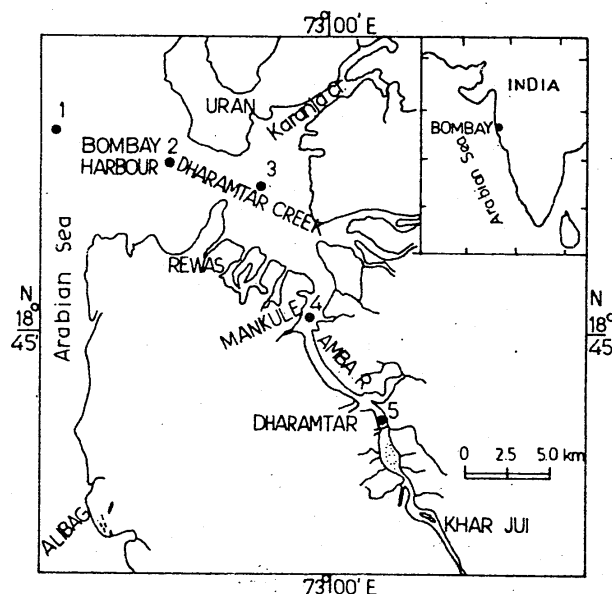


Fig. 1—Map showing the location of the stations.

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collected from the surface and bottom using clean plastic bucket and Niskin water sampler respectively. Sampling was done every month during September 1984 to November 1985. Physico-chemical parameters were analysed following standard methods⁵⁻⁷.

Chlorophyll *a* and phaeophytin were estimated in 500 ml water samples following the standard methods⁶. Qualitative and quantitative enumeration of phytoplankton was carried out adopting Lugol's iodine technique⁸. The cell count was done using a Sedgwick Rafter counting chamber. Identification of phytoplankton was done as per Subramanyan⁹, Desikachari¹⁰ and Nair¹¹. Phytoplankton diversity indices Shannon & Weaver¹² *H* and Margalef's *D*¹³ were calculated. Regression values were calculated and significance of values were presented at 5 and 1% levels¹⁴.

Results and Discussion

Abiotic features of Dharamtar creek were influenced mainly by the tides and monsoons of the tropics. Some of the parameters showed wide temporal and spatial variations (Table 1). Temperature varied from 23.6 to 33.6°C the average being 27.8°C. The pH variation was in a narrow range of 7.48 - 8.37 (av. 7.76). Relatively low values were obtained during monsoon due to influence of riverine flow. Salinity variation was well marked ranging from almost freshwater (0.07×10^{-3}) to high saline condition (37.99×10^{-3}). During premonsoon period, the entire water column was homogeneous due to limited influence of freshwater and the creek was completely tide dominated. With the onset of monsoon, the creek became freshwater dominated due to influx of freshwater from Amba river. Salt wedge formation was also noticed near the mouth during peak monsoon period and salinity decreased to almost freshwater condition at sts 4 and 5. During postmonsoon period, the stratification was broken as the creek became tide dominated. Fairly high level of DO (3.02 - 6.32 ml l⁻¹; av. 4.25 ml l⁻¹) and low level of BOD (0.22 - 3.6 ml l⁻¹; av. 1.34 ml l⁻¹) indicated effective assimilation of organic load leading to good water quality of the system. Phosphate concentration fluctuated between 0.44 and 3.60 µg-at l⁻¹ (av. 1.82 µg-at l⁻¹). Nitrite, nitrate and ammonia showed variations with respective

ranges of 0.10 - 3.1 (av 0.88), 0.97 - 42.38 (av 16.1) and 0.10 - 6.8 (av 1.52) µg-at l⁻¹. In general, the difference in the concentration of nutrients between outer and interior zones was limited except for nitrate, the level of which were higher at the interior locations.

Chlorophyll *a* and phaeopigments

Dharamtar creek maintained fairly high concentration of chlorophyll *a* ranging between 0.53 and 6.4 mg m⁻³ (av. 1.94 mg m⁻³). The maximum value of chlorophyll *a* was recorded at st 3 from the bottom water during September'85 which coincided with the highest cell count of phytoplankton (1414×10^3 l⁻¹) recorded for that station (Fig. 2). This was also associated with the bloom of *Skeletonema costatum* (902.4×10^3 l⁻¹). There was gradual increase in chlorophyll *a* from the outer part towards the interior of the creek, the ratio being 1.8:2.1. Some of the important physico-chemical factors which regulate chlorophyll *a* concentration include nitrate flux and vertical stability¹⁵. The water column within the creek system was vertically well mixed except during monsoon period and nutrients never became a limiting factor in Dharamtar creek. The correlation between chlorophyll *a* to phytoplankton cell count and nutrients were not significant suggesting that instantaneous concentration of these nutrients was not influencing production of phytoplankton. The ratio of surface and bottom chlorophyll *a* (0.98) was comparable with that obtained for phytoplankton (0.8) suggesting comparable production rate.

The trend in the distribution of phaeophytin was comparable with that of chlorophyll *a*. However, the zone between st 1-3 maintained higher values of chlorophyll *a* than the phaeophytin while the area between 4-5 showed a reverse trend. The biological processes which influence the spatial distribution of chlorophyll are phytoplankton production, cellular senescence and zooplankton grazing¹⁶. The chemical (H⁺ and/or enzyme) environment associated with the zooplankton digestive system is capable of stoichiometrically converting chlorophyll *a* to phaeophytin and then to phaeophorbide *a*¹⁷. Hence, elevated level of phaeophytin could indicate enhanced zooplankton grazing activity. Inside the creek, the fringing mangrove vegetation must also have added to relatively high phaeophytin values.

Table 1—Variations in different physico-chemical and biological parameters of surface and bottom waters. (Values in parentheses are mean values).

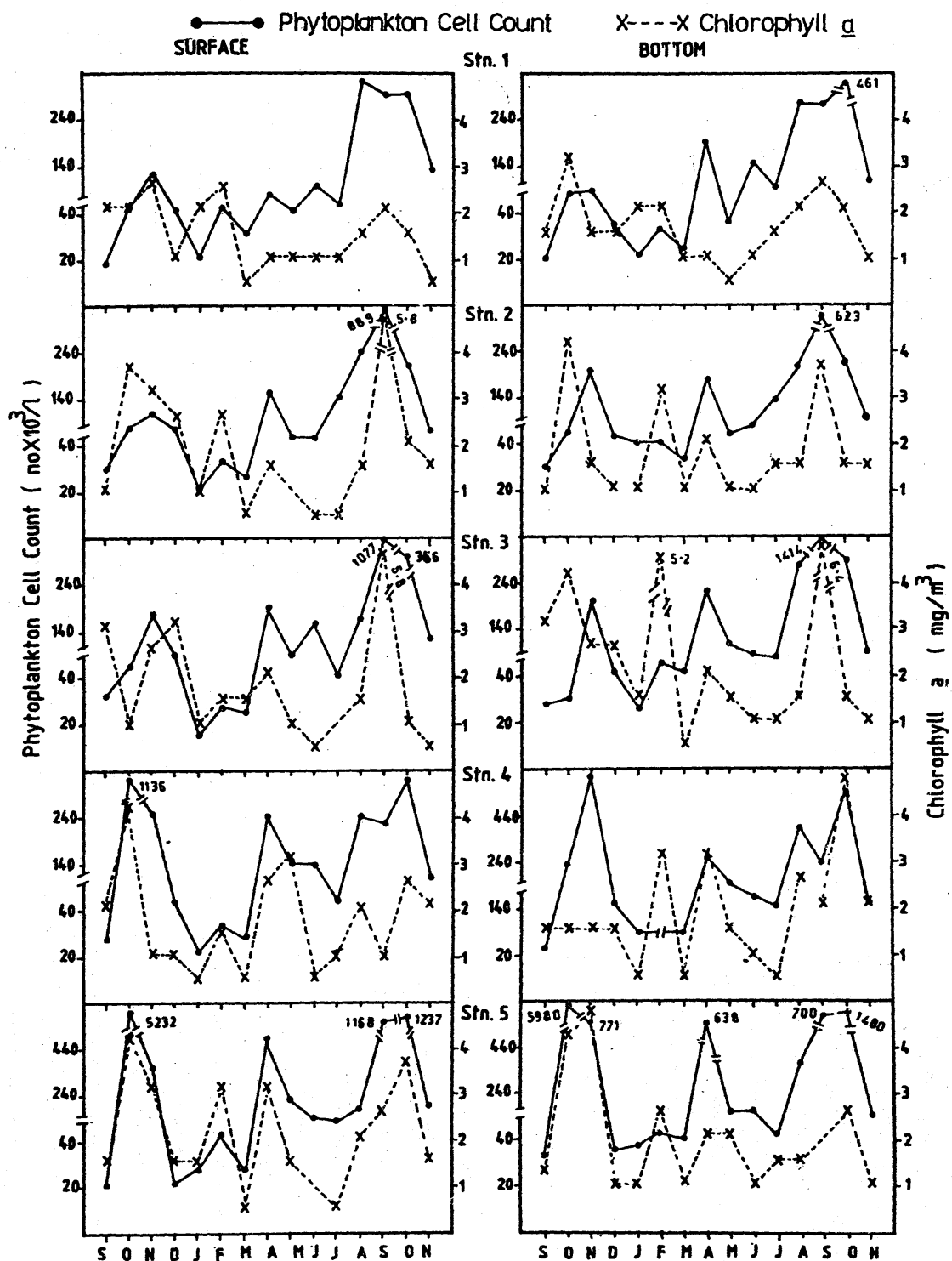
	Stations				
	1	2	3	4	5
Temperature (°C)	24.7-31.5 (27.6)	23.6-32.0 (27.7)	24.0-32.2 (27.8)	24.0-32.4 (28.1)	24.4-33.6 (27.9)
pH	7.5-8.3 (7.8)	7.5-8.2 (7.8)	7.5-8.4 (7.8)	7.5-8.3 (7.7)	7.5-8.3 (7.7)
Salinity ($\times 10^{-3}$)	23.6-36.6 (32.8)	8.1-36.9 (31.6)	1.7-6.5 (27.7)	0.2-37.2 (23.9)	0.1-38.0 (21.2)
DO (ml l ⁻¹)	3.1-6.3 (4.1)	3.4-5.4 (4.3)	3-5.3 (4.4)	3.1-5.3 (4.2)	3-5.2 (4.3)
BOD (ml l ⁻¹)	0.2-3.8 (1.4)	0.2-3.4 (1.3)	0.4-2.9 (1.3)	0.4-3.3 (1.4)	0.2-2.9 (1.4)
PO ₄ -P (μ g at l ⁻¹)	0.6-3.4 (1.9)	0.6-3.5 (2)	0.6-3.1 (1.7)	0.4-3.6 (1.8)	0.6-3 (1.7)
NO ₂ -N (μ g at l ⁻¹)	0.2-3.1 (1.1)	0.1-1.9 (0.7)	0.2-2.2 (0.9)	0.2-2.3 (0.8)	0.2-2.8 (0.9)
NO ₃ -N (μ g at l ⁻¹)	5.1-21.8 (13.7)	1.0-33.9 (15.1)	3.6-24.3 (16.1)	3.9-30.6 (17.9)	4.2-42.4 (18.8)
NH ₃ -N (μ g at l ⁻¹)	0.2-6.6 (1.5)	0.1-6.8 (1.5)	0.1-5.1 (1.2)	0.1-4.9 (1.5)	0.1-5.6 (1.7)
Chlorophyll <i>a</i> (mg m ⁻³)	0.53-3.20 (1.62)	0.53-5.87 (1.94)	0.53-6.4 (2.18)	0.53-4.81 (1.85)	0.53-4.81 (2.11)
Phaeophytin (mg m ⁻³)	0.05-5.18 (1.37)	0.05-12.23 (1.70)	0.05-12.01 (1.65)	0.05-12.01 (2.11)	0.05-16.5 (2.61)
Phytoplankton cell count ($\times 10^3$ l ⁻¹)	18-462 (123)	22-890 (126)	17-1414 (290)	23-1136 (202)	20-5980 (675)
Shanon's Diversity Index	1.24-3.61 (2.33)	1.38-3.51 (2.57)	1.57-3.46 (2.60)	0.54-3.48 (2.47)	0.29-3.32 (2.15)
Margalef's Diversity Index D	1.7-4.74 (2.97)	1.63-4.93 (3.13)	1.49-4.24 (3.07)	1.14-3.89 (2.88)	1.22-4.2 (2.75)

Phytoplankton

Variation in phytoplankton cell count was enormous ($17-5980 \times 10^3$ l⁻¹) and the average cell count for the entire area was 266×10^3 l⁻¹. The overall distribution of phytoplankton indicated a bimodal pattern with the population maximum during September-October followed by a secondary peak in April (Fig. 2). Outburst of phytoplankton during monsoon period synchronised with low salinity and high nutrient values similar to the observations for Cochin backwaters¹⁸. Gopinathan¹⁹ reported sudden proliferation of diatoms following break in monsoon condition at a salinity range of 22.2 to 30.1×10^{-3} in Cochin backwaters. In general, the area between sts 1-3 behaved identically with peak phytoplankton production during the monsoon period while at sts 4 and 5 maximum was restricted to postmonsoon season. At the interior most locations of Dharamtar creek, salinity was very low during monsoon season and almost freshwater

dominated the area. Probably this would have led to the shifting of population maximum for the postmonsoon period along the interior part of the creek system. The population maximum generally coincided with peak values of chlorophyll *a* (Fig. 2). Significant positive correlation at 1% level was observed between chlorophyll *a* and phytoplankton population for sts 2-5.

A total of 58 genera of phytoplankton were recorded from the area of which 46 belonged to diatoms, 6 to dinoflagellates and 6 to other algae. The diatoms were represented by *Amphiprora*, *Amphora*, *Asterionella*, *Bacteriastrum*, *Biddulphia*, *Campylodiscus*, *Cerataulina*, *Chaetoceros*, *Climacosphenia*, *Cocconeis*, *Corethron*, *Coscinodiscus*, *Coscinosira*, *Cyclotella*, *Denticula*, *Detonula*, *Diploneis*, *Ditylum*, *Eucampia*, *Fragilaria*, *Grammatophora*, *Guinardia*, *Gyrosigma*, *Hemiaulus*, *Hemidiscus*, *Hyalodiscus*, *Lauderia*, *Leptocylindrus*, *Licmophora*, *Melosira*,

Fig. 2—Variations in chlorophyll *a* and phytoplankton cell count at different stations.

Navicula, *Nitzschia*, *Pinnularia*, *Planktoneilla*, *Pleurosigma*, *Rhabdonema*, *Rhizosolenia*, *Skeletonema*, *Streptotheca*, *Surirella*, *Synedra*, *Thalassionema*, *Thalassiosira*, *Thalassiothrix*, *Triceratium* and *Tropidoneis*. The dinoflagellates encountered were *Ceratium*, *Dinophysis*, *Goniaulax*, *Noctiluca*, *Peridinium* and *Prorocentrum*. Other algae included *Anabaena*, *Gloeotheca*, *Nodularia*, *Oscillatoria*, *Phaeocystis* and *Spirulina*.

The average contribution of diatoms, dinoflagellates and other algae to phytoplankton was respectively 97.6, 2.0 and 0.4%. *Thalassiosira* exhibited the maximum percentage contribution (av.34.5%) to the phytoplankton community, followed by *Skeletonema* (22.2%). Blooms of *Skeletonema* occurred during October-November which was more prevalent in the interior creek stations. Distribution pattern of the common genera of phytoplankton showed variations between stations (Figs 3-7). *Coscinodiscus*, *Nitzschia*, *Thalassiosira* and *Thalassiothrix* were encountered

at all the stations throughout the period of study. *Biddulphia*, *Cerataulina*, *Navicula*, *Pleurosigma*, *Rhizosolenia*, *Surirella* and *Synedra* were the other genera occurring very frequently in the area. *Peridinium* and *Dinophysis* were the most common genera of dinoflagellates.

Swarming of phytoplankton was common feature along the coastal waters of India. A bloom of *Skeletonema* extended from sts. 2-5 with percentage contribution as high as 97.2% for surface and 96.4% for bottom during October '84. Occurrence of bloom of *Skeletonema* during November and December was reported by Qasim¹⁸ in Cochin backwaters. Curl & McLeod²⁰ deduced optimum salinity range for *Skeletonema* as $15-20 \times 10^{-3}$ whereas Nakanishi & Monsi²¹ reported 18×10^{-3} as the optimum salinity. The highest peak of *Skeletonema* observed in the present study coincided with a salinity range of $20.23-21.7 \times 10^{-3}$. Gonzalves¹ also reported increase in number of *Skeletonema* during September-October from Bombay waters. Dinoflagellate

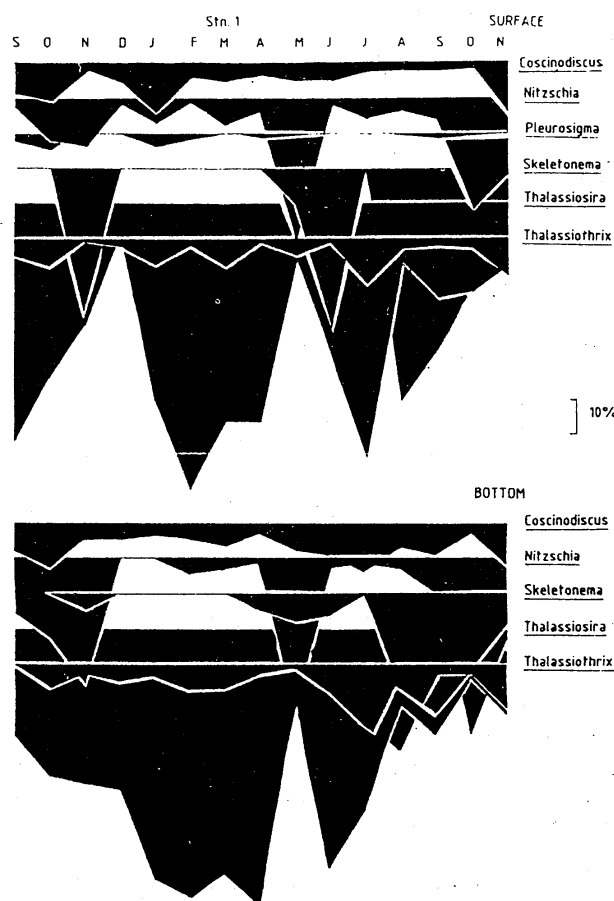


Fig. 3—Distribution pattern of common genera of phytoplankton at st 1.

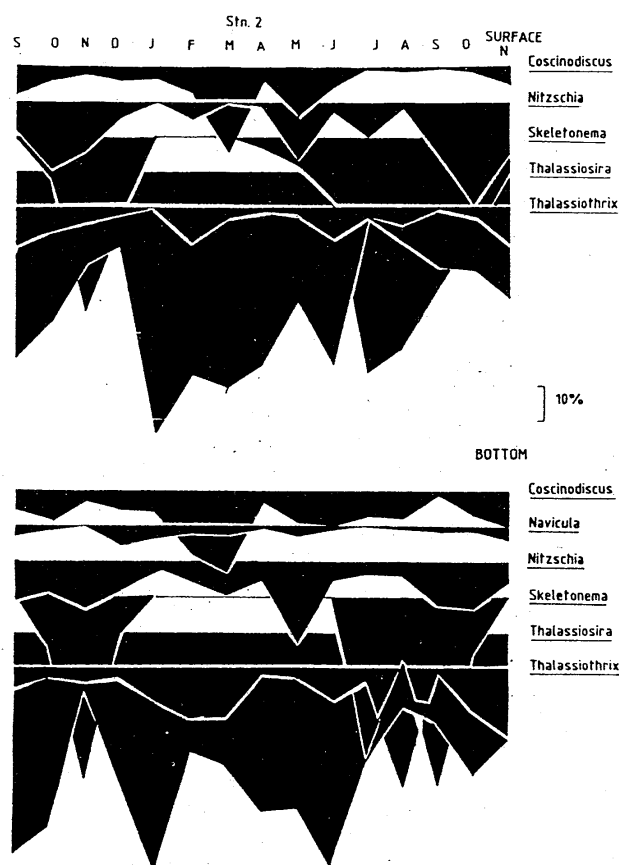


Fig. 4—Distribution pattern of common genera of phytoplankton at st 2.

Table 2—Succession of phytoplankton genera in Dharamtar creek

Zone a (Sts 1 - 3)		
<i>Thalassiosira</i>	<i>Skeletonema</i>	<i>Thalassiosira</i>
<i>Thalassiothrix</i>	November-December	<i>Thalassiothrix</i>
<i>Nitzschia</i> (September-October)		<i>Coscinodiscus</i> (January-March)
<i>Nitzschia</i> (April-May)	<i>Skeletonema</i> (June-October)	<i>Nitzschia</i> (November)
Zone b (Sts 4 and 5)		
<i>Thalassiosira</i>	<i>Skeletonema</i>	<i>Peridinium</i>
<i>Thalassiothrix</i>	(October-November)	<i>Leptocylindrus</i>
<i>Nitzschia</i> (September)		<i>Detonula</i> (December)
<i>Thalassiosira</i> (January-March)	<i>Skeletonema</i> <i>Nitzschia</i> (April-June)	<i>Nitzschia</i> <i>Navicula</i> <i>Gyrosigma</i> (July)
<i>Skeletonema</i>	<i>Skeletonema</i>	
<i>Thalassiothrix</i>	<i>Thalassiosira</i>	
<i>Thalassiosira</i> (August)	(September-November)	

Peridinium led to a bloom in December accounting for 76% of the total phytoplankton count at st. 4. A maximum of 50.4% contribution by *Peridinium* in Cochin backwaters at 28.5×10^{-3} salinity was reported¹⁸ while the bloom of *Peridinium* in the present study coincided with salinity of 31×10^{-3} .

Succession of species occurs when the environmental conditions become exceptionally favourable for certain organisms to appear in high aggregations. Environmental disturbance produces changes in many growth variable upsetting the previous equilibrium leading the community to recognise itself²². Eventhough *Thalassiosira* occurred in fairly large numbers throughout the creek system and maintained its predominancy for most of the months, generic succession was evident within the creek. The pattern of succession given in Table 2 for sts 1-3 (zone a) and 4 and 5 (zone b) indicated variation.

Shannon's diversity index H' varied in the range of 0.29 - 3.61 while Margalef's D from 1.14 to 4.93.

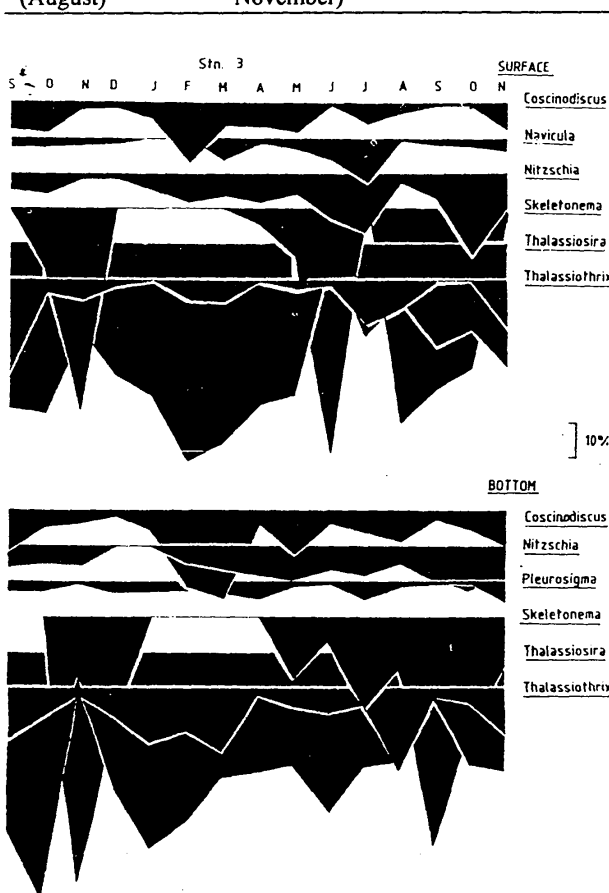


Fig. 5—Distribution pattern of common genera of phytoplankton at st. 3.

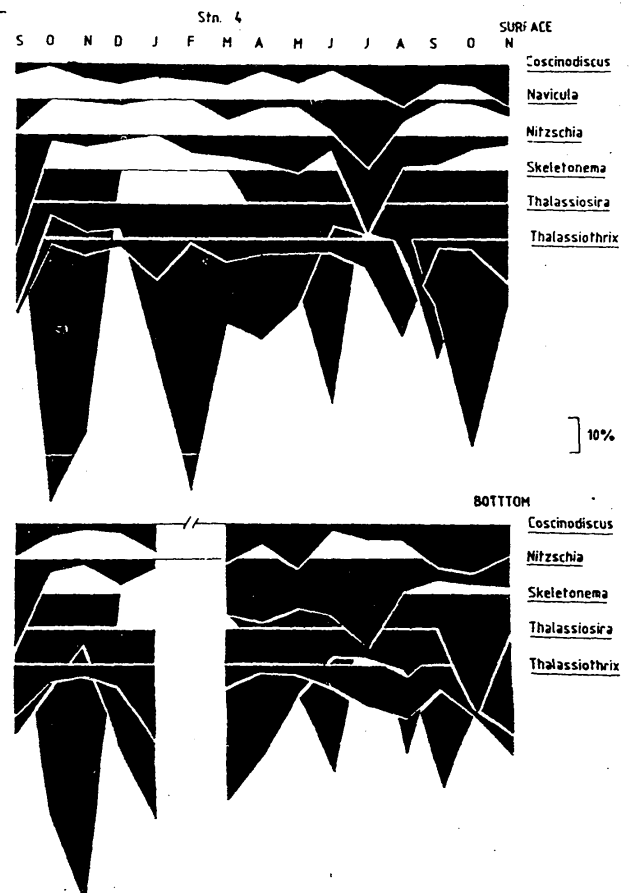


Fig. 6—Distribution pattern of common genera of phytoplankton at st. 4.

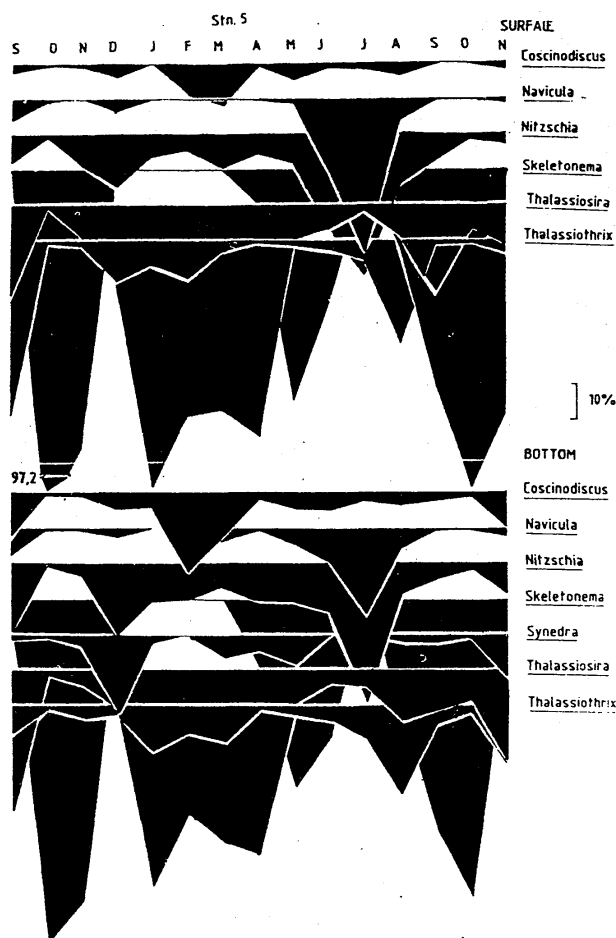


Fig. 7—Distribution pattern of common genera of phytoplankton at st. 5.

The lowest value of H' and D coincided with either the bloom or with the minimum number of genera. The average diversity index H' for the outer zone was 2.45 and that for the interior zone was 2.41. The respective D values were 3.05 and 2.90. Reduction in the number of species and species diversity and an increase in the cell number of *Skeletonema costatum* are some of the changes associated with domestic and industrially polluted environments²³⁻²⁶. Occurrence of *Skeletonema* bloom in October in the present study appears to be a recurring phenomenon as it was repeated in October '85. Hendey²⁷ classified marine habitat on the basis of species diversity as severely (0-1), moderately (1-2) and slightly (2-3) polluted. Considering mean diversity indices (H' -2.42 and D -2.96), it can be concluded that Dharamtar creek sustained fairly healthy phytoplankton community. Relatively higher diversity indices in the outer zone may be attributed

to higher salinity and contribution of immigrant population from the offshore waters.

Dharamtar creek was rich in phytoplankton and supported a diverse community. The spatial heterogeneity between the creek and nearshore waters was well defined. The present baseline information on the phytoplankton pigments and community structure are useful for future ecological assessment and monitoring of the coastal ecosystem of Mumbai.

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