

Plankton Dynamics in Coastal Waters of NCPA, Mumbai, India

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Abstract

An attempt was made out to study the plankton dynamics in the near shore water of NCPA (Nation Center of Performing Arts), South Mumbai which forms the important component of the food web in marine ecosystem. Highest abundance values were recorded for *Pleurosigma* spp. in March (43,200/100 liter). Various diversity indices including Shannon's diversity index, Simpson's diversity index, Margalef's richness index and Pielou's index were calculated. Hierarchical clustering and N - MDS ordination from Bray-Curtis similarity matrix of plankton group abundance data show maximum similarity between *Coscinodiscus* spp. and *Pleurosigma* spp. indicating co-occurrence in the coastal water. Shepard's diagram indicated highly stressed condition of this ecosystem.

Key words : Diversity, Plankton, Hierarchical clustering, Shepard's diagram, Pollution.

Growing awareness of biodiversity issues has brought the need for comparable and meaningful measures of diversity at many scales into sharp focus (1). In particular, factors controlling the biodiversity of an area and thus ecosystem function, are central to biodiversity research (2). One important aspect is the influence of patterns of movement and migration within the motile component of assemblages on both community structure and diversity measurements, particularly because these are believed to be important mechanisms in maintaining biodiversity (3). Plankton diversity is the important primary component of an aquatic ecosystem functioning since plankton are responsible for production at higher level of food web. The important work on phyto- and zooplankton community structure from Indian waters has been carried out by Subrahmanyam (4), Gonsalves (5) and Nair and Thampy (6). The plankton population in coastal region is affected by discharge of pollutant into it. The anthropogenic disturbances affecting community structure and ecological disbalance has been notified by Foster Hodgson (7). Degradation of Mumbai's coastal water has resulted into disturbance of plankton density around Mumbai (8—10). Therefore the present work was proposed to study the diversity of the near shore plankton and to assess the environmental factors affecting plankton population

and Mumbai coast.

Methods

Mumbai, the Island city is situated on west coast of India (lat. 18°54' to 19°09' N and long. 72°47' to 72°56' E). The near shore water of coastal stretch adjacent to the NCPA (National Center for Performing Arts) south Mumbai was studied for physico-chemical properties and plankton. Physico-chemical parameters of water sample collected at low tide level were estimated by following standard method (11). Air and water temperature was measured using mercury thermometer, pH by conductivity meter, salinity by refractometer, dissolved oxygen and 5-day BOD by Winker's methods, NH₄-N, NO₃-N, NO₂-N and PO₄-P by colorimetric method. For the qualitative and quantitative analysis, the plankton samples were collected using bolting silk cloth (40 μ aperture) plankton net of 50 cm diameter from the selected site following standard methods (11). The samples were collected every month in triplicate. The zooplankton samples were preserved in 5% formalin and phytoplankton in 0.3% Lugol's solution for further examining under a compound microscope (12, 13).

The counting of phytoplankton was carried out using Sedgwick- Rafter (S-R) cell. Strip counting

Table 1. Biodiversity indices for the monthly abundance of plankton from NCPA shore. S—Number of species, d—Margalef richness index (1958), J'—Pielou's evenness index (1975), H'—Shannon's diversity index (1949), 1-λ'—Simpson's diversity index (16).

Indices	DEC	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
S	8	10	8	7	5	10	7	8	11	10	9
d	0.66	0.81	0.62	0.57	0.38	0.87	0.59	0.75	0.99	0.87	0.76
J'	0.63	0.89	0.70	0.78	0.86	0.76	0.93	0.81	0.85	0.74	0.72
H' (loge)	1.30	2.06	1.46	1.51	1.39	1.75	1.81	1.68	2.03	1.70	1.58
1-Lambda	0.66	0.85	0.67	0.74	0.72	0.77	0.82	0.78	0.84	0.76	0.73

method (11) was utilized to count the cells. The results were estimated in terms of cells/100 liter following the formula

No/ml=(C* 1000 mm³ / L*D*W*S) where, C=No. of organisms counted, L=Length of each strip (S-R cell length) (mm), D=Depth of a strip (S-R cell depth) (mm), W=Width of a strip (mm) and S=No. of strip.

For the quantitative study of zooplankton, a Sedgwick-rafter counting cell was used adopting the procedure outlined by Welch (14) and minimum of five sub-samples were counted to determine statistical validity. The results were estimated in terms of cells / 100 liter, following the formula

$$\text{Number of plankton / liter} = \frac{a \times c \times 1000}{L}$$

Where, a=average number of plankton in one small counting cell, c=volume of concentrate in ml and L=volume of water filtered in liters.

Various diversity indices including Shannon's diversity index (15), Simpson's diversity index (16),

Table 2. Yearly variation of physico-chemical parameters in the intertidal water at NCPA.

Parameters	Mini- mum	Maxi- mum	Mean ± SE	SD
Air temperature (C)	28.5	32	30.04±0.34	1.18
Water temperature (C)	27	31	28.58±0.32	1.12
Salinity (ppt)	26.5	34	31.79±0.73	2.54
pH	7.45	8.35	7.81±0.08	0.27
DO (mg/l)	5.4	6.8	6.06±0.13	0.46
BOD (mg/l)	9.6	11.8	10.96±0.22	0.75
NH ₄ -N (mg/l)	0.14	0.37	3.32±3.06	10.61
NO ₃ -N (mg/l)	0.19	1.3	0.54±0.09	0.3
NO ₂ -N (mg/l)	0.04	0.12	0.07±0.01	0.03
PO ₄ -P(mg/l)	0.37	1.2	0.679±0.08	0.28

Margalef's richness index (17) and Pielou's evenness index (18) were calculated. Hierarchical clustering, ordination of samples by non-metric multi-dimensional scaling (MDS), principal component analysis (PCA) were also performed to draw proper conclusion. To express the stress level over the plankton population the Shepard's diagram method was followed. The data were log transformed as log (X + 1) (19) and statistical software PRIMER Ver.6 (Plymouth Research Lab., UK) was used for various type of analysis.

Results

A total of 17 plankton groups were recorded from the near shore water of TIFR. Month-wise plankton abundance (number / 100 liter) was highest for *Pleurosigma* spp. in March (43,200 / 100 liter). Highest plankton group diversity was recorded in September to February (11 groups). Maximum values of Pielou's evenness index in July (0.92) suggests the evenness of distribution pattern of species in this month (Range : 0.62—0.92). Shannon's index (1949) was highest in February (2.05). Higher values of Margalef richness index was recorded in September

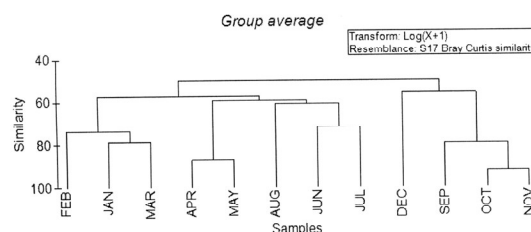


Figure 1. Dendrogram from Bray-Curtis similarity matrix of plankton abundance data [log (X + 1) transformed] for the monthly occurrence at NCPA shore.

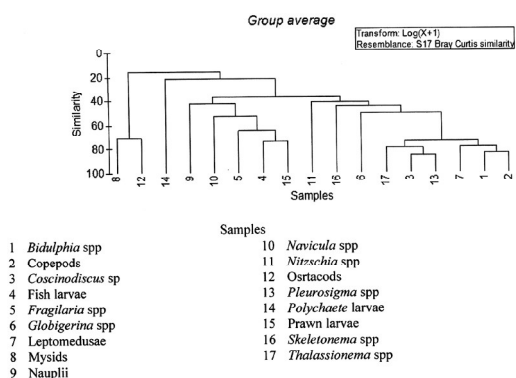


Figure 2. Dendrogram from Bray-Curtis similarity matrix of plankton abundance data for the species wise occurrence at NCPA shore.

(0.99) and another in June (0.86) indicating two peak (one immediately after postmonsoon and another premonsoon) of abundance of plankton group. The Simpson index (16) $[1 - \lambda' = 1 - \{\sum Ni(Ni - 1)\} / \{N(N - 1)\}]$ varied between 0.66—0.85, whereas the diversity of the community sample was highest in February (0.85) (Table 1).

Dendrogram from Bray-Curtis similarity matrix for monthly plankton abundance show maximum similarity in plankton abundance in October and November (Fig. 1). While, the dendrogram and N - MDS ordination from Bray-Curtis similarity matrix of plankton group abundance show maximum similarity between *Coscinodiscus* spp. and *Pleurosigma* spp. (88.73)

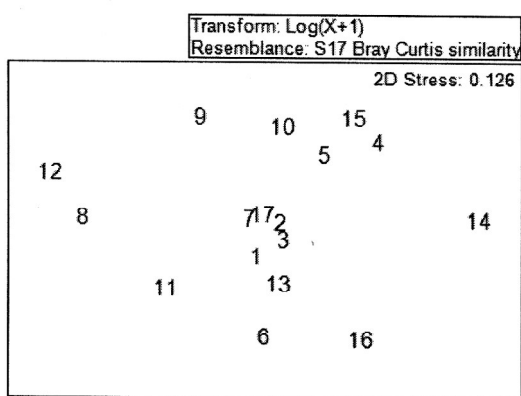


Figure 3. Non-metric MDS ordination of Bray-Curtis similarity matrix of plankton abundance data for the species wise at NCPA shore.

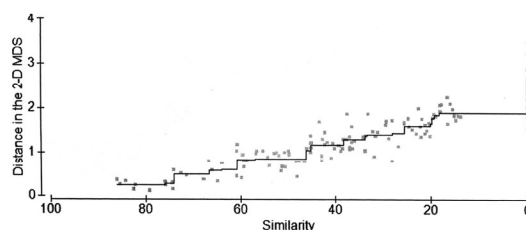


Figure 4. Non-parametric regression line of Shepard diagram fitted stress values of NCPA intertidal organisms over the year, about the line.

(Figs. 2—3), presenting similar type of occurrence for the two groups. Shepard diagram indicates stressed condition for the plankton community (Fig. 4). Two dimensional PCA ordinations indicates that *Fragilaria* spp., *Pleurosigma* spp., *Skeletonema* spp. are the dominant group responsible for making the variation in the abundance of the plankton community in Mumbai water (Fig. 5). Figures 6 and 7 reveal the lower value of salinity during the monsoon period and lower range of NO_2-N , NO_3-N and PO_4-P during the monsoon and higher during post-monsoon period (Table 2).

Discussion

Gajbhiye et al. (20, 21) reported the rich plankton groups from Mumbai coast. The reduction in the plankton and abundance may be due to higher indus-

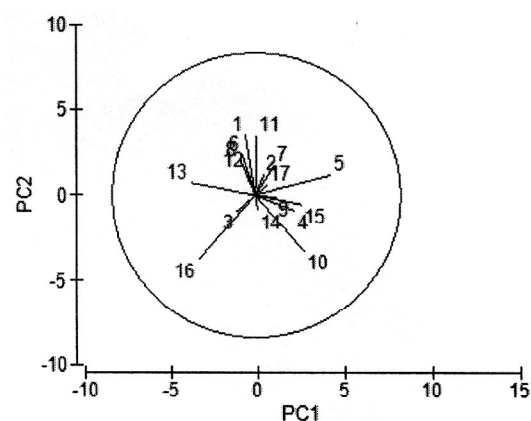


Figure 5. Two dimensional PCA ordination of monthly abundance data of plankton group variables for the NCPA.

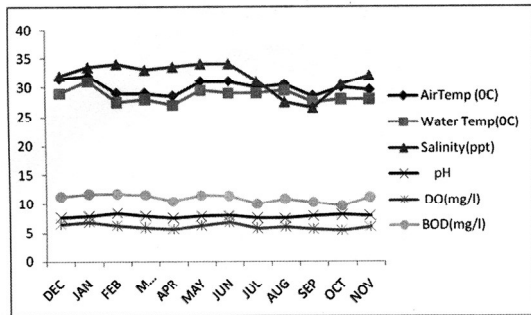


Figure 6. Month-wise variation of air temperature, water temperature, salinity, pH, DO (mg/liter) and BOD (mg/liter) from NCPA shore.

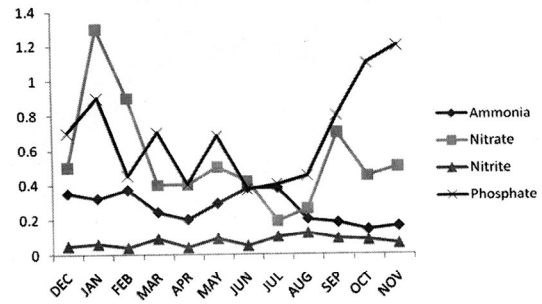


Figure 7. Month-wise variation of $\text{NH}_4\text{-N}$ (mg/liter), $\text{NO}_3\text{-N}$ (mg/liter), $\text{NO}_2\text{-N}$ (mg/liter) and $\text{PO}_4\text{-P}$ (mg/liter) of water from NCPA shore.

trial and sewage pollutant load in near shore water of the Mumbai and position of NCPA near the port is also responsible as oil pollution is maximum in the area due to the shipping activity. The plankton study at Kulai, close to northern part of the New Mangalore harbor, and Padubidri along the Karnataka coast by NIO (22) revealed range of H' from 1.16 to 3.52 at Padubidri and 1.42 to 2.99 at Kulai and 'd' from 4 to 11.6 at Padubidri and 3 to 9.4 at Kulai. In the present observation comparatively lower range of H' (1.30 to 2.02) and Margalef's richness index (d) 0.37 in May - 0.99 in September indicating less biodiversity of the plankton group. As coastal waters of Mumbai receives industrial discharges up to 230 million liters per day (MLD) and domestic wastes of around 2,200 MLD of which, 1800 MLD are untreated (23) this must have affected the water and sediment quality, with consequent effect on aquatic communities, same cause was reported by Ramaiah (24), for lower plankton species diversity in the Mumbai harbor—Thane creek region.

A scale of pollution in terms of species diversity (3.0—4.5 slight, 2.0—3.0 light and 1.0—2.0 moderate and 0.1—1 heavy pollution) has been described by Staub et al. (25). The Shannon diversity index (16) for plankton group in the entire study area fluctuated between 1.30—2.02, which indicates moderately polluted condition as HENDY'S (26) classification also. A community becomes more dissimilar as the stress increases and accordingly species diversity decreases with decreasing water quality. Hence community dominated by relatively few species would indicate environmental stress (27). The evenness index reveals

moderate evenness of distribution of various species in a sample indicating moderately disturbed condition. Shannon index is maximum when all the species in a sample are equally abundant, decrease towards zero as the relative abundance of species diverse away from the evenness (28).

The lower abundance of the plankton in monsoon is due to lower salinity. Grasshoff et al. (29) who studied the plankton of the Cochin backwaters (CBW), of southwest coast of India, attributed its lower abundance to lower salinity. Nair et al. (30) reported copepod as the major herbivore community that contributed 76—83% to total zooplankton population. Variability in copepod population was also observed along two transects of Mahim and Versova of Mumbai by Gajbhiye et al. (21), where copepod was 72.7 and 79.7%, respectively. In the present study also copepods were the major herbivore among the plankton community in the near shore of Mumbai. Gajbhiye et al. (20) worked on the distribution of planktonic fish eggs and larvae from Versova, Mahim Harbour and Thane where fish eggs and larvae were more abundant during pre- and post-monsoon similar to present observation from NCPA area.

Environmental studies in the Cochin backwaters, India by Grasshoff et al. (29) showed that seasonal fluctuation in salinity created by the monsoonal rainfall and associated run off is the major factor controlling the distribution and abundance of micro- and mesozooplankton. Similar fluctuation in salinity was observed in the present study also. The physico-chemical parameters of water along with DO values are almost the same as the findings of Dhargalkar

and Komarpant (31) who recorded water temperature of 26.9 to 27 C with DO as 5.8 to 6.3 mg/liter from Colaba, south Mumbai. The observed level of nutrient like phosphate, nitrate, nitrite and ammonia at Colaba lies at a lower than that observed by Dhargalkar and Komarpant (31). Nair et al. (30) reported the temperature, salinity, pH, DO and BOD varied from 21—32 C, 2—36.8 ppt, 7.5—8.3, 1.4—9.1 mg/liter and 0.5—4.9 mg/liter, respectively from four location of Mumbai water, whereas the nutrient quality of phosphate, nitrate, nitrite varied from 0.2—14.8, 0.1—31.9, 1.3—77.0 mg/liter, respectively. Present study also recorded similar results with higher range of BOD and lesser amount of nutrient, indicating increase in pollution. Lower range of the salinity during monsoon period (26 ppt) shows an inverse relation with species diversity and Margalef richness index. Stability in the salinity over the 30 ppt during post-monsoon period also has a strong positive effect over the species abundance, Shannon index and Pielou's evenness index.

The study revealed that severe decreasing in the abundance of plankton group (important component in the food web) in the near shore water of Mumbai. Ecologically moderately polluted condition may be attributed to higher anthropogenic stress from nearby localities and sea transport.

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