Impact of Sea- Sand Filling in the Paravur-Kappil Backwaters, Southern Kerala with Special Reference to Phytoplankton Productivity

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Abstract— **Paravur- Kappil backwaters, a major estuary in Kerala, was studied from six selected stations covering three seasons. Sea sand filling in Paravur backwater was the most important factor controlling the phytoplankton productivity, growth and succession of major number of species. It was observed that, in Paravur – Kappil backwater, phytoplankton productivity was the important factor controlling the qualitative and quantitative distribution and abundance of fishes. Moreover, temperature, nutrients (nitrate, nitrite, phosphate, and silicate), dissolved oxygen and monsoon variation influenced the fluctuations of phytoplankton productivity.**

Index Terms— **Net primary productivity, Gross primary productivity, Nutrients, Chlorophyll 'a'.**

I. Introduction

The basis for nearly all life in the aquatic system is the photosynthetic activity of the aquatic plants and phytoplankton. In an estuary, all organic matters are primarily synthesized by the primary production and the products are transferred to consumers through different trophic level. The amount of primary production is the most significant factor, which determines the importance of the water body from the fisheries angle. Studies on the primary productivity of the estuarine waters of India are limited. The abundance of phytoplankton will reflect the primary production of the particular ecosystem. They nourish the other microorganisms present in that aquatic system. This will increase the fish production of the water body directly or indirectly. Primary productivity values have been used in estimating the productivity of aquatic environment (Vijayaraghavan, 1971). In an aquatic ecosystem, fishes entirely depend on natural foods. So there is a close dependence of fish production upon the levels of primary productivity (Boyd and Litchkoppler, 1979).

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The present study area Paravur backwater situated 15km south of Kollam town is a famous trading city of Kollam District, Kerala State. It is located between 8°47' – 8°59'N latitude and 76°38' – 76°49'E longitude. The catchment area of Paravur *Kayal* is about 662.46 ha. The 2.14 km long Paravur canal connects Kappil estuary with the Paravur backwater and lies almost parallel to the adjoining Arabian Sea for some distance and maintains temporary and artificial permanent estuary. The present attempt is aimed at studying the effect of sand deposition on primary productivity of the Paravur *Kayal* and Kappil estuary. The study is particularly relevant in the context of the increasing threat to the estuarine ecosystem of pollution such as domestic waste, high salt-water intrusion and sand deposition due to tidal effect. In order to exploit any aquatic ecosystem, information on phytoplankton productivity is essential for the estimation of level of fish production.

II. Material And Methods

The collection of water samples for the analysis of primary productivity was done from the selected six stations from February 2001 to January 2002 at regular intervals. The analysis of primary productivity was done between 10 a.m. to 1 p.m. in all the stations. The samples were collected monthly from six different stations of Paravur and Kappil backwater. Gross and net primary productivity in the surface and bottom water were analysed by following the light and dark bottle technique (Strickland and Parsons, 1968; Vollenweider, 1969). The samples were incubated in the site for three hours. Chlorophyll 'a' was estimated by the method of APHA, 1995. Simple correlation between the various parameters of water quality with rate of primary productivity and chlorophyll 'a' was worked out. Analysis (ANOVA) of each of the parameter between stations, months and seasons were worked out statistically. Mean SE of productivity and chlorophyll 'a' for the three seasons were also worked out.

III Results

The general distribution of gross primary productivity (GPP) for the whole region fluctuated from below detectable level to 452.45 mgC/m^3/hr (Table.1). The season wise distribution of gross primary productivity in surface water showed that the values remained minimum during post monsoon except in Stations III and IV, where minimum value was recorded during monsoon. The maximum value of gross primary productivity was recorded during premonsoon season except Station IV, where maximum productivity was found during post monsoon. However, in the bottom water lowest seasonal mean gross primary productivity value was observed during post monsoon except in Stations III, IV and VI where minimum was noted during monsoon season. The maximum gross primary productivity value was observed during premonsoon except in Stations II, IV and V. Maximum value was registered during monsoon at Station II and V and during post monsoon at Station IV. Minimum annual mean was recorded at station III and maximum at station V in the surface water, while in the bottom water the minimum was at station I and maximum was at station II. Analysis of variance revealed that the variation in the surface water GPP between three seasons were significant at 5% level (Table.2).

Throughout the period of study, the net primary productivity (NPP) was recorded from below detectable level to 408.39 mgc/m3/hr. The seasonal mean wise distribution of NPP in surface water at different stations showed a dissimilar pattern. Minimum value of NPP was noted during premonsoon, except in Stations III and IV, where the minimum was noted during monsoon. But, Station I showed minimum NPP during post monsoon. The maximum NPP was noted during post monsoon except in Stations I and II, where maximum was at monsoon. In the bottom water, the minimum NPP was noted during premonsoon, except in Stations I and III, where minimum was during monsoon. The maximum value of season wise NPP was observed during premonsoon (Station III and I), monsoon (Station II) and at post monsoon (Station IV, V and VI). Annual mean of NPP was low at Station III and was high at station II in both the surface and bottom waters. Statistical analysis revealed that the variations in NPP were significant at 1% level between months within the seasons in surface water only (Table.2).

The pattern of monthly distributions of chlorophyll ‘a’ in the six stations is shown in Table.1. In general, the chlorophyll ‘a’ values showed wide fluctuations and it ranged from below detectable level to 45.576 mg/m^3. A distinct seasonal variation was observed in the fluctuation of chlorophyll ‘a’. This value showed an increase during premonsoon, with the highest recorded in June. By the on set of monsoon, a noticeable decline was observed. But only in the month of September it increased. During post monsoon, a steady decline was observed. The mean seasonal values of chlorophyll ‘a’ are shown in Table 1. During post monsoon and premonsoon the chlorophyll ‘a’ concentration was the lowest and during monsoon it was highest in all the six stations. The annual mean was lowest at Station VI and highest at Station I. Analysis of variance of chlorophyll ‘a’ revealed that the variations between seasons and between months within seasons were significant at 1% level. The simple correlation coefficients between gross and NPP and chlorophyll ’a’ with the different physico-chemical parameters of water are shown in the Table- 2.

IV. DISCUSSION

The primary productivity of the estuaries of Kerala is comparatively high. Probably this may be due to high fertility with regard to the availability of nutrients and large standing crop of mixed derived from marine, estuarine and fresh water masses suspended in a widely fluctuating ambient medium. In the present study, GPP was higher than that of NPP and lower value of net and gross productivity was below detectable level. Similar observations were made by Anuradha (1995) in Kadinamkulam Lake and Shibu (1991) in Paravur Lake. Gross primary productivity touched zero values at Station I, III and IV and in case of NPP zero values were observed at all stations mostly during premonsoon followed by monsoon. Water samples collected from Paravur-Kappil backwater showed minute suspended particles in certain months. These particles become very distinct as dark brown bodies with the addition of Winkler’s reagent. This may be due to the photochemical oxidation take place in the estuary at the utilization of dissolved oxygen in the ambient medium. Dugdale and Wallace (1960) explained the depletion of oxygen in light bottle as the result of photochemical oxidation of humic materials. The observation of Wetzel (1975) revealed that decomposition of autochthonous oxidizable material take place in the upper euphotic zone and that the rate is higher when the temperature is high, lends further reason for the reduction of oxygen. The extent of utilization of oxygen masks the probable oxygen production by photosynthetic activity in the light bottle.

Surface water productivity was observed to be higher than that of bottom water. The observed higher production in the surface water could be on the account of the prevalent high light intensity. Further, availability of nutrients such as nitrate and silicate were more and salinity and turbidity were low in surface water. The most obvious ecological factor influencing the primary production is the amount of solar energy reaching the surface water (Nair and Thampy, 1980) and it depends on the altitude of sun and changing weather pattern. In General, seasonal variation showed that GPP was maximum during premonsoon and minimum in monsoon. Net primary production was maximum during post monsoon and minimum in premonsoon. This may be due to high level of dissolved oxygen during post monsoon and low during premonsoon. According to Thomas and Abdul Azis (1995), the seasonal variation in the primary production generally seems to be controlled by the interaction of light, temperature and phytoplankton population. The rate of primary production within the estuary itself is determined particularly by the availability of light (Dobson and Chris Frid, 1998). Transparency was maximum during post monsoon, when net productivity was also maximum. But there is no relationship between transparency and gross primary production. This shows that the variation of light penetration did not act as a limiting factor in the production as a whole. Steemann Nielsen and Jensen (1957) pointed out that in shallow regions, where the bottom is in direct contact with overlying water, an indirect influence of temperature would cause an enhancement in the regular process to some extent, which would reflect in the rate of primary production. In the present study, high temperature during premonsoon seemed to coincide with high gross primary production and low temperature in monsoon coincides with low gross productivity. Apart from this temperature did not show any direct effect on the variation of primary productivity.

The relation between dissolved oxygen and GPP increased and decreased along with fluctuation in the oxygen concentration (Nair and Abdul Azis, 1987). But during the present study, there was no relationship between oxygen and GPP. However, in Ashtamudi estuary it has been found that the depletion of dissolved oxygen in the surface and bottom waters caused total failure of primary productivity especially in polluted areas (Nair *et al.*, 1984). In the present study, gross primary productivity was high in premonsoon coincided with the high phytoplankton production and low GPP in monsoon coincided with the lower phytoplankton production. The high dissolved oxygen concentration in Paravur-Kappil backwater during post monsoon coincided with high net primary production. The present study revealed that salinity was maximum in post monsoon coincided with high net productivity in monsoon. Apart from this, salinity did not show any direct effect on the variation of primary productivity. Ragothaman and Reddy (1982) observed that less salinity leads to less production in Tapi estuary. Anuradha (1995) pointed out that seasonal variation in hydrogen ion concentration seemed to have an inverse effect on the productivity in the Kadinamkulam Lake. The present study showed no relationship between hydrogen ion concentration and productivity. The variation in nutrient concentration was recognized as one of the major factor controlling primary production (Fee *et al*., 1988). These statements do not agree with the observations of the present study. No single environmental factor or physico-chemical or nutrients had any significant influence on the rate of production. Combined effects of a number of factors and nutrients are likely to influence the rate of primary production in estuarine habitat of Paravur-Kappil backwater. Panikkar and Sindhu (1994) and Shibu *et al.* (1995) made similar observations.

Earlier work in Paravur backwater (Shibu, 1991) revealed that maximum GPP was 211 mg C/m^3/hr and NPP was 70.75 mg C/m^3/hr. The present study in Paravur backwater showed that high GPP was 451.75 mg C/m^3/hr and high NPP was 408.39 mg C/m^3/hr. Higher productivity during the present study may be due to the shallow water body in Paravur backwater enhancing the rate of productivity. The most obvious ecological factor influencing the primary productivity is the amount of solar energy reaching the surface water (Nair and Thampy, 1980). Another factor was the effluent from the prawn culture fields, which enters into the aquatic system. This enhances the rate of production because the effluent contained nutrients and higher organic materials. Maximum values of gross and net production were observed at Station V. This may be due to the shallowness of water body. Present study agrees with the observations of Steemann Nielson and Jenson (1957) that in shallow region where the bottom is in direct contact with the overlying water, and direct influence of temperature would cause an enhancement in the regulation process to some extent, which would reflect in the rate of primary production. In Station V, below detectable level of net primary productivity was observed during six months, especially in premonsoon, both in surface and bottom water, when the water level was very low. This paradox clearly showed that wide fluctuation pattern of productivity in shallow region and it will lead to ecosystem degradation. Sand filling/sand terrace formation in Paravur backwater system causes shallowness of water body and destroys the natural ecology of estuarine environment. Shallow region of Paravur backwater enhanced the rate of gross production in premonsoon and at the same time lowered the net production was observed. This may be the reason for the high fluctuation pattern of productivity varying from below detectable level to maximum level of net and gross production. Observations revealed that gross and net productions were high in Station V, yet the ecosystem was unhealthy because below detectable level of NPP was observed during six months of a year. From the observations of Station V, it is very clear that shallowness of the estuary enhances the environmental degradation. The average depth of this area is nearly 1.2 m. In Paravur backwater, sand deposition occurred above the water level at different regions. This might have resulted in the wide fluctuation of productivity. Annual variation of net primary productivity showed the maximum value at Station- II, both in surface and bottom waters, followed by Station VI, where Ithikkara River joins the estuary. Similar trend occurred in case of gross productivity. This may be due to the direct effect of polluted effluent from the prawn culture fields. Lower productivity value was observed at Station III, located near spillway shutter. This may be due to the high tidal effect, which reduced the rate of productivity.

Chlorophyll ‘a’, as an indicator of phytoplankton abundance, which can change exponentially in a matter of hours or days. So monthly samples are not adequate to evaluate the true cycle of phytoplankton abundance (Happ *et al*., 1977). Present study also confirmed the above statement because a wide seasonal fluctuation was observed between the concentration of chlorophyll ‘a’ and phytoplankton density. The seasonal variations of chlorophyll ‘a’ concentration showed maximum in monsoon and minimum in post monsoon. At the same time phytoplankton population was high during post monsoon and low during monsoon. Shah (1970) and Gopinathan *et al.* (1984) observed high chlorophyll ‘a’ concentration in monsoon at Cochin backwaters. Chlorophyll ‘a’ concentration was low during post monsoon when turbidity was also low and chlorophyll ‘a’ concentration was high during monsoon when turbidity was also high. Thus chlorophyll ‘a’ and turbidity showed direct relationship. Present study agreed with the observation of Mc Mahon *et al.*, (1992), that chlorophyll ‘a’ is maximum associated with the turbidity maxima in the Shannon estuary. However Anuradha (1995) reported high turbidity and low light penetration during the premonsoon and during that time chlorophyll ‘a’ was also maximum. Temperature was low during monsoon and at the same time chlorophyll ‘a’ concentration was high. Apart from this there was no significant relationship with temperature and chlorophyll ‘a’. However, Anuradha (1995) pointed out a direct relationship between temperature and chlorophyll ‘a’ concentration in Kadinamkulam Lake. Low temperature during post monsoon coincided with the lower concentration of chlorophyll ‘a’ and high temperature coincided with high concentration of chlorophyll ‘a’. Present investigation revealed that high salinity reduces the chlorophyll ‘a’ concentration and low salinity enhanced the chlorophyll ‘a’ concentration. Thus chlorophyll ‘a’ has an inverse relationship with salinity. However, other parameters like dissolved oxygen and hydrogen ion concentration did not have any distinct relationship with the fluctuations in chlorophyll ‘a’ concentration.

High nitrate concentration in monsoon may enhance the chlorophyll ‘a’ concentration in monsoon. This observation agrees with the study of Szarek (1994). In the present study, high value of silicate during monsoon was associated with high concentration of chlorophyll ‘a’ and lower concentration of silicate in post monsoon coincide with lower chlorophyll ‘a’ concentration. Anuradha (1995) also observed that silicate and chlorophyll ‘a’ concentration have direct relationship, i.e., silicate and nitrate seem to have a similar seasonal fluctuation as that of chlorophyll ‘a’. Desai *et al.* (1984) reported that high nitrate concentration associated with high pigment values. According to Shah (1970), inorganic phosphate seems to limit phytoplankton production and it probably controls the seasonal variation of the plant pigments. Anuradha (1995) pointed out that phosphate and nitrite seemed to have an inverse relationship with fluctuations in chlorophyll ‘a’ concentration. However, present observation revealed that nitrite and phosphate concentrations did not have any significant relationship with chlorophyll ‘a’ concentration. Balachandran *et al*. (1989) pointed out that nutrient availability of the ambient waters governs the rates of chlorophyll concentration. Anuradha (1995) observed that nutrients seem to be limiting factor in the synthesis and production of chlorophyll ‘a’. Present study confirmed these views.

Annual variation of chlorophyll ‘a’ concentration showed that it was high at Station I. This may be due to high transparency and high phytoplankton populations. It was low in Station VI, due to low transparency and low phytoplankton population. In Station -VI, discharge from Ithikkara River also reduces the chlorophyll ‘a’ concentration. Chlorophyll concentration was high during June and September at all stations. This may be due to high silicate and nitrate concentrations. Over all study of the chlorophyll ‘a’ concentration in Paravur–Kappil backwaters showed that its concentration influenced by nutrients and other physico-chemical parameters like temperature, transparency, turbidity and salinity. Phytoplankton populations also influenced the chlorophyll ‘a’ concentration. Paravur backwater is one of the productive estuaries in Kerala. But the actual fact is that severe environmental/ecosystem degradation is prevailing in Paravur backwater system due to sea sand filling and other anthropogenic activities. Sea sand filling and other anthropogenic activity mainly may cause the depletion of phytoplankton and this in turn may adversely affect the trophic dynamics and food web pattern. Immediate action should be taken for the maintenance and conservation of these two backwaters.

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Table.1 Seasonal and an nual mean (±S.E) of gross and net primary productivity (mgC/m3/hr) and chlorophyll' a' (mg/m3) of Paravur- Kappil backwaters during February, 2001 to January, 2002

		Surface Water				**Bottom Water**			
		Seasonal Mean			Annual Mean	Seasonal Mean			Annual Mean
		Premonsoon	Monsoon	Post monsoon		Premonsoon	Monsoon	Post monsoon	
Net productivity	I	152.44±65.72	182.52±64.66	116.61±49.93	150.52±32.68	152.79±65.63	131.82±76.56	125.96±43.96	136.86±33.39
	II	102.45±72.69	265.73±25.98	228.14±15.21	198.77±31.75	118.71±68.45	271.15±24.59	195.1±34.30	194.99±30.70
	III	152.09±50.70	65.91±47.83	172.37±51.37	130.12±29.62	153.84±51.30	71.68±52.65	108.91±34.39	111.48±26.51
	IV	132.87±80.90	101.75±60.59	200.18±73.11	144.93±39.65	102.1±58.95	107.87±56.68	158.22±72.95	122.73±33.94
	V	138.46±85.48	141.96±57.95	289.68±66.33	190.03±42.72	BDL	117.65±55.47	223.25±53.99	113.63±36.11
	VI	76.05±48.54	153.49±66.00	280.25±38.47	169.93±37.31	102.09±41.4	106.09±33.21	197.51±46.32	135.23±25.08
Gross productivity	I	280.24±48.80	187.59±9.71	167.31±59.34	211.71±27.69	204.19±40.83	134.26±34.12	132.09±51.87	156.85±24.60
	II	280.92±47.49	265.39±107.33	213.64±74.56	253.31±42.89	217.13±8.96	265.38±87.38	205.95±63.99	229.49±33.72
	III	278.84±76.05	101.40±50.36	223.08±11.71	201.10±35.65	229.89±63.76	122.03±64.20	218.71±29.99	190.21±32.72
	IV	254.19±97.45	106.82±43.63	329.55±90.08	230.18±50.58	304.89±58.95	104.13±23.78	280.24±68.61	229.75±39.06
	V	366.61±55.71	254.54±60.86	183.56±47.02	268.23±36.60	228.84±63.71	264.69±52.28	171.5±48.00	221.68±31.03
	VI	329.54±48.54	234.61±44.42	182.51±75.43	248.88±35.36	304.19±58.54	179.00±43.03	180.59±75.03	221.26±36.16
Chlorophyll 'a'	I	12.97±4.63	22.76±11.16	9.92±2.87	15.22±4.10				
	II	6.71±2.27	25.69±10.47	9.07±2.58	13.83±4.19				
	III	6.69±3.00	20.54±10.03	2.97±0.85	10.07±3.91				
	IV	6.60±2.54	22.85±8.53	3.54±0.95	11.00±3.72				
	V	6.88±2.04	20.19±8.87	8.84±3.71	11.97±3.45				
	VI	3.69±1.02	14.21±10.53	3.78±0.90	7.23±3.53				

Table .2.Analysis of variance of surface and bottom water primary productivity and chlorophyll 'a'.

Sources	df	F ratio				
		Net primary productivity		Gross primary productivity		Chlorophyll 'a'
		SW	BW	SW	BW	
Stations	5	0.561	0.979	0.445	0.773	0.548
Seasons	2	3.729	1.79	5.32*	2.42	34.96**
Months	11	2.87**	1.449	1.74	1.737	28.208**

*Significant ($P<0.05$) **Significant ($P<0.01$)

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Table.3.Correlation between the rate of primary production, chlorophyll ‘a’ and physico-chemical parameters of water at Station I to VI

	Parameters	Temp.	Transp.	Turb	pH	DO	BOD	Salinity	Silicate	Nitrite	Nitrate	Phosphate.	Potassium	Sodium
Station-I	GPP	0.106	0.065	0.318	-0.084	-0.057	-0.17	0.459	-0.43	-0.33	0.58*	-0.12	0.485	0.509
	NPP	0.269	0.289	-0.53	-0.21	0.212	0.164	-0.075	-0.121	-0.387	-0.122	-0.129	0.038	-0.030
	Chl. ‘a’	0.091	-0.429	0.048	-0.082	0.115	-0.293	-0.342	0.409	0.237	0.209	-0.261	-0.388	-0.324
Station-II	GPP	0.141	0.099	0.064	0.235	0.325	0.022	0.065	-0.260	-0.443	-0.131	0.126	-0.036	0.097
	NPP	-0.315	-.0217	-0.423	0.541	0.704*	0.361	-0.057	0.297	0.008	0.01	0.061	-0.033	-0.052
	Chl. ‘a’	-0.214	-0.688*	-0.164	0.428	0.090	0.134	-0.400	0.255	0.133	0.087	0.165	-0.361	-0.339
Station-III	GPP	0.75**	0.416	-0.289	0.452	-0.369	-0.155	0.454	-0.401	0.071	0.136	-0.142	0.411	0.318
	NPP	0.271	0.001	-0.029	0.251	-0.389	-0.393	0.266	-0.165	0.203	-0.074	0.060	0.157	0.165
	Chl. ‘a’	-0.184	-0.613*	0.256	-0.615*	0.222	0.232	-0.551	0.645*	-0.086	0.010	-0.309	-0.468	-0.516
Station-IV	GPP	-0.056	0.452	0.049	0.479	-0.267	0.409	0.458	-0.507	0.283	0.095	-0.051	0.455	0.424
	NPP	-0.214	0.411	0.07	0.262	-0.197	0.185	0.349	-0.278	0.118	0.189	-0.286	0.281	0.294
	Chl. ‘a’	-0.179	-0.765	0.324	-0.397	0.528	-0.067	-0.537	0.571	-0.135	0.366	-0.263	-0.470	-0.459
Station-V	GPP	0.010	0.258	0.035	0.370	-0.185	-0.368	0.088	0.288	0.115	-0.410	0.282	0.070	0.115
	NPP	-0.503	0.146	-0.390	0.284	-0.037	0.099	0.005	-0.014	0.230	0.253	-0.013	0.106	-0.023
	Chl. ‘a’	0.104	-0.738**	0.642*	-0.195	0.213	-0.022	-0.607	0.571	-0.088	0.485	0.205	-0.577	-0.529
Station-VI	GPP	0.244	0.020	-0.024	0.291	-0.418	-0.263	0.255	0.002	-0.407	-0.306	-0.467	0.247	0.293
	NPP	-0.333	0.176	-0.509	0.127	-0.063	0.430	0.381	0.043	0.481	0.220	-0.174	0.378	0.388
	Chl. ‘a’	-0.367	-0.783	0.681*	-0.144	0.231	-0.222	-0.274	0.340	-0.014	0.154	-0.147	-0.239	-0.243

*Significant (P<0.05) **Significant (P<0.01)

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