

# Diurnal Variation in Phytoplankton Pigments of Mandovi Estuary, Goa

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Mandovi is a positive estuary with heavy freshwater run-off. The environment differs at the mouth and mid reaches and in these 2 areas diurnal variation in phytoplankton pigments is studied during 3 seasons of the year 1971-72. Mean values of total chlorophyll over a period of 24 hr show that in the mouth and mid reaches there is a minimum concentration of chlorophyll during monsoon month and maximum during premonsoon. The magnitude of diurnal variation in chlorophyll at mouth is 0.82 to 7.53 mg/m<sup>3</sup> in monsoon, 1.66 to 4.71 mg/m<sup>3</sup> in postmonsoon and 2.21 to 7.77 mg/m<sup>3</sup> in premonsoon; the values for mid reaches (station 2) are 2.22 to 8.17 mg/m<sup>3</sup> in postmonsoon and 3.60 to 10.92 mg/m<sup>3</sup> in premonsoon. These studies indicate a strong influence of tidal conditions on chlorophyll concentration, and higher concentration of chlorophyll is noticed at low tide with lower salinity values. At both the points chlorophyll a is dominant. The ratios of chlorophyll a to chlorophyll c and that of chlorophyll a to carotenoids are fluctuating but invariably more than 1 which indicate that phytoplankton is active for photosynthesis.

MANDOVI estuary, one of the two main estuaries of Goa, has a heavy freshwater run-off. It is connected with the other large river Zuari through Cumbarjua canal on one side and opens into the Arabian Sea very close to the opening of the river Zuari. This is a positive estuary influenced by semidiurnal tides, which make the environment highly dynamic. Certain aspects of diurnal variation of this estuary have been reported by Dehadrai<sup>1</sup> while Dehadrai and Bhargava<sup>2</sup> have given the monthly variation in chlorophyll. Barring these, no data are available from these waters. Qasim and Reddy<sup>3</sup> and Shah<sup>4</sup> have studied the pigment distribution in the Cochin backwaters and off Cochin respectively.

The present investigations are carried out to study the diurnal variation in phytoplankton pigment which is one of the major factors responsible for the changes in photosynthesis and primary production. These investigations form part of the Institute's programme to study the ecology and marine living resources of Mandovi and Zuari estuarine ecosystem.

## Materials and Methods

Two stations were selected for this study, one was very near the mouth of the river and the other in mid reaches of the river, about 7 km away from the first station (Fig. 1). From these 2 stations, surface samples at intervals of 3 hr were collected for 24 hr. The observations were made once corresponding to each season, monsoon, postmonsoon and premonsoon. The day and dates were so fixed that the tides were maximum for that month. Observations were made in August and December 1971 and in May 1972. The average depths at these two stations were 8 and 3.5 km respectively. The difference in collection time at the two stations was about 30 min.

The sampling procedure included collection of surface water by a plastic bucket for temperature, salinity and dissolved oxygen measurements.

For pigment analysis 500 ml of water was filtered through a membrane filter of pore size 0.45  $\mu$ . soaked with 1% MgCO<sub>3</sub>. Due to high turbidity, specially during the monsoon months, it was not convenient to filter more than 500 ml of water without causing undue delay. Chlorophyll (chl.) and carotenoid contents were then determined after Richard with Thompson<sup>5</sup> on a VSU-2P spectrophotometer using the equation of Strickland and Parsons<sup>6</sup>.

The time and tidal height mentioned here are according to the Indian Tide Table.

## Results

*Monsoon* - During monsoon, only station 1 was covered on 6/7 August 1971 at 3 hr intervals starting from 0815 hArs. The results are shown in Fig. 2. Temperature varied between 27.8° and 29°C with peak at 1715 hrs; the salinity showed large variations according to the tides and varied from 2.45 to 18.7‰. Low tide conditions were encountered

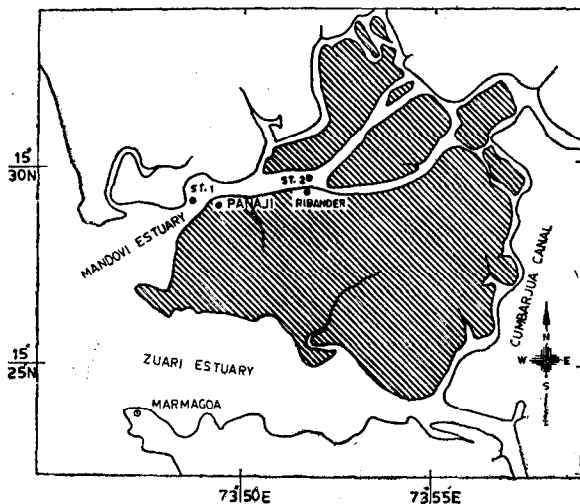


Fig. 1 — Location of stations in Mandovi estuary

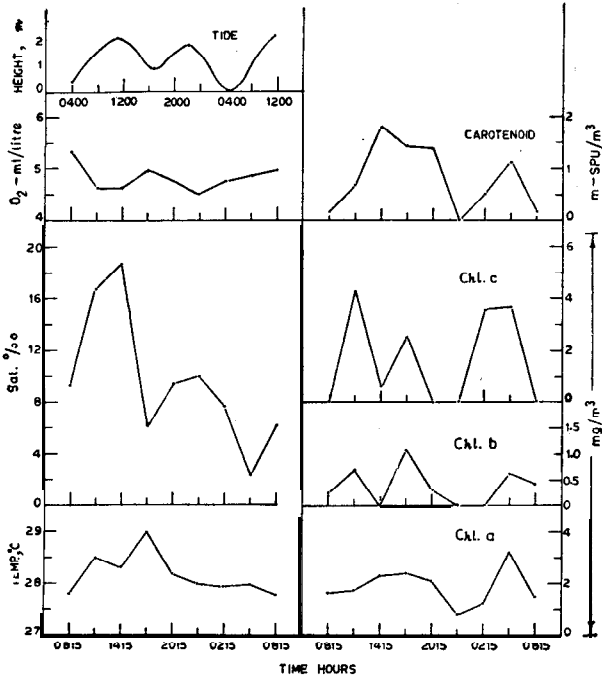


Fig. 2 -Variation in hydrographic features and pigments at station 1 during monsoon

3 times during 24 hr period at 0815, 1715 and 0515 hrs when the salinity went down reaching its minimum at 0515 hrs. Maximum salinity observed was 18.69‰ at 1415 hrs with secondary and tertiary peaks at 2315 and 0815 hrs respectively. The dissolved oxygen varied from 4.52 to 5.34 ml/litre showing a reverse trend to salinity.

The range of chl. a, b, c and carotenoid found were 0.82 to 3.23, 0 to 1.09, 0 to 4.34 mg/m<sup>3</sup>, and 0 to 1.84 mSPU/m<sup>3</sup> respectively (Fig. 2). The maximum concentration of chl. a was observed in the early hours of the morning at 0515 hrs with a second maxima at 1715 hrs. The high values of chl. c occurred at the same time of the day. The extract probably also included inactive chl. and other similar material present in the turbid waters<sup>3</sup>. The trend of chl. b and c and carotenoid was similar to that of chl. a. The total chlorophyll was inversely related to salinity. The higher the temperature and oxygen, lower was the salinity. This combination led to a greater concentration in total chlorophyll (Fig. 2, Table 1). Table 1 (i) shows the percentages of chl. a, b and c and carotenoid contents and the ratios of chl. a to chl. c and chl. a to carotenoid. The ratios are highly fluctuating and always greater than one.

*Postmonsoon* — In this season 2 stations about 7 km apart as shown in Fig. 1 were covered. The observations were made on 2nd and 3rd December 1971.

The temperature was lower than the earlier season and it showed small variations at both the stations. The minimum and maximum temperature was noticed in morning and in the afternoon and ranged between 25.5° and 26.5°C (Figs. 3 and 4). The salinity was higher at station 1 where typical estuarine conditions prevailed and varied between 28.17 and 34.4‰. At station 2 the minimum (20.08‰) and maximum (33.28‰) salinities were observed at low and high tide respectively. The dissolved

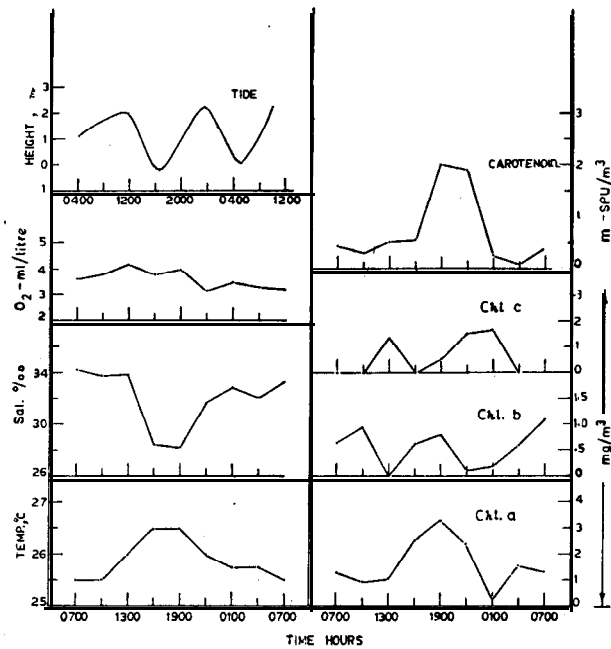


Fig. 3 — Variation in hydrographic features and pigments at station 1 during postmonsoon

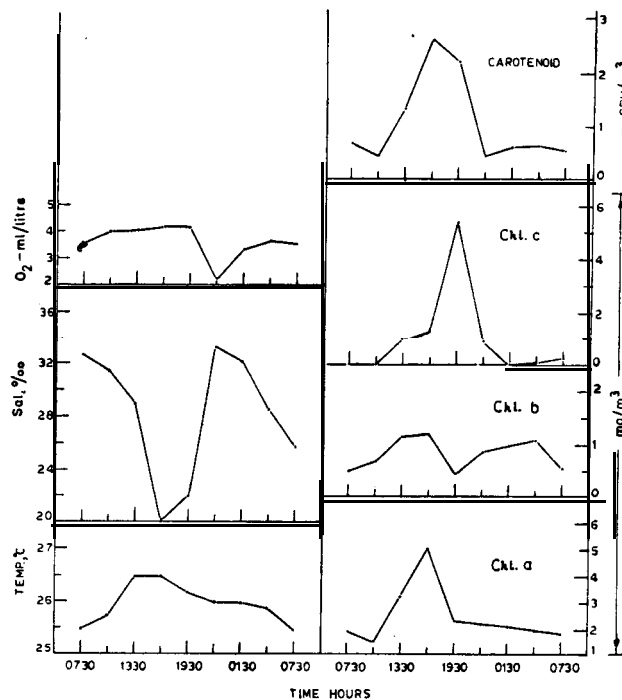


Fig. 4 — Variation in hydrographic features and pigments at station 2 during postmonsoon

oxygen value varied between 3 and 4 ml/litre at both the stations with a single exception at 2230 hrs at station 2 when it dropped down to 2.24 ml/litre. Here the low oxygen value was found when the tide was high and salinity was maximum.

The distribution of plant pigments is shown in Figs. 3 and 4. Total chlorophyll, along with the percentages of different pigments and ratios are given in Table 1 (ii). The values of chl. a, b and c were higher at station 2 than at station 1, and at both the stations total chlorophyll as well as chl. a was

## BHARGAVA: DIURNAL VARIATION IN PHYTOPLANKTON PIGMENTS

TABLE 1—DISTRIBUTION OF PLANT PIGMENT AND THEIR RATIOS AT (i) STATION 1 DURING MONSOON, (ii) STATIONS 1 AND 2 DURING POSTMONSOON. AND (iii) STATIONS 1 AND 2 DURING PREMONSOON

Sampling time hrs	Total chlorophyll (a+b+c) mg/m <sup>3</sup>	Percentage in total chlorophyll				Ratios	
		Chl. a	Chl. b	Chl. c	Carotenoid mSPU/m <sup>3</sup>	a/c	a/car.
(i) MONSOON							
Station 1							
0815	1.91	85.86	14.14	—	0.16	—	10.25
1115	6.77	25.40	10.48	64.10	0.69	0.39	2.49
1415	2.92	78.77	—	—	1.84	3.71	1.25
1715	4.99	47.70	1.80	21.3 50.50	1.47	0.95	1.62
2015	2.44	86.89	13.11	—	1.41	—	1.50
2315	0.82	100.00	—	—	—	—	—
0215	4.84	25.83	8.63	74.17	0.53	0.35	2.36
0515	7.53	42.90	—	—	1.17	0.89	2.76
0815	1.88	78.19	21.81	—	0.16	—	9.18
(ii) POSTMONSOON							
Station 1							
0700	1.96	66.84	33.16	—	0.45	—	2.91
1000	1.66	57.23	42.77	—	0.32	—	2.97
1300	2.44	44.26	20.25	55.73	0.94	0.77	1.94
1600	3.16	79.75	—	—	0.61	—	4.13
1900	4.71	70.49	18.26	11.25	2.03	6.26	1.64
2200	4.10	58.78	2.93	38.29	1.90	1.54	1.27
0100	2.15	11.16	9.77	70.07	0.29	0.14	0.83
0400	2.14	71.96	20.04	—	0.11	1.54	14.00
0700	2.43	54.73	45.27	—	0.42	1.33	3.17
Station 2							
0730	2.45	79.59	20.41	—	0.69	—	2.83
1030	2.22	68.92	31.08	—	0.45	—	3.40
1330	5.42	59.78	21.40	18.82	1.33	3.18	2.44
1630	7.61	66.76	16.03	17.21	2.64	3.85	1.91
1930	8.17	28.57	5.74	65.69	2.22	0.43	1.05
2230	4.07	55.77	21.62	22.60	0.45	2.47	5.04
0130	3.19	68.65	31.35	—	0.62	—	3.53
0430	3.25	62.77	34.46	2.77	0.64	—	3.19
0730	2.70	70.37	21.11	8.52	0.56	8.26	3.39
(iii) PREMONSOON							
Station 1							
0800	4.50	100.00	—	—	0.37	—	12.16
1100	4.67	90.58	—	9.42	1.28	9.61	3.30
1400	7.77	44.27	—	55.73	2.22	0.77	1.55
1700	3.83	96.87	3.13	—	1.36	—	2.72
2000	2.75	100.00	—	—	3.25	—	0.85
2300	2.50	100.00	—	—	1.01	—	2.77
0200	2.21	100.00	—	—	0.16	—	13.81
0500	5.55	53.87	—	46.13	2.08	1.17	1.47
0800	5.73	100.00	—	—	1.70	—	3.37
Station 2							
0830	10.92	78.75	—	21.75	1.99	3.71	4.32
1130	8.55	76.14	—	23.86	2.21	3.19	2.95
1430	3.66	76.50	—	23.50	0.62	3.26	4.52
1730	7.50	59.47	—	40.53	2.45	1.47	1.86
2030	8.87	64.71	1.24	34.05	2.03	1.98	2.87
2330	4.23	68.09	—	31.91	2.08	2.13	2.27
0230	4.02	56.97	—	43.03	1.01	1.32	2.27
0530	8.23	69.50	—	30.50	2.50	2.28	2.29
0830	7.23	89.35	—	10.65	1.82	8.39	3.55

maximum in the evening and this peak is related to low salinity. The same trend was observed during monsoon also as described earlier. As regards the ratio of chl. a to chl. c and chl. a to carotenoid it was fluctuating and greater than one as in monsoon.

Premonsoon — The observations were made on 17/18th May 1972 at the same 2 stations. At this

time the hydrographic conditions remained more or less uniform. The temperature ranged between 28° and 29°C at station 1 while it varied from 28.30 to 30.05°C at station 2 (Figs. 5 and 6).

The salinity values showed similar trends at the 2 stations. At station 1, which is more influenced by the intrusion of sea water than station 2, the

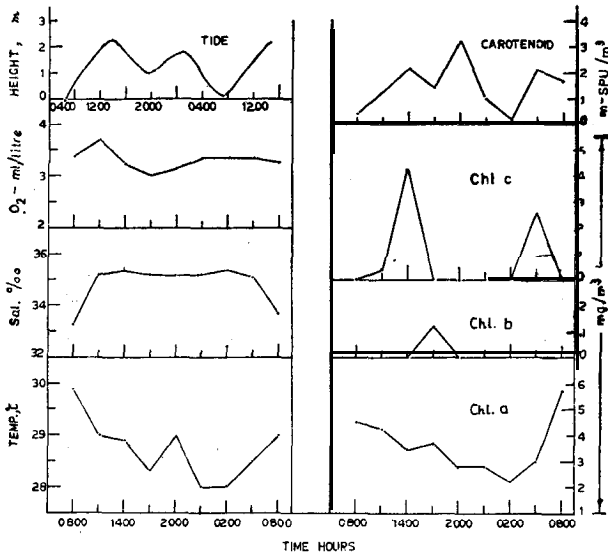


Fig. 5 -Variation in hydrographic features and pigments at station 1 during premonsoon

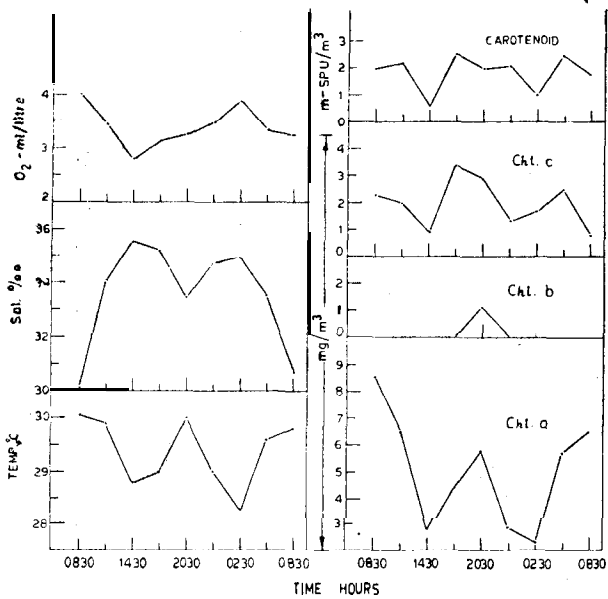


Fig. 6 - Variation in hydrographic features and pigments at station 2 during premonsoon

salinity varied from 33.25 to 35.33‰. At station 2 the maximum was almost the same while the minimum reached as low as 30.1‰ during low tide. The values of dissolved oxygen varied between 3.7 ml/litre at station 1 and 2.8 and 4.05 ml/litre at station 2.

The pigment distribution is shown in Figs. 5 and 6 at the two stations. At both the stations chl. a was maximum in the morning and minimum at midnight. At station 2 this peak was more pronounced. These peaks were found to be related to low tide hours with low salinity irrespective of the time of the day. Chl. b at both the stations was negligible and below detection limit. This probably may be due to the dominance of diatoms which contain very little of chl. b. Chl. c also was negligible during most of the time at station 1 and at station 2 it varied

from 0.8 to 3.4 mg/m<sup>3</sup>. but was always less than chl. a.

Carotenoid at station 1 varied from 0.16 to 3.25 mSPU/m<sup>3</sup>. Once at 2000 hrs it exceeded the value of chl. a. This may be attributed to possible mixing and sediment coming in, thus increasing the value of carotenoid with other pigments<sup>3</sup>. At station 2 there were not marked variations and the low values of carotenoids coincide with minimum values of chl. a.

The total chlorophyll shows moderate values at station 1 and higher values at station 2, particularly at the time of low salinities [Table 1, (iii)]. At both the stations chl. a dominated. Once at 1400 hrs chl. c exceeded the value of chl. a at both the stations and the ratio of chl. a to chl. c was less than 1. The ratio of chl. a to carotenoid at station 1 was unusually high at 0800 and 0200 hrs (otherwise ranged between 0.85 and 3.5) while at station 2 it was always more than one and reached its maximum to 4.32.

**Discussion**

The phytoplankton crop consisted mostly of diatoms and dinoflagellate. The mean chlorophyll (mg/m<sup>3</sup>) for the day (24 hr) at 2 stations in different seasons was as follows:

Season	Station1	Station2
Monsoon	3.79	—
Postmonsoon	2.79	4.34
Premonsoon	4.53	7.02

It is thus seen that the total chlorophyll concentration at station 2 was higher than at station 1. The average concentration of chlorophyll was maximum in the premonsoon season. From the foregoing account it is observed that the dominant pigment was chl. a and the peak of chlorophyll is related to lower salinity during all the 3 seasons. This shows that freshwater flora was probably richer in chlorophyll. Dehadrai<sup>1</sup> has also pointed out that the flora is dominant when the salinity is low in Mandovi estuary. Yentsch and Ryther<sup>7</sup> and Yentsch and Scagel<sup>8</sup> have attributed light as the factor responsible for the diurnal distribution of chlorophyll but it seems in this estuary the tidal changes dominate the light conditions as the quantity of chlorophyll is more influenced by the ebb and flood tides rather than light.

The ratios of chl. a to chl. c and chl. a to carotenoid are highly fluctuating at both the stations during all the seasons particularly in monsoon and postmonsoon. Such fluctuating ratios were also reported by Yentsch and Scagel<sup>8</sup> in the waters of East Sound, Washington. The lower ratio of chl. a to carotenoid indicates an unhealthy and chlorotic phytoplankton population<sup>9</sup>. In the present study this ratio was always found to be greater than 1 which is supposed to be a prerequisite for the good physiological state of phytoplankton. However, due to turbidity and suspended matter particularly during monsoon months, it is difficult to say that chlorophyll remains active and healthy and how much of this pigment comes from living organisms alone and what part is contributed by detritus and other particulate matter. It is, therefore, necessary to study in greater detail the different aspects before coming to a definite conclusion.

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