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CHLOROPHYLL a AND PHEO - PIGMENT AS INDICES OF BIOLOGICAL PRODUCTIVITY IN THE INSHORE SURFACE WATERS OFF COCHIN

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ABSTRACT

Estimations of surface chlorophyll *a* and pheo-pigment concentrations were made at two stations (10 and 20m) in the inshore waters off Cochin which are correlated with related environmental parameters. In 1987 the maximum chlorophyll *a* production in both the stations was during pre-monsoon (2.3 and 2.1 mg/m^3) while in 1988 it was during post monsoon period (3.4 and 3.2 mg/m^5). In general a considerable reduction in overall production was noticed in 1987 over 1988, particularly during both monsoon and post-monsoon periods. The total annual chlorophyll *a* production was found to be 38.4 mg/m^3 in 1987 whereas in 1988 it was 62.2 mg/m^5 adding stations I & II together. The total annual pheo-pigment production was estimated to be 37.2 mg/m^3 for stations I and II put together in 1988, contributing about 62% of chlorophyll *a*. As regards the environmental parameters, nutrients, especially phosphate showed positive correlation and nitrite negative relation to chlorophyll production. Variations in the observed values during 1987and 1988 are attributed to the intensity of monsoon rain fall and the freshwater discharge from the river and lake system.

INTRODUCTION

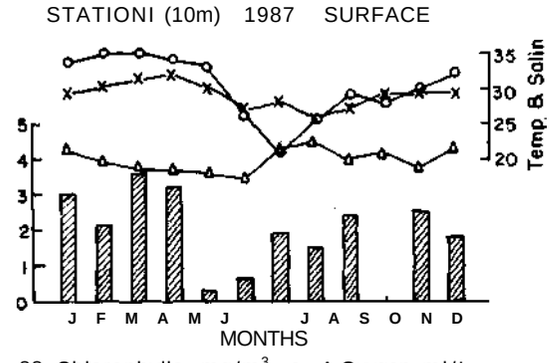
Extensive studies have been carried out on various aspects of primary production and related parameters in the Cochin back waters and Vembanad lake (Qasim *et al., 1967,* 1969, 1973;Gopinathan,1972,1874;Nairef«/.(1975). Gopinathan (1981) measured the primary production of the inshore waters off Cochin based on organic carbon(^{14}C) and cell counts. Nair *et al.* (1985) have examined the chlorophyll and pheo-pigment contents in the waters of fishing grounds off Cochin for post-monsoon seasons in 1980,1981 and 1982. In recent years the remote sensing technology is used as the most powerful tool for scanning surface chlorophyll over vast areas for which the acquisition of sea truth data on chlorophyall is very essential and useful (Narain *et al*, 1985; Neera Chaturvedi *et al.* ,1985; Dwivedi *et al.,* 1985). However, so far there is no information on the seasonal fulctuations in the rate of production based on chlorophyll *a* in the inshore fishing grounds off Cochin. The present account embodying the result of an investigation of primary production and related parameters in the sea off Cochin during 1987 and 1988 is expected to fill up the gaps in our knowledge.

MATERIAL AND METHODS

The study was carried out in the inshore waters off Cochin upto 20 metre depth zone during 1987-'88. Two stations were fixed, one at 10 metre and the other at 20 metre depth in the fishing grounds. Weekly/fortnightly surface collections were made during the year 1987 for the study of chlorophyll a, temperature, salinity and oxygen. Observations on pheo-pigments and nutrients (phosphate and nitrite) were also made during the year 1988 in

addition to the above parameters. Chlorophyll *a* and pheo-pigments were determined by trichromatic method of Richards and Thomson as modified by Parsons and Strickland (1963) and estimated using the revised formula of Strickland and Parsons (1968). Oxygen, salinity and nutrients were determined by standard methods.

The data obtained have also been pooled for three seasons i.e., pre-monsoon (February - May), monsoon (June-September) and post-monsoon (October-January) and the results are also discussed.



Fie. 1. Monthly variations of cholophyll *a* temperature, salinity and oxygen at station I (10 m) during 1987 (surface).

RESULTS

Temperature

The monthly variations of surface temperature recorded from two stations (10 and 20 m) for the years 1987 and 1988 are given in Figures 1,2,3 and 4. The temperature in station I during 1987 fluctuated from 26°C in August to 31.6°C in April whereas the minimum and maximum temperature recorded for 1988 in 10 m station were 24.6° C in July and 30.9° C in April respectively indicating a lower trend of temperature in the latter year. A marked increase in temperature by about 3.5° C was observed in July, 1987 in station I (28° C) compared to the same month in 1988 (24.6° C). The seasonally pooled average data (Fig.5) for 1987 in station 1 showed maximum of 30.5° C during pre-monsoon followed by 29.2° C during post-monsoon and 27° C in monsoon period. Though more or less the same trend was maintained during pre- and post monsoon periods, in 1988 above 1° C decrease in temperature was noticed during monsoon (Fig. 8).

At station II the surface temperature in 1987 ranged from 26.6° C in August to 31.4° C in April while during 1988 the range was 24.5° C in July to 30.5° C in March. As seen from Figure 7, the temperature was maximum during pre-monsoon period. The temperature curves for station II in both the years (1987 and 1988) showed a similar trend, they being maximum during pre-monsoon months extending upto May, minimum during monsoon and moderate during post-monsoon. But slight drop in temperature (about 1.5° C) was noticed during the monsoon period in 1988 than the corresponding period in 1987.

Salinity

The monthly and seasonal data (Figs. 1,2,5 and 6) in station I clearly indicated that there were distinct monthly and seasonal va-iations in salinity during 1987 and 1988. The significant variation in salinity in the surface waters at station I in 1988 over 1987 was a sudden drop in salinity during May and the fluctuations during monsoon and post-monsoon periods. The salinity values recorded during August and September 26‰ and 27 ‰ respectively) were higher than the values of corresponding months 21‰ and 19‰

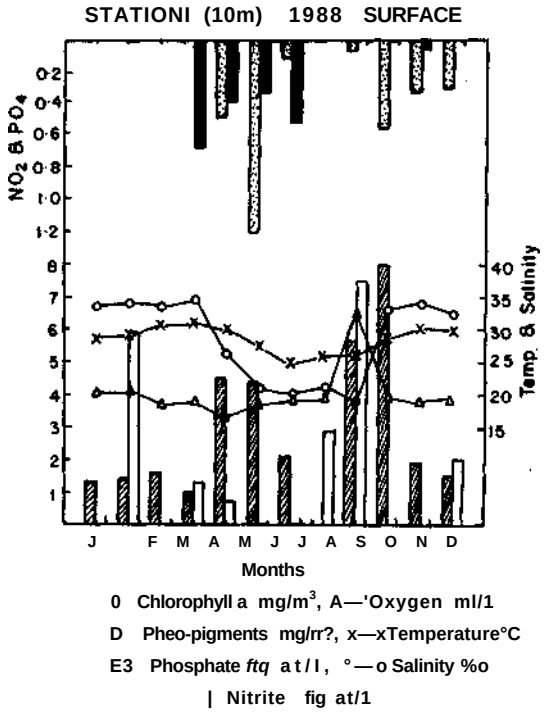
in 1988. The annual range in salinity in station I during 1987 was 21.2 *%o* injuly to 35%o in March and in 1988 it was 19.1 *%o* in September to 35.5 *%o* in January and April.

The seasonally pooled data (Figs. 5& 6) showed that in station I there were variations in salinity during the two years. The pre-monsoon and monsoon salinity values were lower in 1988 than 1987. However, the post-monsoon period recorded higher valueinl 988 than the corresponding period in 1987. A decrease in salinity of the order of 3.7 *%o* during monsoon (June-September) period was observed in 1988 over that of 1987.

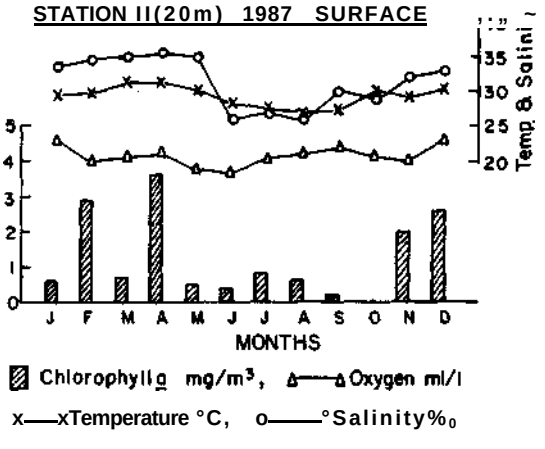
The monthly salinity fluctuations in station II (20 m) during 1987 and 1988 are given in Figures 3 & 4. As in station I, here also the monthly variations were quite pronounced between the two years. The salinity value in 1987 ranged from 26%o in June-August 135 *%o* in April, the range in 1988 being 17.1 *%o* in July to 35.3 *%o* in April. The highest values recorded during 1987 were during March and April whereas the maximumsalinity observed in 1988 were during April and October. In 1987 the salinity started to decrease from June reaching its minimum in August and again reached the maximum in the pre-monsoon period while in 1988 the reduction in salinity was noticed from April and reached the minimum in July. However, from August on wards the salinity values increased until the maximum of 35.3%o has attained in April. The seasonal trend in salinity was the same as in station I for both the years; reduction in values was found during 1988 (Fig. 8).

Oxygen

Dissolved Oxygen did not show much fluctuations in the surface waters at station I during 1987 and 1988 (Figs. 1&2). However,



Fie. 2. Monthly variations of cholophyll *a,* pheo-pigments temperature, salinity phosphate and nitrates at station I (10 m) during 1988 (surface).



Fie. 3. Monthly variations of cholophyll *a,* temperature, salinity and oxygen at station II (20 m) in 1987 (surface).

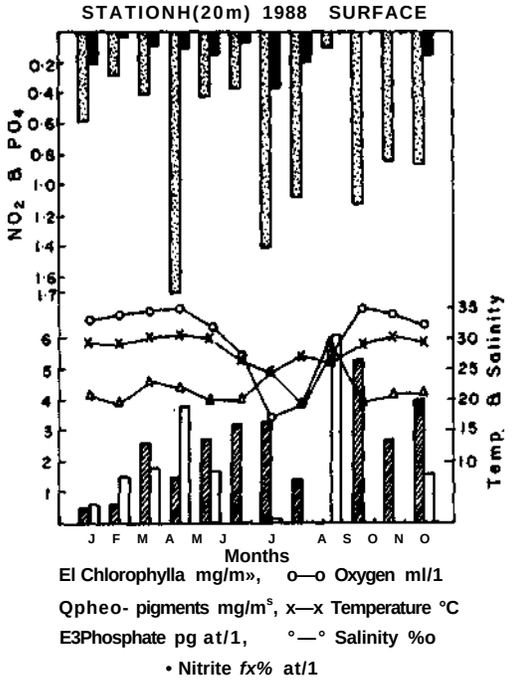


FIG. 4. Monthly variations of cholophyll *a*, pheo-pigments temperature, salinity, phosphate and nitrate at station II (20 m) in 1988 (surface).

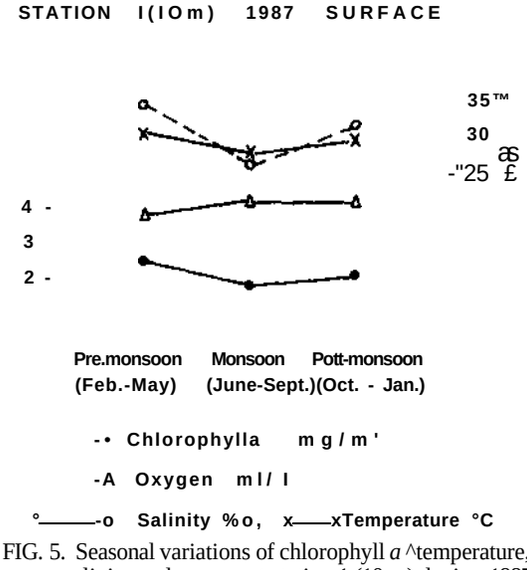


FIG. 5. Seasonal variations of chlorophyll *a* ^temperature, salinity and oxygen at station 1 (10 m) during 1987 (Surface).

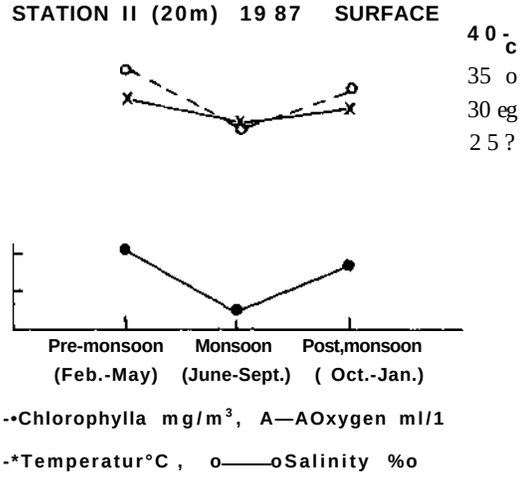


FIG. 6. Seasonal variations of chlorophyll *a* ,temperature, salinity and oxygen at station II (20 m) in 1987 (surface).

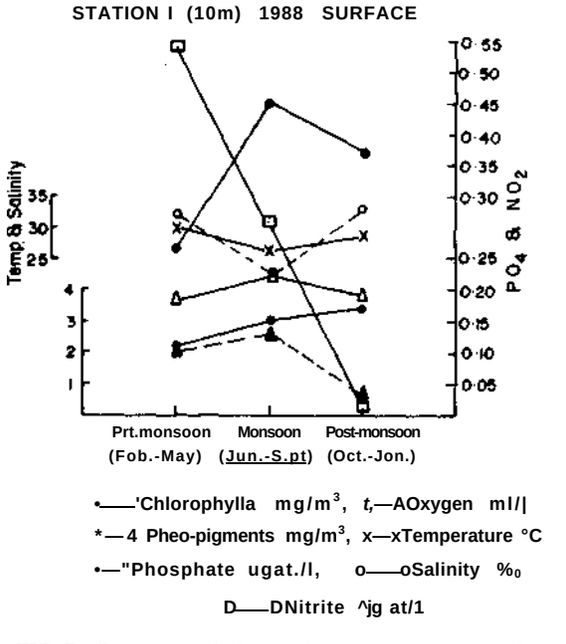


FIG. 7. Seasonal variations of chlorophyll *a*, pheo-pigments, temperature, salinity, oxygen, phosphate and nitrate at station I (10 m) in 1988 (surface).

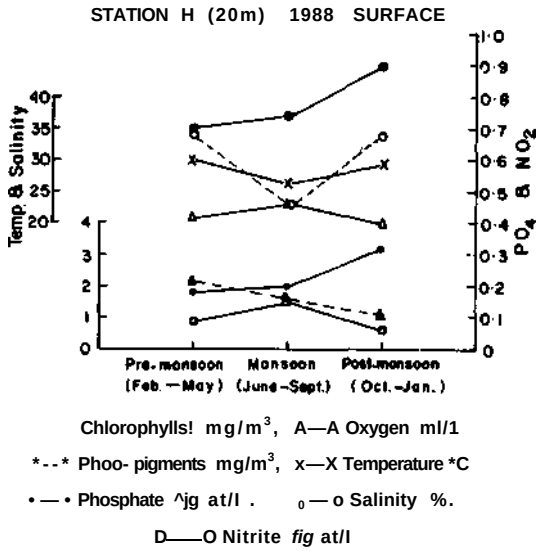


FIG. 8. Seasonal variations of chlorophyll *a*, pheo-pigments, temperature, salinity, oxygen, phosphate and nitrate at station II (20 m) in 1988 (surface).

some variations in oxygen content could be noticed during monsoon months. The oxygen values fluctuated from 3.5 ml/1 in June to 4.5 ml/1 in August during 1987. During 1988 oxygen content did not fluctuate much except a high value of 6.4 ml/1 during September. The minimum value of 3.3 ml/1 was recorded in May. The values of dissolved oxygen for the seasons were 3.7,4.1 and 4.1 ml/1 during 1987 while 3.7, 4.4 and 3.8 ml/1 were the corresponding seasonal values during 1988 (Figs. 5 &6).

In station II (20 m) during 1987, the oxygen values varied from 3.7 ml/1 in June to 4.6ml/l in January/December (Fig.3) indicating less fluctuations. But during 1988 distinct monthly as well as seasonal variations were noticed (Fig.4). Three peaks were observed, 4.6 ml/1 in March, 4.9 ml/1 in July and 5.8 ml/1 in September. A sudden decrease from4.9ml/l in July to3.8ml/l in August was noticed here. The oxygen concentrations for three seasons during 1987 (Fig.7) were almost equal. The oxygen value observed during 1988 monsoon period was higher than the pre and post-monsoon periods (Fig. 8)

Phosphate

The data on inorganic phosphate in station I during 1988 (Fig.2) showed moderate primary and secondary peaks during monsoon and post-monsoon periods. The PO_4 ranged from 0.04 ug at/1 in April to 1.2 ng at /l in June. The values for pre-monsoon, monsoon and post-monsoon seasons were 0.26, 0.45 and 0.37 ug at/1 respectively.

In station II (20 m) there were three distinct seasonal peaks noticed (Fig.4). The maximum value of 1.7 ug at/1 was during April which happened to be primary peak; the secondarypeakbeingduringJuly-August. The third consistant peak was during October-December. Unlike in station I the maximum seasonal PO_4 value of 0.90 ug at/1 observed here was during post-monsoon period; the other seasonal values being 0.74 and 0.70 ug at/1 for monsoon and pre-monsoon periods respectively (Fig.8).

Nitrite

The nitrite concentration in station I showed two peaks (Fig.2); one during April-May and the other during June-July. The highest value of 1.4 ug at/1 was in April. The nitrite values were almost nil during the post-monsoon periods.

In station II (Fig.4) the distribution of nitrite appeared to be of less magnitude ranging from nil to 0.36 ug at/1 when compared to station I especially during monsoon months.

The maximum concentration of 0.36 ng at/1 was during July. Most of the values noticed during post-monsoon months were nil as in station I.

Chlorophyll a. and pheo-pigments

The pattern of monthly distribution of chlorophyll *a* for 1987 and 1988, and the data on pheo-pigments for 1988 are given in figures 1-8.

At station I (10 m) during 1987 the surface chlorophyll *a* production showed wide monthly fluctuation (Fig 1). The chlorophyll *a* values indicated three seasonal peaks, a high primary peakduringpre-monsoonand secondary and tertiary peaks of low orders during monsoon and post-monsoon periods respectively. The highest value of 3.6 mg/m^3 obtained here was in March while the lowest value of 0.24 mg/m^3 in May. The seasonal chlorophylla production in monsoon months was not of high magnitude (ranging 0.64 mg/m^3 in June to 2.4 mg/m^3 in September) averaging 1.6 mg/m^3 for the season. The average value for pre and post-monsoon periods were 2.3 and 1.9 mg/m^3 respectively. The total annual chlorophyll *a* production registered was 23mg/m^3 with a monthly average of 2 mg/m^3 (Table 1).

The chlorophyll *a* and pheo-pigment composition in station I during 1988are shown on Fig. 2. The rate of production in terms of chlorophyll *a* at the surface during this period indicated two peaks; one in May -June and the other with high amplitude during September-October. The chlorophyll *a* values ranged from nil in August to 8 mg/m^3 in October. The monsoon values recorded were moderately high (3 mg/m^3) on average. The maximum production occurred during post monsoon period (3.4 mg/m^3) in contrast to the maximum production in 1987 during pre-monsoon. More or less similar values (3 and 3.4 mg/m^3 respectively) were found during monsoon and post/monsoon periods. The total annual chlorophyll *a* during this year was 33 mg/m^3, the average monthly value being 2.8 mg/m^3 (Table 1) indicating an increase in production over 1987.

The pheo-pigment concentration in station I during 1988 showed two peaks; February and August-September (Fig. 2). The values fluctuated from nil to 7.5 mg/m^3, most of the values confining to zero. In August when chlorophyll *a* was nil the pheo-pigments at the rate of 3 mg/m^3 were recorded. The total yearly pheo-pigment prod uction was 20 mg/m^3 with monthly average of 1.7 mg/m^3 constituting 60% of the chlorophyll *a* production (Tablel). The seasonally pooled data has shown that maximum pheo-pigment production was during monsoon and minimum during post-monsoon period.

During 1987 at station II (20 m) the surface chlorophyll *a* production indicated two seasonal peaks, a primary peak during pre-monsoon and the other during post-monsoon (Fig. 3). The magnitude of production during monsoon months was very poor ranging from 0.24-0.80 mg/m^3 (Table 1). The maximum production (3.6 mg/$m^{3)}$ was noticed during April while the other two high values were 2.9 and 2.64 mg/m^3 during February And December respectively. The maximum seasonal production recorded here (2mg/m^3) was also during pre-monsoon period as in station I the other two values for monsoon and post-monsoon being 0.51 and 1.7 mg/m^3 respectively. The annual chlorophyll *a* production here was 15.4 mg/m^3 with mean of 1.54 mg/m^3 indicating lower trend than at the 10 m station. The total average annual production for stations I and II together for 1987 was found to be 38.4 mg/m^3.

TABLE 1. *Distribution ofchlophyll* a *and pheo-pigment in the inshore surface waters off Cochin during 1987 and 1988*

Months	1987		1988			
	Station I	Station II	Station I		Station II	
	Chlorophyll *a* (mg/m^3)	Chlorophyll *a* (mg/m^3)	Chlorophyll *a* (mg/m^3)	Pheo-pigments (mg/m^3)	Chlorophyll *a* (mg/m^3)	Pheo-pigments (mg/m^3)
January	3.01	0.56	1.28	0.00	0.48	0.56
February	2.14	2.85	1.44	5.85	0.56	1.52
March	3.60	1.21	1.62	0.00	2.56	1.84
April	3.23	3.60	1.04	1.28	1.52	3.77
May	0.24	0.53	4.48	0.68	2.68	1.72
June	0.64	0.40	4.41	0.00	3.24	0.00
July	1.92	0.80	2.10	0.00	3.32	0.08
August	1.49	0.60	0.00	2.88	1.36	0.00
September	2.40	0.24	5.61	7.48	0.00	6.14
October	-	-	8.01	0.00	5.34	0.00
November	2.48	2.00	1.87	0.00	2.67	0.00
December	1.84	2.64	1.45	2.00	4.14	1.60
Total	22.99	15.43	33.31	20.17	27.87	17.23
Mean	2.09	1.40	2.78	1.68 (60%)	2.32	1.44 (62%)

The monthly variations in chlorophyll *a* and pheo-pigments in 20 m station during 1988 are shown in Figure 4. Three peaks were observed in abundance of chlorophyll *a.* The maximum production of 5.3 mg/m^3 and 4 mg/m^3 were noticed during October and December respectively. The lower values were recorded during pre-monsoon period ranging from 0.5-15 mg/m^3. Consistantly moderate values of 2 mg/m^3 (average) were observed during the monsoon months. Nil value of chlorophyll *a* was noticed during September (the only collection that could be taken during that monthdue to prevailingincliment weather conditions). Seasonally pooled data showed maximum production (3.2 mg/m3) in post-monsoon period while the other two seasons (monsoon and pre-monsoon periods) showed more or less same magnitude of production (about 2 mg/m^3) with monthly mean of 2.3 mg/m^3. The total average annual production in 1988 in both the stations put together would be 61.2 mg/m^3 indicating higher magnitude of production than 1987.

The pheo-pigment distribution at station II (20 m) during 1988 ranged from zero to 6 mg/m^3 in different months (Fig.4). It showed two peaks, a high peak (6 mg/m^3) in Septem-

ber and a moderate one during April. The highest peak coincided with nil chlorophyll *a*. The total yearly pheo-pigment production was 17.2 mg/m^3 with monthly average of 1.4 mg/m^3 contributing 62% of chlorophylla (Table 1). The seasonal picture (Fig. 8) had shown that there was no direct relationship between chlorophyll *a* and pheo-pigment production.

DISCUSSION

Primary production and standing crop of phytoplankton of the west coast of India have been studied by Subrahmanyan (1959) and Nair *et al.* (1968). Radhakrishna (1969) examined these in Alleppey coastal waters. Shah (1973) has studied the chlorophyll *a* from inshore waters of Cochin. Chennubhotla (1969) and Subrahmanyan *et al.* (1967) have studied the biomass and the total cells of phytoplankton of the west coast of India. Gopinathan *et al.* (1974) investigated the phytoplankton standing crop in the inshore areas of Cochin. All these investigationsrevealedthatall along the west coast of India phytoplankton production is at its highest during the southwest monsoon. Varshney *et al.* (1983) in their study of primary productivity in near shore waters of Thai, Maharashtra coast have shown that chlorophyll *a* maximum were spread over the July/August period and that correlation between nutrients and production was very low suggesting that instantaneous concentration of nutrients was insignificant. However, during the present investigations an entirely different picture of productivity in terms of chlorophyll was obtained in the sense that monsoon maximum was not obtained either in 1987 or 1988. Radhakrishna (1989) has reported high phytoplankton production during post-monsoon months extending upto March-April and low in the southwest monsoon from thecoast of Maharashtra. Dehadrai and Bhargava (1972a) made measurements of chlorophylla for a period of 9 months. (September, 1969 to May, 1970) in the coastal waters from Goa to Bombay. According to them during the period November-January, (post-monsoon) chlorophyll *a* was found to increase at most locations ranging from 2.4 to 18.8 mg/m^3.

Contrary to usual monsoon maximum, a considerable reduction in magnitude of production in both the stations was noticed in 1987. This can be attributed to the late onset of monsoon and also scanty rains experienced during this year as evidenced by the June to August rain fall data in this area (1,063 mm in 1987 against 1,634 mm in 1988 which is considered to be normal).

During the present investigation the data for 1987 from two stations (10m and 20m) indicate that the surface chlorophyll *a* is subjected to monthly variations between the stations. The highest production (3.6 mg/m^3) in 10m station was recorded during March when the salinity was at its maximum (35‰), the temperatureat31°Candthedissolved oxygen content at 3.7 ml/1 while in station II, 35.3‰, 30.9°C and 4.1 ml/1 were the corresponding values for salinity, temperature and oxygen respectively where the chlorophyll *a* was 1.2 mg/m^3- The monthly fluctuations of chlorophyll *a* production along with hydrographic features in station I (10m) than in station II (20m) may be due to the proximity of the former to the estuarine conditions.

The seasonal data for 1987 (Fig. 5) showed that chlorophylla production was high during pre-monsoon and comparatively low during monsoon months. The station II recorded half the production at station I though more or less the same stabilized hydrographic conditions prevailed in both the stations during monsoon period indicating no influence of

hydrographic factors on chlorophyll *a* production.

It has been seen from the present studies that unlike the year 1987,1988 with timely occurrence of the southwest monsoon and subsequent normal hydrographic conditions, presented ideal situations for the cyclical changes in the trend in primary production.

In the present study (1988) the production of chlorophyll *a* in station I (10m) has indicated three peak periods, a minor peak in January-May, a moderately high peak during May-June and a high peak during September-October. Gopinathan (1981) (MS) has pointed out three peaks of phytoplankton production in 10m stations, first peak in April-June, second in August-September and the third in November-December from the same area. The high production that occurred during monsoon months might have been due to falling in salinity and temperature (salinity from 34.5 to 19.6‰ and temperature from 30.9 to 24.6° C). The phytoplankton bloom noticed (from a single observation as mentioned elsewhere) during September in station I might probably be due to wave action caused by strong wind and rain that experienced during the day of observation which might have carried down the rich estuarine phytoplankters to this region from the adjacent backwaters. In 10 m station pheo-pigments showed no correlation to chlorophyll *a*.

Gopinathan (1981) has indicated two phytoplankton production peaks during January and May from 20 m station of this area during 1976-'77. But on the contrary, the present study revealed four peaks of chlorophyll *a* production in 20 m station during 1988; the first in March, the second during May-July, the third in October and the fourth in December. High production occured here also as in station I during October when salinity was at its maximum(35‰ and temperature at 25°C). The marked seasonal changes in salinity, due primarily to the monsoonal climate appeared to be responsible for triggering the blooming, of plankton during May-July period.

The earlier surface chlorophyll *a* values of 1.93 mg/m^3 and 3.18 mg/m^3 in 10 and 20 m stations respectively reported by Nair *et al.* (1985) from this area during 1980 December, were comparable with the present values obtained in December, 1988 (1.5 mg/m^3 in 10 m and 4.2 mg/m^3 in 20 m stations). They also obtained values such as 1.98 mg/m^3 for chlorophyll *a* and 1.44 mg/m^3 for pheo-pigments inl 0m station and 1.60mg/m^3 for Chlorophyll *a* and 1.05 mg/m^3 for Pheo-pigments in 20 m station during October, 1981. Here, in 1988 higher values of chlorophyll *a* (8mg/m^3 in 10 m and 5.34 mg/m^3 in 20 m) were recorded in the corresponding month with no pheo-pigments in both the stations. However, in a study off Cochin under a Joint Remote Sensing Programme (Narain *et al.*, 1983) higher chlorophyll *a* value of 6.4 mg/m^3 was observed in October, followed by sharp fall during November, (1.7mg/m^3) and December, (1.4mg/m^3) from this region. Again the reported valuesof*Nairetal.* (1985)duringNovember, December, 1981 and November, 1982 were also almost comparable with the corresponding present monthly values obtained in 1988.

According to the coverage of Qasim *et al.* (1978) from Dabhol to Tuticorin during March, there has been large variations in the magnitude of chlorophyll *a* from station to station in the inshore waters itself within a short time frame. The chlorophyll values were found to range from 0.05 to 4.18 mg/m^3 with an average of 0.655 mg/m^3. Such variations in the inshore waters in a short time frame cannot

be attributed to diurnal variability. Invariably the chlorophyll values have been proportionate with carbon production indicating a strong positive relationship binding it with nutrient related factors rather than seasonal or diurnal fluctuation.

It is very evident from seasonal data presented in figures 5,6,7 and 8 that among the environmental parameters examined, phosphate (inorganic) and nitrite appeared to have directly influenced the chlorophyll *a* production in the inshore waters of Cochin. The present study indicates a general positive relationship between inorganic phosphate and chlorophyll *a* production confirming the earlier studies that it is the nutrient availability of the ambient waters that governs the instantaneous rates of chlorophyll and carbon production (Fig.8). Qasim *et al.* (1969) have stated that while there was a close correlation between the cycles of phosphorous and organic production in the backwaters, nitrogen was completely independent of productivity rhythm, for most part of the year there was little or no nitrite in the water. In the present investigation too while no effect of nitrite could be noticed in station I, in station II a close negative correlation was found between nitrite and chlorophyll *a* production. Pillai *et al.* (1975) have reported from Cochin backwaters that while the nitrite did not show any relationship with primary production rates, the phosphates showed negative relationship and that increase in primary production rates was associated with low organic phosphate during the post-monsoon period.

It is possible to conclude that regeneration of nutrients consequent on monsoon related factors followed by stability of water column coupled with abundant sunlight, trigger the chlorophyll production while intense grazing accounts for abrupt increase in pheopigment production resulting in partial or sometimes total depletion of the phytoplankton standing stock in the inshore waters of Cochin.

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