

Phytoplankton Ecology of the Cochin Backwater

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Average concentration of phytoplankton in the Cochin backwater varied from 22200 to 299700 cells/litre. The minimum and maximum numbers were observed during September and November. Diatoms, dinoflagellates and other algae had their maximum concentration during postmonsoon, premonsoon and monsoon periods respectively. On few occasions diatoms and dinoflagellates were found to bloom. The maximum concentration observed during a bloom was 2 million cells/litre. A negative correlation was found between cell concentration and salinity. Variation of phytoplankton was directly related to that of phosphate and nitrite. Cell numbers and organic carbon production showed a positive relation. Species diversity index varied from 1.59 to 4.50 and the lowest was observed during a phytoplankton bloom,

INVESTIGATIONS on the distribution of phytoplankton communities of tropical waters are very few³. This is especially true of the regions surrounding the Indian coasts. No account on the quantitative distribution of phytoplankton from the Cochin backwater (a tropical estuary) is so far available. Environmental parameters, primary productivity and related aspects of the Cochin backwater^{4,7} have been reported.

Materials and Methods

Fortnightly observations were made from 4 locations in the backwater. Surface water was collected in 1 litre bottles and preserved in 2-3% formalin. After shaking the bottles thoroughly, a 50 ml sample from each was transferred into a sedimentation chamber and allowed to settle for 2 days. The supernatant was removed and the organisms in the chamber were counted under an inverted microscope. Nannoplankton was not included in the total counts. The cell counts observed at each station for every fortnight were averaged. The average values included the counts obtained during bloom period as well.

Results and Discussion

Fig. 1 shows the monthly average of phytoplankton counts. The phytoplankton cell concentration varied from 22200 to 299700 cells/litre. The minimum and maximum counts were observed during September and November respectively. Phytoplankton was mainly composed of 3 important groups, viz. diatoms, dinoflagellates and other algae (Chlorophyceae and Cyanophyceae). The counts of each of these have also been shown in Fig. 1. Diatoms always dominated the crop and ranged from a minimum of 53% (September) to a maximum of 91% (December) of the total phytoplankton population. The next important groups were dinoflagellates and other algae, the percentages of which varied from 1 to 28 and from 2 to 44 respectively. During premonsoon (February to May), monsoon (June to September) and postmonsoon (October to January) months, diatoms contributed 62-84, 53-61 and

64-91% respectively; dinoflagellates 3-28, 0-3 and 1-8%; and other algae 2-20, 37-44 and 8-34% respectively. While diatoms showed maximum concentration in the postmonsoon months, dinoflagellates had their highest concentration in premonsoon period and other algae in the monsoon months. During the present study, the number of genera of the phytoplankton organisms observed varied from 17 to 30, the minimum and maximum were during April and June respectively.

Table 1 shows the percentage occurrence of different organisms in different months. Phytoplankters having their concentrations >1% of the total have been shown by a plus sign. If all the organisms with concentrations greater than 5% of the total (expressed in numbers) are taken as dominant species, very few will fall under this convention. Then, only three forms come in the dominant category in May, constituting 89% of the total phytoplankton, while during August, 5 forms constitute about 40% of the total population.

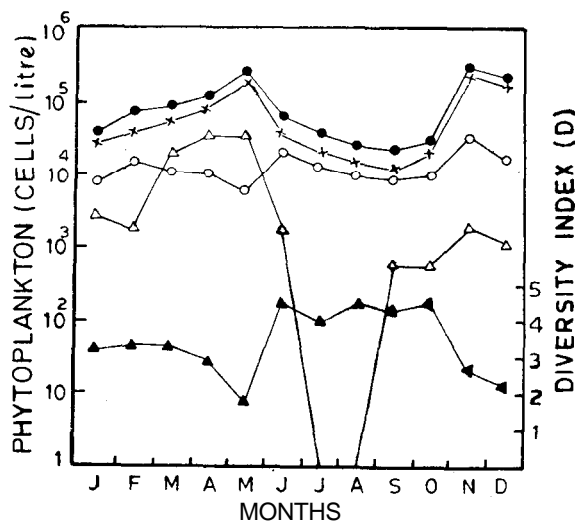


Fig. 1 — Concentration of surface phytoplankton from the Cochin backwater along with its diversity index (●, total cells; X, diatoms; A, flagellates; O, other algae; A, diversity index)

TABLE 1 — DISTRIBUTION OF PHYTOPLANKTON IN THE COCHIN BACKWATER

(Values are given in per cent. Phytoplankton concentration which is less than 1% is indicated by +)

	Jan.	Feb.	March.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
DIATOMS												
<i>Amphora</i> sp.	1	+	1	+	+	3	2	2			+	
<i>Asterionella japonica</i>				+	+							+
<i>Bacillaria</i> sp.						+		2				
<i>Bellrochea</i> sp.								2		2	+	
<i>Biddulphia</i> sp.	+		+		+							
<i>Ceratulina</i> sp.		12	2	1	+						2	
<i>Chaetoceros</i> sp.	5	+	1		+						3	-I-
<i>Cocconeis</i> sp.								2				
<i>Coscinosira</i> sp.	3											
<i>Coscinodiscus</i> sp.	7	1	3	3	+	6	14	8	13	7	3	;
<i>Cyclotella</i> sp.	29	13	5	2	2	3	2		5	6	+	+
<i>Denticula</i> sp.							2	2				
<i>Ditylum</i> sp.			+									
<i>Eucampia</i> sp.												+
<i>Fragilaria oceanica</i>	1	+			+				3	2	+	+
<i>Grammatophora</i> sp.								4				
<i>Gyrosigma</i> sp.		+	+	+	+	+		2			+	
<i>Navicula</i> sp.	6	26	13	4	1	5	8	11	4	10	3	7
<i>Nitzschia</i> sp.	7	17	25	11	75	15	7	7	7	4	7	6
<i>Pleurosigma</i> sp.	1	1	5	1	+	2	9	4	5	4	+	+
<i>Rhizosolenia</i> sp.	3	+	1						3			2
<i>Rhizocolonium</i> sp.											+	+
<i>Skeletonema costatum</i>	1	1	2	3	2	22	18	8	15	2:	53	63
<i>Surirella</i> sp.								3		2		
<i>Synedra</i> sp.	3							2				
<i>Thalassionema</i> sp.										4		
<i>Thalassiosira</i> sp.	2	1		39							12	4
<i>Thalassiothrix</i> sp.	2	2	+			+					3	4
DINOFLAGELLATES												
<i>Ceratium</i> sp.	+	+			7						+	+
<i>Dinophysis</i> sp.				+	+							
<i>Peridinium</i> sp.	6	2	22	17	7	3			3	2	+	+
SILICOFLAGELLATE												
<i>Dictyocha</i> sp.	2											
OTHER ALGAE												
<i>Actinastrum</i> sp.										2		
<i>Anabaena</i> sp.						+						
<i>Ankistrodesmus</i> sp.									3		+	
<i>Calothrix</i> sp.		+										
<i>Chlorella</i> sp.	19	18	11	7	2	15	14	6		6	8	7
<i>Chroococcus</i> sp.						+			3	2	+	
<i>Closterium</i> sp.							2			2		
<i>Cosmarium</i> sp.						+	2	4	3			
<i>Desmidiium</i> sp.						+		2	2	2		
<i>Dimobryon</i> sp.						+						
<i>Gloeothece</i> sp.						2		2				
<i>Holopedium</i> sp.						+						
<i>Hydrodictyon</i> sp.									2	2		
<i>Kirchneriella</i> sp.							2					
<i>Lynghya</i> sp.	+	+	-I-	+		+		2		2	+	+
<i>Merismopedia</i> sp.						+	6	7	11	2	1	+
<i>Microcystis</i> sp.								2	5	1		
<i>Micrasterias</i> sp.										1		
<i>Mougoetia</i> sp.							3	5	2	2	2	
<i>Nostoc</i> sp.								2				
<i>oocystis</i> sp.						+		1		2	1	+
<i>Oscillatoria</i> sp.	1	+	-k	-I-	+	+					+	
<i>Pediastrum</i> sp.						+					+	
<i>Phormidium</i> sp.						+					+	
<i>Scenedesmus</i> sp.						-I-	1	3	2			
<i>Selenastrum</i> sp.							1			1		
<i>Sphaerzosma</i> sp.							2		2	2	+	
<i>Spirulina</i> sp.												
<i>Staurastrum</i> sp.						T- 3		4	2	2	+	
<i>Xanthidium</i> sp.								2				

Smayda⁸ while studying the phytoplankton of the Gulf of Panama mentioned that at one of the stations 2 of the total of 103 species constituted 47% of the total standing crop when these were expressed in numbers. Species succession among diatoms was found to occur in the following order: *Cyclotella* sp., *Navicula* sp., *Thalassiosira* sp., *Nitzschia sigma* and *Skeletonema costatum*.

Present studies show that dinoflagellates were not very abundant throughout the year. Among silicoflagellates *Dictyocha* sp., was the only form observed. This species contributed about 2% of the total population in January. However, among other algae, *Chlorella* sp., was present throughout the year, though during the monsoon months large numbers of freshwater forms were encountered in the backwater. Maximum concentration of *Chlorella* sp., was observed during the postmonsoon months.

Phytoplankton showed a bimodal variation with peaks in May and November (Fig. 1). From the west coast, Subrahmanyam² observed phytoplankton maxima in June- July and minima during November. From Porto Novo (east coast of India) Ramamurthy and Krishnamurthy⁹ showed that the phytoplankton peaks were in March and August while the lowest values were found in April. In Waltair, Ganapati and Rao¹⁰ found peaks in February, April and October to December. Devassy and Gopinathan¹¹ reported that phytoplankton population was much higher in August as compared to March in the Vembanad lake (Kerala). Dehadrai and Bhargava¹² found a bimodal peak of phytoplankton along the central west coast of India during the pre- and postmonsoon periods. Hulbert et. al.¹³ reported a regular annual cycle of phytoplankton with a unimodal peak from the surface waters of the Sargasso Sea. The observations from the Cochin backwater showed relatively higher phytoplankton population as compared to the counts from the Sargasso Sea¹³.

During the course of investigation, several instances of diatom and dinoflagellate blooms were observed. Noticeable blooms were those of *Nitzschia sigma* (in May), *Ceratium furca* (in March), *Peridinium* sp. (in April) and *Skeletonema costatum* (in November) (Table 2). It is evident from the foregoing account that these blooms coincide with the pre- and postmonsoon periods. The salinities observed during March, April, May, November and December were 31.82, 28.50, 20.30, 19.10 and 27.20-29.20‰ respectively.

Subrahmanyam² showed that almost all peaks in the phytoplankton production coincided with

lower salinity as in the present case. Thus, during July 1955 when salinity was 20.74‰, a sudden increase in phytoplankton, many a time greater than those of the other years, was recorded by Subrahmanyam². However, a bloom of *Asterionella japonica* was found when salinity was around 34.8‰, off Waltair¹⁴.

Table 2 shows the number of cells during the blooms along with the salinity values. Here again the counts do not include nanoplankters. *Skeletonema costatum* was found to bloom in the salinity range of 19-29‰ and for *Nitzschia sigma* it was 20-30‰. *Peridinium* sp. and *Ceratium furca* showed their maximum when salinities were 28.50 and 31.82‰ respectively. It is clear from the table that *S. costatum* constituted 45.2-77.2% of total cells, *N. sigma* 93%, *Peridinium* sp. 52% and *C. furca* 65.7%.

Phytoplankton and salinity — When the phytoplankton population of an estuarine system is considered the importance of salinity cannot be ignored. Qasim et al.¹⁵ have shown that salinity is an important factor to be considered. Fig. 2 shows the scatter diagram for salinity and cell concentrations. Present studies showed a negative correlation between cell concentration and salinity ($r = -0.79$). Monsoon salinity values have not been used for the purpose of calculating the regression equation, for mostly fresh water forms were present during that period.

Further, Qasim et al.¹⁵ have shown that photosynthetic rates of different phytoplankters are higher

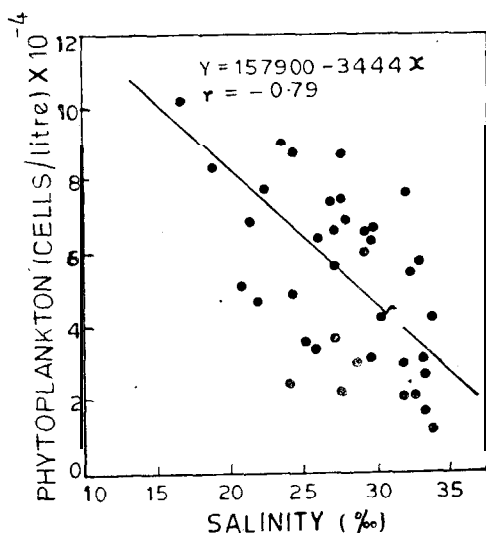


Fig. 2 — Relation between phytoplankton cells and salinity

TABLE 2 — CONCENTRATION OF PHYTOPLANKTON (CELLS/LITRE) DURING BLOOM SITUATION ALONG WITH SALINITY AND DIVERSITY INDEX

Months	Species	Salinity ‰	Cell No.	Total cells	Per cent of total	Diversity index
March	<i>Ceratium furca</i>	31.82	123000	187200	65.7	2.64
April	<i>Peridinium</i> sp.	28.50	59100	113700	52.0	1.65
May	<i>Nitzschia sigma</i>	20.30	1406400	1514000	92.9	0.64
November	<i>Skeletonema costatum</i>	19.10	902400	1998400	45.2	1.37
December	<i>Skeletonema costatum</i>	27-20	503400	652200	77.2	1.44
December	<i>Skeletonema costatum</i>	29.20	292800	379200	77.2	1.35

when salinities are between 10 and 25‰. Thus, several blooms have been noticed at this salinity range. Subrahmanyam² has reported a sudden outburst of phytoplankton in the west coast, when salinity became low (20.74‰). The present study also shows that salinity is a prominent ecological factor controlling the phytoplankton growth and distribution in the estuaries and inshore waters. However, salinity will have very, little influence on the phytoplankton distribution in the sea, for in the open ocean, variations in salinity are so little to have any pronounced effect on the biogeographical data^{16,17}.

Studies from the Cochin backwater reveal that with the increasing influx of freshwater the salinity gets progressively reduced and the phytoplankton population increases. This however happens, up to a limit, as mentioned earlier, of the reduction in salinity. A similar situation has been found by Rvther et al.¹⁸ from the Senix Creek where the correlation between cell counts and salinity was found to be high ($r=-0.875$). In the backwater, the regression equation of cell concentration and salinity has the relation $y=1579003444x$ where the variation of the regression coefficient was ± 740 . In the Gulf of Panama, however, Smayda⁸ found that when salinity was higher phytoplankton was also higher. Probably these organisms were of typically marine nature.

Phytoplankton and nutrients — Inorganic phosphate concentration was low during January-April⁷. During the monsoon period, phosphorus values attained maximum and later declined. In the case of nitrate nitrogen little or no variation was observed for most of the year except during the monsoon months when very high values, of the order of 25-35 μg at/litre were observed. The peak concentrations of phytoplankton showed direct relation with the peaks of phosphate and nitrite concentrations recorded. Such a relation was not found with the nitrate values. The direct relation, as mentioned above suggests that in warmer waters the rate of regeneration of nutrients is more important than their concentrations at a given time¹⁹.

Production and cell concentration — A direct comparison between phytoplankton cells and ¹⁴C uptake has the inherent assumption that all cells are having equal importance in their activity irrespective of the species and cell size. However, Paasche¹⁰ has shown that such a comparison will favour the smaller but usually numerous species of the community. In the present studies an attempt has been made to find out how the production⁶ and cell numbers are related (Fig. 3).

The fact that there is a positive relationship between cell number and ¹⁴C uptake perhaps indicates that all communities were in a similar dynamic state at the time of sampling. For most of the period, except in November and December, there was a direct relationship between cells and production values. The regression equation has the form:

$$\log y = -3.4237 + 0.6310 \log x$$

where y =production rate and x =cell concentration.

The variation in regression coefficient is 0.138. Good correlation was found between production and cell concentration and the correlation coefficient was high (0.85).

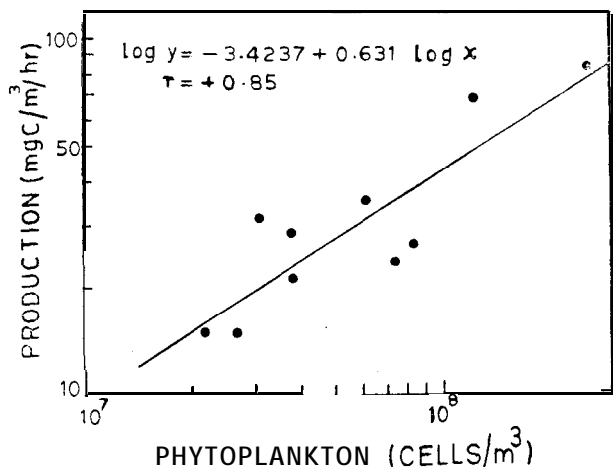


Fig. 3 — Relation between production and phytoplankton

Species diversity — Diversity index gives a measure of the way in which individuals in an ecological community are distributed among species. Individuals of naturally occurring biological population are distributed among species according to a log normal distribution²¹. This is applicable to diatom population from soft and brackish water^{22,23}. Thorington-Smith²⁴ has applied this to phytoplankton samples from the Indian Ocean. Shannon and Weaver²⁵ have derived another relationship from information theory to show how the diversity index is related to the population figure. Relationship used in the present investigation to find out the index of diversity (D) is:

$$D = \sum_{n=1}^S p_n \log_{1/p_n} \left(\frac{1}{p_n} \right)$$

where p_n is proportion of sample belonging to n th species and S is the total number of species in the sample.

In the Cochin backwater the species diversity index varied from 1.59 to 4.50 (Fig. 1). During the monsoon period, the values were always around 4 or >4 . The lowest value of 1.59 was found in May, which was due to *Nitzschia sigma* bloom.

Edden²⁶ showed that, for phytoplankton from the Indian Ocean, the diversity index varied from 2.23 to 4.54. According to Ewing and Dorris²⁷, phytoplankton populations attains maximum values of species; diversity of 4-6. Borowitzka²⁸ found the algal species diversity in an intertidal region to be lower than those reported by the other workers for phytoplankton. The variation in the diversity observed during present studies agreed with those reported by the other workers.

As has been pointed out earlier, there were occasions when blooms occurred. Species diversity indices have been calculated for such situations and given in Table 2. During blooms, the diversity index was less and varied from 0.64 to 2.64. The lowest value of 0.64 was found when 93% of the cells was contributed by *Nitzschia sigma*. Platt and Subba Rao²⁹ have measured the variation in the diversity index as a bloom progressed and reported the values between 0.57 and 3.30. Although we could not continue to measure the bloom as it progressed, from the diversity index, it appears

that most of our observations were made when the blooms were not at the peaks, except in the case of *N. sigma* when the value of diversity index was 0.64.

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