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PRIMARY PRODUCTIVITY IN POLLUTED ENVIRONMENTS OF BOMBAY

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ABSTRACT

The coastal areas of Bombay are generally turbid and the euphotic zone in these waters hardly exceeds 6 m. Primary productivity is largely confined to surface layers. Nearshore polluted stations have low values of dissolved oxygen, salinity and pH. Nutrients, on the other hand, are high. Carbon assimilation in these polluted environments was high and the values ranged from 19.92 mg C $m^{-3} d^{-1}$ in July (st-1) to 2868.60 mg C $m^{-3} d^{-1}$ in April (st-4). Concomitant to this, the environmental conditions towards the offshore in the cleaner zone, were characterised by high dissolved oxygen, salinity and comparatively low nutrients, indicating low productivity. Primary productivity in these areas was 16.86 mg C $m^{-3} d^{-1}$ in October (station-3). Column production for all the four stations ranged from 10.32 to 2511.30 mg C $m^{-2} d^{-1}$. A direct co-relation was found between nutrients and productivity values.

INTRODUCTION

Reports on the primary productivity of coastal waters of Bombay are limited (Krishnamoorthy and Vishwanathan, 1968; Bhattathiri and Devassy, 1977; Abidi, 1981 and Varshney et al., 1983). The present study is the first detailed account on the primary production in the coastal waters of Bombay in relation to the prevailing environmental conditions.

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MATERIALS AND METHODS

Four stations were selected at three different locations. Two stations (1 & 2) were in the Versova region while one each was at Mahim (3) and Thana (4). The stations 1 and 4 were close to the coast and were highly polluted, while the stations 2 and 3 were relatively in the clean zone. The locations of the four stations are shown in Fig.1. The stations 1 was inside the creek while station

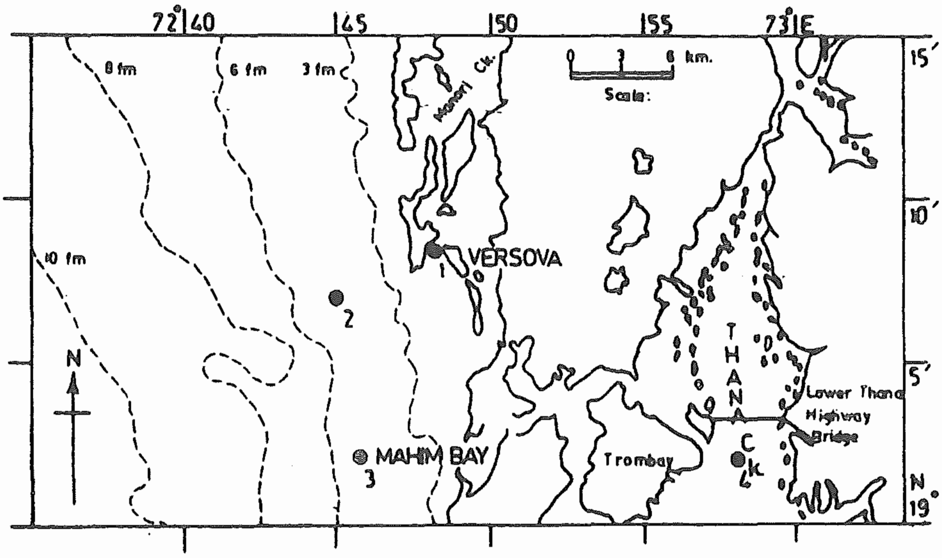

Fig.1 : Map showing the location of Stations.

2 in Versova was at a distance of about 1 km from the station 1 towards offshore. The station 4 was about 2 km from the Apsara reactor in the Thana creek. The depth at these stations varies from 6 to 12 m. Primary production was estimated by ^{14}C method adopting the insitu incubation(Vollenweider, 1974 and Strickland & Parsons, 1968). Monthly observations were made at all the stations from January 1980 to December, 1980. Because of navigational difficulties, samples could not be collected in June and July at the station 1 and in June at the other stations

Samples were taken from three depths where the light penetration was 100%, 30%, and 1% and were incubated accordingly for 4 hours. Radioactivity was determined in a G.M. counter and the efficiency of the counter was determined by a comparison with the liquid scintillation system. The counts were corrected for dark uptake and respiration and daily production rates were estimated. By integrating the values for the different depths, production rate for the water column was obtained. Salinity, oxygen, nitrate and phosphate were estimated following the standard method (Strickland and Parsons, 1968).

RESULTS

Physicochemical parameters and rate of production are presented in Fig.2 and Tables 1 & 2 respectively. The variations

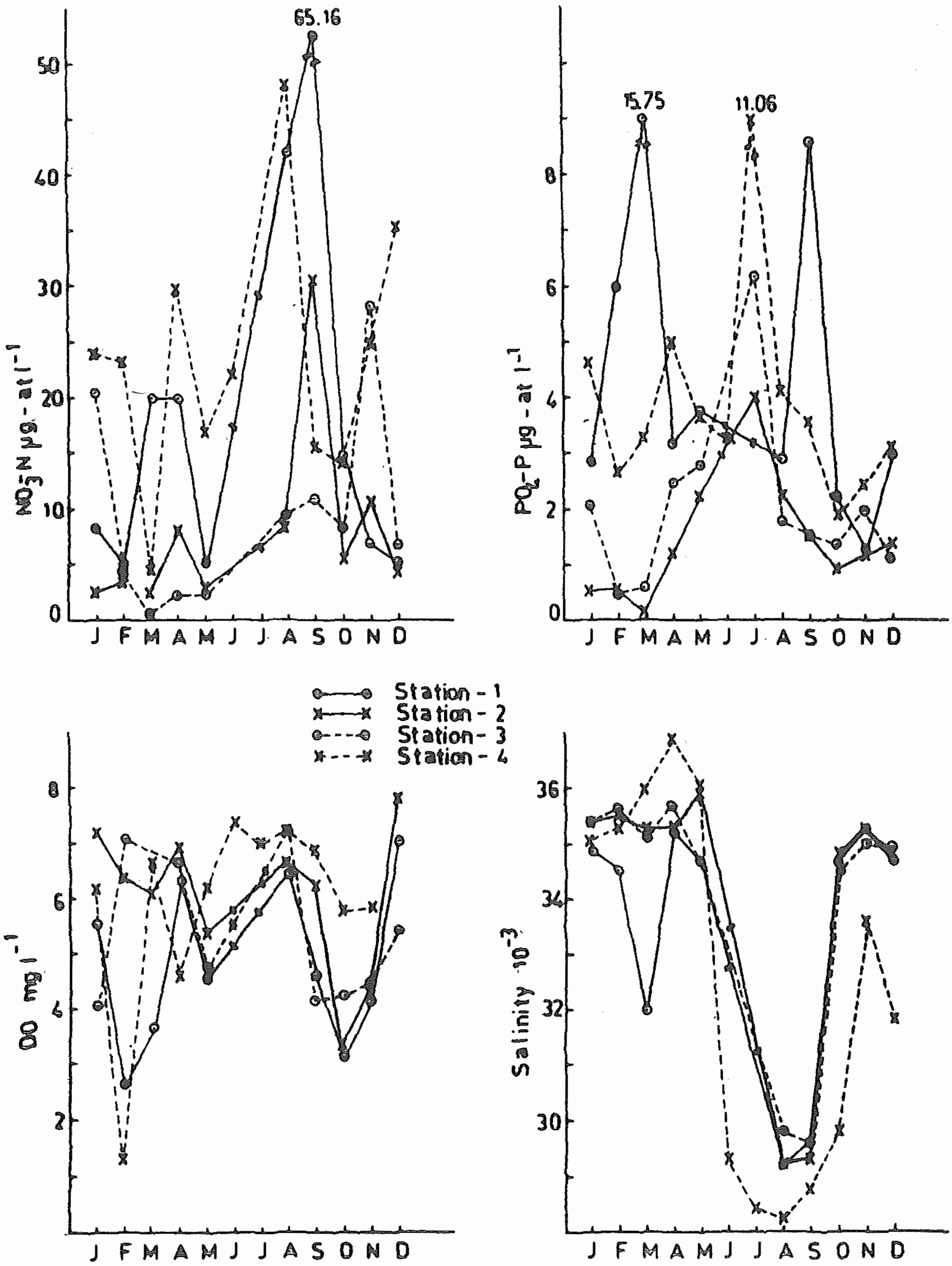

Fig. 2 : Variations in Physico chemical parameters.

TABLE 1 : PRIMARY PRODUCTIVITY OFF BOMBAY

	STATION 1 (Polluted) ($mg\ C\ m^{-3}\ d^{-1}$) LIGHT PENETRATION			STATION 2 ($mg\ C\ m^{-3}\ d^{-1}$) LIGHT PENETRATION			STATION 3 ($mg\ C\ m^{-3}\ d^{-1}$) LIGHT PENETRATION			STATION 4 (Polluted) ($mg\ C\ m^{-3}\ d^{-1}$) LIGHT PENETRATION		
	1 100%	30%	1%	100%	30%	1%	100%	30%	1%	100%	30%	1%
Jan.80	233.88	115.80	28.14	16.86	1.14	0.08	764.76	447.36	18.48	75.96	24.00	17.10
Feb.	535.38	37.19	44.34	18.90	2.16	1.92	64.62	45.06	10.62	510.42	433.80	356.52
Mar.	1682.94	443.82	145.08	48.60	12.48	0.92	148.86	72.36	55.70	567.12	375.30	130.74
Apr.	2868.60	961.80	115.08	102.48	55.14	11.46	80.52	58.86	22.74	132.18	75.84	85.68
May.	147.60	123.64	84.00	139.98	130.14	50.28	738.66	471.30	56.22	373.74	730.20	491.82
Jun.	-	-	-	-	-	-	-	-	-	243.72	127.26	85.60
Jul.	-	-	-	21.24	6.00	2.88	61.32	70.82	35.82	19.92	3.96	24.60
Aug.	151.50	196.02	66.48	92.04	31.06	34.50	29.34	9.36	3.78	38.88	27.54	22.20
Sep.	138.96	88.20	26.88	43.86	30.48	20.94	72.30	58.08	17.76	209.82	116.94	86.26
Oct.	127.38	95.58	73.14	128.94	93.24	82.44	880.92	208.18	260.34	657.72	986.40	70.84
Nov.	368.70	186.36	48.36	44.28	19.38	14.10	270.32	172.32	53.20	126.90	49.86	48.30
Dec.	41.88	39.36	26.94	124.68	4.22	1.86	128.22	48.42	37.92	96.42	65.22	58.56

TABLE 2 : COLUMN PRODUCTION (mg C m^{-2} d^{-1}) DURING 1980

Month/Station		2	3	4
Jan. 80	210.81	10.32	643.14	91.08
Feb.	461.14	18.26	186.45	631.22
Mar.	826.14	21.96	119.09	732.94
Apr.	2264.74	145.41	151.29	199.15
May.	164.49	236.61	716.25	1330.40
Jun.	–	–	–	298.78
July	–	12.67	86.25	16.20
Aug.	159.63	354.28	64.98	32.47
Sep.	228.65	110.79	176.39	366.60
Oct.	140.10	215.08	849.80	2511.30
Nov.	260.63	65.31	446.10	93.27
Dec.	53.46	85.53	214.55	162.30

in the physico-chemical parameters were not large and hence the values given in the figures are for the surface. Coastal waters of Bombay are very turbid because of high suspended load resulting from the discharge of sewage and industrial waste. Varshney (1985) and Prasad (1983) have stated that high current speed at the bottom contributes to the stirring up of the sediments. Maximum euphotic depth of 6 m was observed in August at the stations 2 and 3. During the monsoon, salinity was very low and range from 5.26 to $28.41^{-10^{3}}$ while during the pre and post monsoons; it range from 31.98 to $36.06^{-10^{3}}$ and 28.33 to $35.43^{-10^{3}}$ respectively. The range of dissolved oxygen was from 1.34 mg 1^{-1} (St - 4) to 7.86 mg 1^{-1} (St - 2). Relatively low values of oxygen were obtained from station 1. Relatively high values of nutrients (nitrates and phosphates) and low values of oxygen were recorded from polluted stations 1 and 4. There was no consistency in the values of different parameters with seasons.

Station 1 : Production rates of all the stations are given in Tables 1 & 2. The range in surface production was 41.88 in December to 2,668.60 mg c m^{-3} d^{-1} in April, at this station. In the month of March also, the rate of production was high, i.e. 1,682.94 - mg C m^{-3} d^{-1}. A gradual reduction in the rate of carbon assimilation was noticed at 30% and 1% light depths, except in the month of February, 1980, when it was high at 1% light depth.

Maximum production was observed in March and April. High values of nutrients coincided well with high production. Overall high production was observed during the premonsoon (Fig.3).

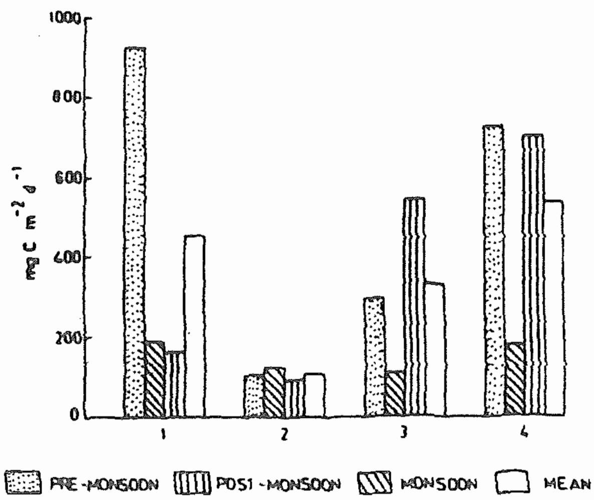

Fig.3 : Seasonal variations in Primary Production.

Station 2 : Rate of carbon assimilation was very low at this station. It fluctuated from 16.86 in January to 139.98 mg C m^{-3} d^{-1} in May for surface. At this station also sometime high values were observed at 1% light depth. A second peak of production of 128.98 mg C m^{-3} d^{-1} was noticed in October. No consistent relationship between nutrients and production could be observed. At 30% and 1% light production the rate of carbon assimilation follows the trend in surface production. Compared to station 1 the rate of production was poor. Mean production was high during the monsoon.

Station 3 : The range in primary productivity was 61.32 to 880.92 mg C m^{-3} d^{-1} at surface in the months of July and October respectively. High values of 764.76 and 738.86mg C^{-3} d^{-1} were also observed in the months of January and May respectively. Subsequently the rate of production was high at 30% and 1% light depth. Production was high during the postmonsoon period.

Station 4 : At this station carbon assimilation varies from 19.22 mg C m^{-3} d^{-1} in July to 657.72 mg C m^{-3} d^{-1} in October for surface. Two peaks were noticed in the months of February (510.42 mg C m^{-3} $^{-1}$) and March (567.12 mg C m^{-3} d^{-1}). Abnormally high values of 730 and 986.40 mg C $m^{-3}d^{-1}$ at 30% light penetration and 491.82 and 702.84 mg C $m^{-3}d^{-1}$ at 1% light depth were recorded in the months of May and October respectively irrespective of surface production. Overall high production was observed during premonsoon and moderate values were noticed during post monsoon.

DISCUSSION

Study of environmental parameter indicated that the nearshore stations 1 and 4 were polluted compared to offshore stations 2 and 3. Low values of dissolved oxygen and higher values of nutrients at Stations 1 & 4 indicate the deterioration of environment. Concomitant to this environmental conditions were comparatively better towards offshore stations 2 & 3, with optimum DO and low values of nutrients, represents a healthy clean zone. Zingde, 1980 and Varshney, 1982 have also reported high values of nutrients, low dissolved oxygen and 100 mg 1^{-1} of BOD off Bombay.

Light penetrations as measured by Seechi disc was limited to a very narrow zone in this area and comparable to the nearshore waters of Thal, Maharashtra (Varshney, Nair and Abidi, 1983). It appears, influx of sewage water, tidal effects and high bottom currents make the water turbid in the coastal regions resulting in reduction of the compensation depth.

Polluted stations 1 & 4 sustained high production (Table 3). Rate of production was moderate at stations 2 and 3. Maximum

TABLE 3 : RELATIONSHIP OF CARBON ASSIMILATION AND NUTRIENTS

Station	Primary Production mg C $m^{-2}d^{-1}$	PO_4 - P µg -at l^{-1}	NO_3-N µg -at l^{-1}
1	474.08	3.65	10.89
2	106.92	1.15	5.66
3	332.20	1.59	9.49
4	533.82	4.00	23.14

mean column productions were 533.82 mg C $m^{-2}d^{-1}$ at Stn. 4 followed by 1 (474.08), 3 (332.20) and 2 (106.92) . Phytoplankton species of euryhaline nature were also found in the nearshore water of Bombay (Abidi, 1981). Due to the external interferences and discharges in the coastal waters of Bombay no clearcut seasonal difference could be observed. But high production observed in the month of October at Stations 3 and 4 and in April and May at Station 1 and 2 respectively.

Maximum uptake was recorded at surface except in some instances where it was at 30%. Invariably high values at 30% and 1% depths at station 2 perhaps seems to be due to high currents, the experimental bottles and come to surface and exposed to more light. Similar instances of higher production at a few meters below surface were reported for Thal region in Maharashtra coast (Varshney, Nair and Abidi, 1983) and Palk Bay (Prasad & Nair, 1963).

Previous studies on the measurement of primary production for unpolluted nearshore waters of Thal, Maharashtra coast showed a variation of 0.69 to 605.21 mg C $m^{-2}d^{-1}$ with an average value of 78.2 mg c $m^{-2}d^{-1}$ (Varshney, Nair and Abidi, 1983). Maximum production was reported in August. In the present investigation the column production (Table II) was comparatively high with respective mean values of 474.08, 106.92, 332.20 and 533.82 mg C $m^{-2}d^{-1}$ at stations 1,2,3, and 4. Krishnamoorthy and Viswanathan 1(1968) reported variation of 0.015 to 4.99 g $Cm^{-3}d^{-1}$ with maximum production in February for the harbour area of Bombay. Results of present study were comparable to this study.

It has been observed that the rate of production was high in polluted zones (Stns. 1 & 4). Ketchum, (1973) also reported that the productivity may be high in polluted environments with less species diversity. Perhaps higher concentrations of nutrients in these localities (Table 3) due to sewage discharge must have contributed to enhanced productivity. Qasim & Joseph (1975) while conducting experiments on utilization of Nitrates and Phosphate by Green Algae Tetraselmis gracilis also observed the high rate of growth with the medium of high nutrients. Low values of productivity synchronised with low values of nutrients as observed for Thal region (Varshey et. at., 1983)

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