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CONTRIBUTION OF PERIPHYTIC ALGAE TO THE BIOPRODUCTIVITY IN COCHIN ESTUARY

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ABSTRACT

The productivity of Cochin estuary and the adjacent backwater have been discussed in the light of significant contribution by periphytic algae. The annual organic production by periphyton has been estimated to be 92,000 tonnes of carbon, the rate being 1.4 gC/m^2/day. This is almost equal to the planktonic production. The values of Net Daily Metabolism (NDM) and Assimilation Number (AN) of periphyton in the backwater indicate relatively a more productive photosynthetic assemblage.

INTRODUCTION

THE TOTAL primary organic production in an aquatic ecosystem is very often used for the assessment of the fishery resources. Estimation of primary production is generally done with phytoplankton community, though other autotrophic groups such as periphyton and macrophytes are present in varying quantities in different environments. In a shallow estuarine ecosystem periphytic and sediment dwelling algae also contribute significantly to the total primary production in addition to phytoplankton. Several studies (Qasim, 1973, 1979, Qasim *et al.*, 1969, 1974; Nair *et al.*, 1975; Gopinathan *et al.,* 1984) were made on the primary production in Cochin estuary. Qasim (1973) estimated the gross production in the estuary to be 0.35 to 1.5 gC/m^2/day. In the Vembanad lake adjacent to Cochin estuary, Nair *et al.*, (1975) have recorded an average production rate of 1.2 gC/m^2/day. This may be an underestimation since the contribution to the total production by autotrophic groups such as periphytic algae, sediment microflora and macrophytes was not included while determining the production values. The quantitative estimation of production in any environment excluding periphytic and benthic algal communities where they are present in significant proportion, is far from the real value. The aim of the study is to assess the role of periphytic algae in the primary productivity of Cochin estuary.

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MATERIAL AND METHODS

Measurements of primary productivity were made using Gaarder and Gran's light and dark bottle method as described by Strickland and Parsons (1972) and APHA (1992).

Sampling : BOD bottles, 300 ml, clear and opaque borosilicate glass with ground glass stopper were used for sample incubation. The bottles were acid cleaned and rinsed thoroughly with distilled water. As precaution the entire bottle (dark) was wrapped in aluminum foil or placed in light proof container during incubation. Small glass slides of known surface area were suspended 30 cm below water surface using a wooden float for simulated colonisation (2 weeks) of periphyton (Sreekumar and Joseph,

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1995). Periphyton community samples for productivity estimation were obtained by *fortnightly collections from ten different* locations in Cochin estuary (Fig. 1).

Procedure : At each station both the light and dark bottles were filled with water from the region and the periphyton samples were

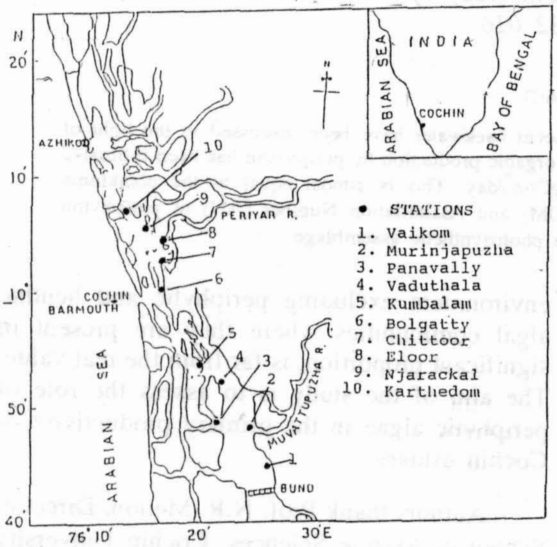

FIG. 1 Map showing the station locations

collected. The bottles were thoroughly rinsed just before use, with water being tested. Productivity and respiration were determined by inserting small glass slides with periphytic growth into the bottles. The samples were incubated for a minimum period of 2 hrs. A set of Gaarder-Gran light and dark bottle productivity and respiration measurements were also made to obtain a correction for phytoplankton metabolism.

Assimilation Number (AN) : It is the amount of carbon assimilated divided by the amount of chl. *a* (mg C/mg chl. *a*/h). This ratio is an index of photosynthetic carbon production per unit chlorophyll (Raymont, 1980). Larger AN values indicate relatively more productive photosynthetic assemblages.

Production/Respiration Ratio (P/R) : Calculated by dividing community production (GPP) by community respiration (CR_{24}). This ratio has been used to classify aquatic systems as *autotrophic* (P / R > 1) or *heterotrophic* (P/R < 1) (Odum, 1957, Vannote *et al.*, 1980).

Net Daily Metabolism (NDM) : It is calculated deducting daily community respiration (CR_{24}) from daily gross primary production. This parameter is equivalent to Woodwell and Whittaker's (1968) net ecosystem productivity, Odum's (1971) net community productivity and Marker's (1976) net photosynthesis. NDM is positive during periods when photosynthesis is greater than respiration (*i.e.*, autotrophy predominates) and the system is accumulating organic matter. NDM is negative when the converse occurs and heterotrophy predominates with the net organic matter degradation.

RESULTS AND DISCUSSION

Gross Primary Production

The highest value of 296.66 mg C/m^2/hr was observed at Panavally station in September whereas the lowest 29.75 mg C/m^2/hr was reported from Eloor during July. The average production for the estuary during different months was in the range 87.86 to 181.56 mg C/m^2/hr. The monsoon, post-monsoon and pre-monsoon mean values of periphyton production were 131.36, 109.03 and 118.78 mg C/m^2/hr respectively. The rate of production was found to be the highest during monsoon and lowest during post-monsoon. The annual mean periphyton production calculated for the ecosystem was 119.77 mg C/m^2/hr.

Marker (1976) had reported 83.62 mg C/m^2/hr periphyton primary production in southern England streams. Very little data is available for comparison of production values of this ecosystem with that of other estuaries. Wiley *et al.*, (1987) found that primary production in a prairie river system from below detection level to about 50g O_2/m^2/day. La

Perriere *et al.*, (1989) had reported 90.63 mg C/m^2/hr and 87.5 mg C/m^2/hr of gross primary production in high subarctic streams such as Chatanika river and Delta clearwater creek respectively.

The variations observed in regard to gross primary production both spatial and temporal were analysed (Table 1) using ANOVA. A significant variation in gross primary production occurred between different stations (ANOVA; $P < 0.05$). Similarly there was a significant variation in primary production during different months of the year (ANOVA; $P < 0.05$). The incidence of three well marked seasons on account of the south west monsoon must be responsible for the temporal variation in primary production. The stations studied were located at places where some of the major rivers join the estuary or near big industrial concerns that discharge effluents into the ecosystems or near barmouth where comparatively higher salinity was observed. The changes in hydrographic parameters due to tidal waves also must have contributed to the variations in primary production spatially.

TABLE 1. *Analysis of variance (ANOVA) for the periphyton primary production*

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F ratio
Bet. Cols	1111115.75	9	12346.19	5.250
Bet. Rows	56433.15	11	5130.29	2.182
Error	232811.34	99	2351.63	
Total	400360.24	119		

Correlation of periphyton production with biomass (chl. *a*), standing crop (cell count), hydrographic parameters such as salinity, temperature, dissolved oxygen, pH and nutrients such as nitrites, phosphates and silicates were studied by working out the correlation coefficient, *r* value (Table 2). There was no consistent correlation between primary

TABLE 2. Correlation coefficient (r value) between periphyton production and chl. *a*, standing crop and environmental parameters

Stn. No.	Chl. *a*	Standing Crop	Salinity	Temp.	DO	pH	SiO_3	NO_2 -N	PO_4 -P
1.	**0.9898	0.0157	-0.5015	-0.6772	0.0204	-0.3338	0.1795	0.1795	0.2874
2.	**0.6756	*0.6689	0.2942	0.0798	-0.1036	0.1227	0.3110	-0.4326	-0.2383
3.	*0.7771	-0.1171	-0.1424	-0.0654	-0.1080	0.0466	0.1610	-0.1662	-0.0459
4.	**0.9831	-0.2562	0.1142	-0.0472	0.2237	-0.1448	0.1423	0.2205	0.2639
5.	**0.8761	**0.8094	-0.1618	-0.0717	-0.3197	-0.2956	0.1014	0.3844	0.1390
6.	**0.9968	0.3796	-0.5696	-0.4514	-0.5548	-0.6417	-0.4589	-0.6828	0.0701
7.	**0.9607	0.3666	-0.1445	-0.2438	0.0183	0.0307	0.4188	-0.2830	0.1857
8.	**0.9833	0.8705	-0.0661	0.3351	0.5420	-0.0170	0.5041	*0.6032	0.1921
9.	**0.9640	0.5427	0.5282	**0.7112	-0.0737	0.3297	-0.2919	-0.3298	-0.0859
10.	**0.9854	**0.8312	0.3548	0.4449	0.4386	0.4291	-0.7237	0.3069	-0.2292

* - Significant at 5% level ($P < 0.005$)
** - Significant at 1% level ($P < 0.001$)
Degrees of freedom = 11

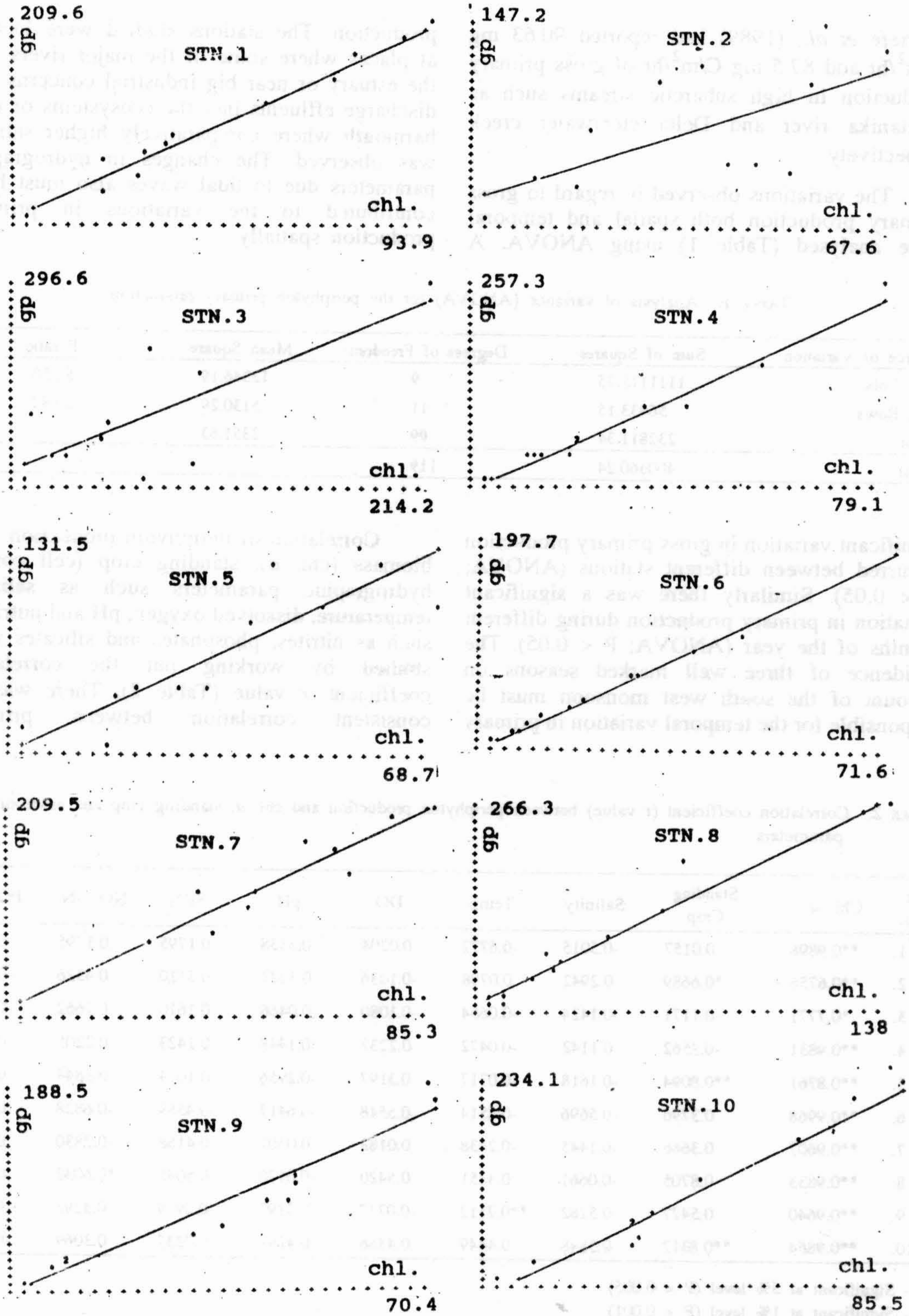

FIG. 2 Linear correlation between chl. *a* (x;mg/m^2) and GPP (y;mgC/m^2/hr) at 10 different stations.

production values and hydrographic parameters studied. However, production values showed significant positive correlation ($r = 0.7112$, $p < 0.01$) with temperature at Njarackal and with NO_2 - N ($r = 0.6032$, $P < 0.05$) at Eloor. Correlation studies of periphyton biomass (chl.*a*) and hydrographic parameters made earlier also yielded similar results. There was significant positive correlation between standing crop (cell count) and production in most of the stations studied. Lack of correlation observed in some stations may be due to the characteristic floral composition of the area. In almost all the stations studied there was significant correlation between gross primary production values and chl. *a* ($P < 0.01$). Significant correlations are shown in scatter plots (Fig. 2).

Assimilation Number

The monthly mean values of assimilation ratio for the periphyton revealed that the highest value of 7.29 was observed in July at Murinjapuzha and the lowest 1.1 in January at Panavally. The monthly mean values of AN for the entire estuary varied from 2.21 to 3.05. The monsoon, post-monsoon and pre-monsoon values were 2.48, 2.49 and 2.54 respectively. Curl and Small (1965) suggest that several factors may affect the assimilation number that it cannot be regarded as a constant. The assimilation number in the estuary, remains more or less the same during the monsoon and post monsoon. A slight increase in the value was noted during pre-monsoon period. This may be due to the extended period of sunshine and sufficient light penetration on account of less turbulence in water. Joint and Pomroy (1981) had suggested a higher rate of primary production when water is less turbid. The conditions are just the reverse during monsoon and post-monsoon. The average value of assimilation number calculated for the periphyton of the estuary is 2.5 which is well within the range (2-6) suggested by Strickland (1965). There is no evidence for the influence of nutrient concentration on periphyton assimilation number in this estuary. Strickland's view was that nutrient deficiency reduces the values of assimilation number is not supported by Steele and Baird (1961). The difference in assimilation number at different stations were analysed using ANOVA. There was no significant variation neither spatial nor temporal with regard to the assimilation ratio of periphytic algae in the estuary (ANOVA; $P < 0.05$).

Community Respiration

Monthly mean values of periphyton community respiration at different stations varied from 10.80 to 120.22 mg C/m^2/hr. The highest monthly average value of 81.62 mg C/m^2/hr for the entire estuary was observed in September while the lowest rate of 39.30 mg C/m^2/hr was noted in October. The monsoon, post-monsoon and pre-monsoon values of community respiration rates were 57.71, 55.05 and 58.22 mg C/m^2/hr respectively. Pre-monsoon recorded comparatively higher respiratory rates possibly due to the increased temperature conditions. The annual mean value of the respiratory rate for the estuary was 55.05 mg C/m^2/hr.

Net Daily Metabolism (NDM)

During monsoon all the stations except Murinjapuzha (stn. 2) Vaduthala (stn. 4) and Karthedom (stn. 10) were dominated by photosynthetic assimilation. In September, respiration was predominant at Murinjapuzha and Karthedom whereas at Vaduthala respiratory activity dominated in August and September. In the post-monsoon, autotrophy again predominated at most of the stations. However, four stations *viz.*, Vaikom, Murinjapuzha, Bolghatty and Chittor showed dominance of respiration during December. During pre-monsoon, heterotrophy (observed as dominance in respiratory activity) dominated in most of the stations except at Panavally and Eloor. But photosynthesis was dominant during April and May at Karthedom. Panavally and Eloor are two stations where autotrophy predominated throughout the year. Almost the same conditions were prevalent at Kumbalam except for March when respiration was dominant. Deviation of NDM from zero on either way can be explained by the dominance of autotroph or heterotroph. Results obtained during the study are explained on this basis. Negative NDM values at Vaikom and Bolghatty during post-monsoon and pre-monsoon resulted from the predominance of heterotrophic components of the periphyton community. These stations by their proximity to sewage discharges are highly polluted due to decomposing organic matters. The environment in these stations facilitates the dominance of heterotrophic component of the periphyton community. During monsoon, heavy freshwater flushing at these stations remove degrading organic matter and NDM will be on the positive side. Eloor station located near the discharge of toxic industrial effluent from FACT and Cominco Binani Ltd. showed positive NDM values throughout the year. This can be possibly due to the harmful effect of toxic material on the more sensitive heterotrophic components. The fact that the environment was not conducive for autotrophy was evidenced from the low incidence of periphyton standing crop as well as chl. *a*. Hornberger *et al.*, (1977) devised a scheme for evaluating water quality on the basis of production and respiration since NDM is affected by a variety of factors influencing autotrophs and heterotrophs, its utility for the evaluation of water quality in the highly fluctuating estuarine environment is doubtful. However, continuous monitoring of specific locations with regard to metabolic activity will reveal the trophic level changes taking place and its relation to the changing environment.

Production/Respiration (P/R)

Monthly mean production/respiration ratio at different stations can also be conveniently used for determining the trophic level existing at different locations and periods. P/R value is > 1 when NDM is positive and is < 1 when NDM is negative. NDM value of zero is functionally equivalent to a GPP: R_{24} value of unity except that NDM is an absolute value whereas GPP : R_{24} is a relative assessment of system metabolism.

According Nair *et al., (1975) planktonic production is 1.2 gC/m²*day and the total production estimated for the estuary and the adjacent backwaters is about 100,000 tonnes of carbon per year. Periphyton production observed during the present study is at the rate of 1.4 gC/m²/day. The estuarine complex spread over 300 sq.km. can assimilate 92,000 tonnes of carbon per year, if 60% of this area support periphytic growth. Periphyton production in the estuary is thus upto 92% of the planktonic production. The phytoplankton and the periphyton together contribute about 1,92,000 tonnes of carbon per year towards total primary production in the estuary.

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