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Physico-chemical and biological properties of the Muthupettai Mangrove in Tamilnadu

T.T. Ajith Kumar, T. Thangaradjou and L. Kannan*

Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai – 608 502, Tamilnadu, India
Email: tt_ajith@yahoo.co.in
** Thiruvalluvar University, Vellore, Email: kannanlk69@yahoo.com*

Abstract

The physico-chemical and biological characteristics of the Muthupettai mangrove waters, south of Chennai in India, indicated marked spatial and temporal variation in various parameters. Most of these parameters were found to be largely influenced by the northeast monsoon. The study also found the presence of higher nutrient and dissolved oxygen concentration and were comparable to conditions in other mangroves along the Indian coast. It is also interesting to note the lower concentration of POC in the waters, which is an unusual feature in the mangrove ecosystem. Statistical analysis of the data showed the relations between different parameters within the stations and between stations.

Keywords: Muthupettai Mangrove, water quality, physico-chemical properties

Introduction

Information on various physical- chemical and biological processes, which control the prevailing environmental conditions of the region, will eventually help to evaluate the ecological changes. Studies on the hydrography of backwaters and mangroves of the east coast of India are limited when compared to the west coast. Mangroves like Sundarbans, Bitherkanika, Coringa and Pitchavaram have been well studied in the east coast. However, not much attention has been given to study the various characteristics of small mangrove along this coast. Considering this fact the present investigation on the physico-chemical and biological characteristics of the Muthupettai mangroves was carried out.

Muthupettai mangroves (lat. 10° 25' N; long. 79°39' E) situated 400 km south of Chennai lies on the southern part of the Kaveri deltaic region along the southeast coast of the Peninsular India (Fig. 1). It spreads to an area of about 6800 ha in which two specialized habitats viz. mangrove and lagoon environment were selected for the present investigation. Koraiyar (Station 1) is the water way leading to the lagoon, flanked by the mangrove vegetation, where tidal fluctuation is meager and the depth of the water channel is 1 to 3 m. Seven major brackish water aquaculture farms have been developed in and around this area. During the monsoon season, this region receives considerable amount of fresh water from the Koraiyar River and the discharges from the aquafarms are also directly mixing in this region. The water channel is flanked by the stands of *Excoecaria agallocha* and *Aegiceras corniculatum*. Station 2 is located in the lagoon about 2 km southwest of the mouth and about 1 km from station 1. During high tides, the neritic waters from the nearby Palk Strait entering through the lagoon mouth predominate. This region is mostly covered by forest and the rest by mud flats, sandy flats and salty soils. Depth of the water channel in the area is about 1 to 2 m.

Materials and methods

Surface water samples were collected at monthly intervals from stations 1 and 2 for a period of two years from January 1996 to December 1997 for the estimation of various physico-chemical and biological parameters. Temperature (air and surface water) was measured using a standard centigrade thermometer. Salinity was estimated with the help of a field refractometer (Atsgo-Japan) and *p*H was measured using an electronic *p*H pen. Dissolved oxygen was estimated by the modified Winkler's method (Strickland and Parsons, 1972). Water samples were filtered using a millipore filtering system and analysed for chlorophyll-*a* and dissolved inorganic phosphate, nitrate, nitrite and reactive silicate, adopting the standards methods described by Strickland and Parsons (1972).

For the estimation of Particulate Organic Carbon (POC), surface water samples were collected in clean one liter polythene bottles and filtered using 4.7 cm Whatman glass fiber filter paper (GF/C) quoted with $NaSO_4$ through a filtering unit. POC was then determined by wet ashing the filter paper with a mixture of potassium dichromate and concentrated sulphuric acid. By measuring the decrease in extinction of the yellow dichromate solution, concentration of POC was determined in UV 220 double beam (Hitachi) Spectrophotometer as described by Parsons *et al.* (1984). Light and dark bottle technique was used for measuring primary productivity. Oxygen values were converted to the organic carbon per unit volume of water (m^3) in unit time (t) and the productivity values have been expressed in mg Cm^{-3} h^{-1}. Simple correlation co-efficient (r) between different physical- chemical and biological parameters of the water and ANOVA has been employed for the Statistical interpretation of data obtained from the study. Based on the cycle of meteorological events, four seasons can be recognized (for the sake of convenience and interpretation of data), each of three months duration, as (i) postmonsoon (January- March), (ii) summer (April- June), (iii) premonsoon (July- September) and (iv) monsoon (October- December).

Results and discussion

The coastal zone comprising mangrove biotope is always subjected to extreme hydro climatic conditions, which are normally governed by a succession of meteorological events. Mangrove ecosystem is also influenced by tides, which are one of the main ecological factors serving as major energy input. The hydrography and nutrient cycling in the mangrove waterways are complicated by the continual mixing of water masses with different physical-chemical properties. Saraya (1984) showed that the environmental conditions of mangrove waters are largely governed by two dominant factors, namely, short term changes resulting from tidal inundation and seasonal changes induced by the monsoonal cycles. In the present study also, tidal inundations and the monsoonal cycles altered most of the physical- chemical and biological parameters observed.

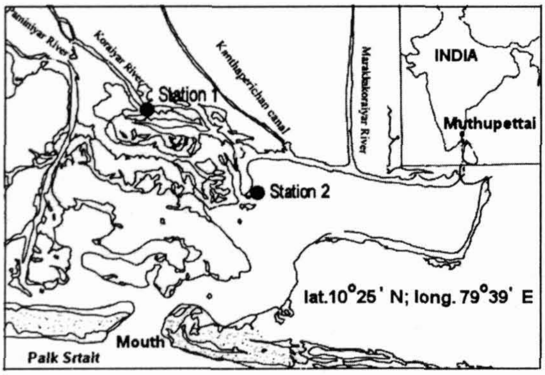

Fig.1. Map showing sampling stations

Atmospheric temperature recorded at the two stations varied between 21.5 and 32.5°C (Fig. 2) while surface water temperature varied from 22 to 33°C (Fig. 3). When compared to the other seasons, summer and early premonsoon seasons recorded higher temperature and minimum during monsoon season at both the stations. In general, both the stations showed similar seasonal changes in surface water temperature largely influenced by the air temperature.

The seasonal mean atmospheric and water temperatures recorded at both the stations were found to be high during the summer and low during the monsoon season. Evidently significant positive correlation could be observed between air and surface water temperatures ($P< 0.001$, $r = 0.994$ at station 1; $P< 0.001$, $r = 0.980$ at station 2). Variations in atmospheric temperature influenced water temperature as reported by Rama Sarma (1970) from the Godavari and Gautami estuaries, Sundararaj and Krishnamurthy (1975) from the Pitchavaram Mangroves and Karthikeyan (1988) and Sampath (1989) from the Kodiakkarai region.

Prevalence of difference in temperature, in general, was due to the factors such as solar radiation, cloud cover intensity and direction of wind currents and thermal exchanges by tidal currents. During the summer season, the clear sky would have favoured intense radiation thereby increasing the air and subsequently the surface water temperature. During the monsoon season, mixing of cold, fresh waters through river run off coupled with lower air temperature has led to reduction of surface water temperature.

Light extinction co-efficient (LEC) values varied from 5.3 to 7.7 (Fig. 4). It was obvious that during the monsoon and postmonsoon seasons, higher values were noticed due to abiogenic turbidity caused by river run off. Further, cloudy nature of the sky associated with reduced air and surface water temperatures during the monsoon season has reduced solar radiation, resulting in lesser light penetration into water column. During the summer and early premonsoon seasons, lower LEC values were recorded due to the inflow of clear neritic waters coupled with penetration of more light in to the water column as reported by Kannan and Vasantha (1992) from the Pitchavaram Mangroves. Light extinction co-efficient values showed negative correlation with air temperature ($P< 0.01$, $r= -0.602$ at station 1; $P< 0.05$, $r= -0.477$ at station 2) and also with surface water temperature ($P < 0.01$, $r= -0.599$ at station 1; $P < - 0.05$, $r= -0.456$ at station 2);

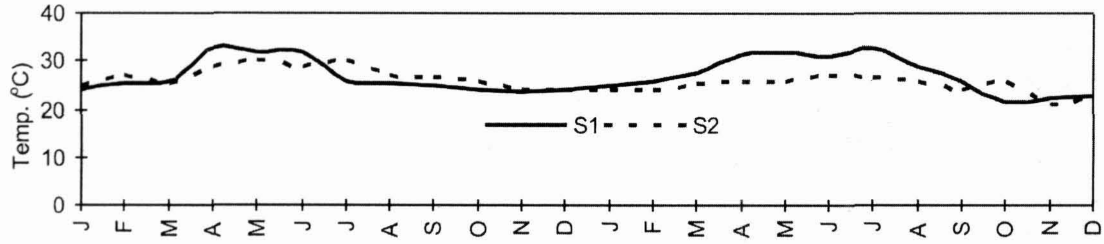

Fig.2. Variations in atmospheric temperature

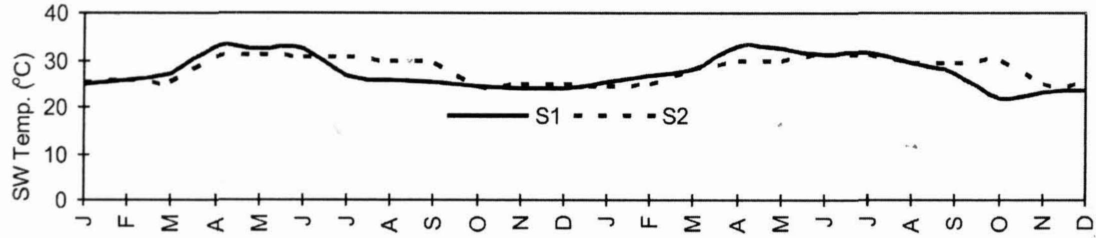

Fig.3. Variations in surface water temperature

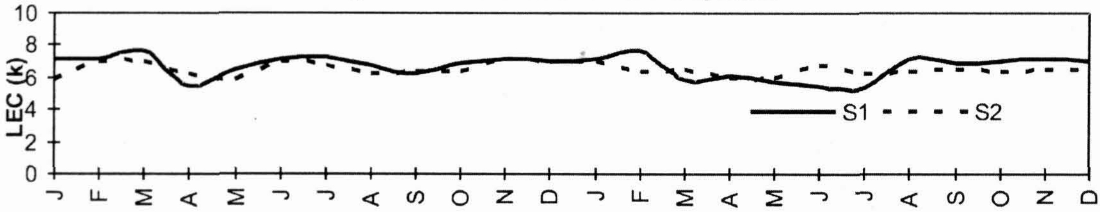

Fig. 4. Variations in light extinction

Salinity ranged from 2 to 29.5‰ (Fig. 5), however, it dropped even to limnetic conditions during monsoon season at station 1. Primary peak (summer season) and the secondary peak (premonsoon) in mean salinity values observed during the present investigation were due to higher rate of evaporation in the shallow lagoon area, with very low inflow of fresh water. Salinity exhibiting a positive correlation with atmospheric temperature ($P< 0.001$, $r= 0.895$ at station 1 and $P < 0.001$, $r= 0.760$ at station 2) supports this fact. Low salinity values recorded during the monsoon and early postmonsoon seasons were due to lesser evaporation rate and higher degree of dilution by copious inflow of fresh water caused by monsoonal rains (513.9 mm rainfall in December 1996). Seasonal mean salinity values observed in the present study ranged from 1.66 to 28.8‰.

Dissolved oxygen concentration ranged from 3.8 to 8.2 ml l^{-1} (Fig. 6). Local production, diffusion and advection, exchange of oxygen across the surface and biochemical utilization are the controlling factors for dissolved oxygen distribution in many aquatic environs (Richards, 1957) and any one or more or all of them could have acted for causing such a variation in dissolved oxygen content during the present investigation. Dissolved oxygen did not show any uniform seasonal distribution at both the stations. Seasonal mean showed lesser variation ranging from 4.9 to 7.6 ml l^{-1} at the two stations.

Hydrogen - ion concentration (*p*H) ranged from 7.2 to 9.2 (Fig. 7) and it was always higher at station 2 than at station 1. This might be due to the higher tidal influence in this station. The seasonal mean values of *p*H observed during the present study were similar to those observed from the Pitchavaram mangrove waters by Kannan and Vasantha (1992) and from the Kodiakkarai mangrove waters by Mohanraju and Natarajan (1992). The *p*H of the lagoonal waters reflects to a large extent the degree of penetration of the neritic water in to the lagoonal area.

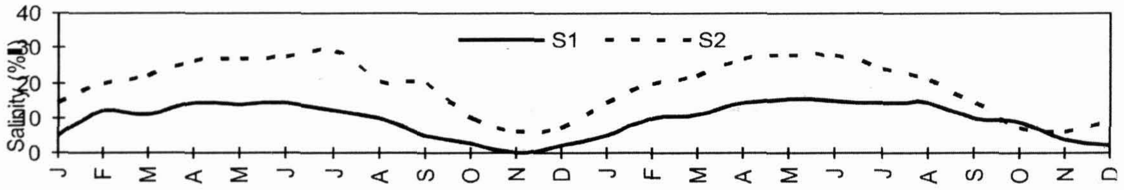

Fig.5. Variations in salinity

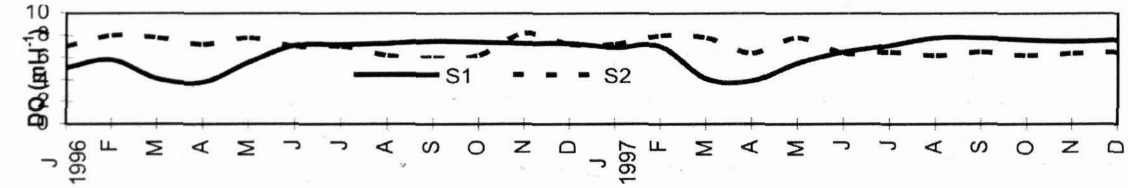

Fig.6. Variations in dissolved oxygen

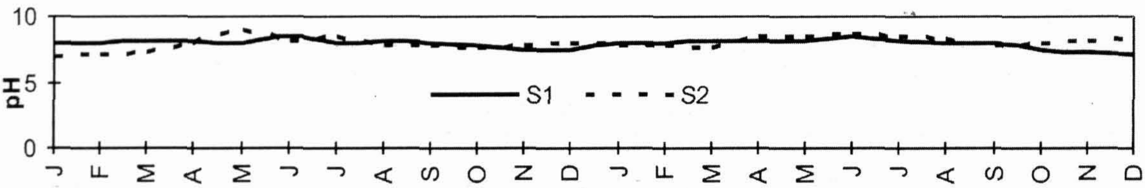

Fig.7. Variations in *p*H

Since the lagoonal area is connected to the sea (Palk Strait) by a mouth, higher *p*H values were encountered. As discussed earlier, fresh water inflow in the study area decreased the salinity of the water body and thereby reduced the *p*H level and was evidenced by significant positive correlation between salinity and *p*H ($P< 0.01$, $r=0.565$ at station 1 and $P< 0.001$, $r= 0.832$ at station 2).

In the tropical mangrove ecosystem, the vegetation and its associated biota play a major role in contributing the organic matter (Jagtap, 1987). POC content of the Muthupet Mangrove waters ranged from 0.20 to1.9 mg C l^{-1} (Fig. 8) The seasonal mean concentration of POC varied from 0.31 to 1.80 mg C l^{-1} registering the primary peak during the premonsoon (station 1) and post monsoon (station 2) seasons. The values were low when compared to the other mangroves environs. This reduction in POC might have resulted due to high tidal amplitudes which would dilute and transported the organic carbon content to the open ocean. As per the reports of Rajendran and Kathiresan (2000) mangrove leaves takes minimum of 10 days to get decomposed in the field which mean there are possibilities of transport of more than 50% of the mangrove leaves before get mineralized.

Mangrove waters are generally turbid because they exist in shallow areas, which are subjected to actions of tides, waves and currents. These cause periodic resuspension of the sediments laden with organic matter, thus enriching the overlying water column with organic matter. Further, during the monsoon, terrestrial runoff contributes more of particulate matter to the mangrove environment. It is worth mentioning here that Jagtap

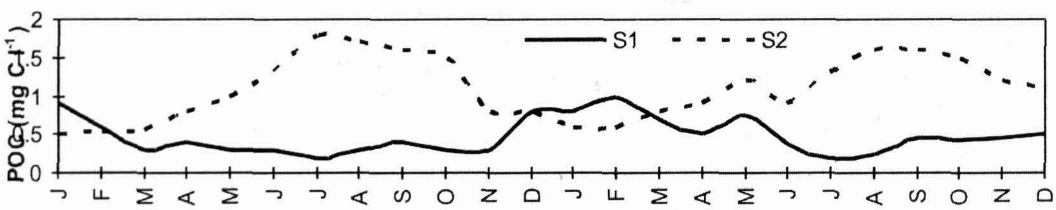

Fig.8. Variations in POC

(1987) and Sreepada *et al.* (1993) have reported that the detrital particles brought down by the rivers and litter production by the aquatic macrophytes and mangroves are the causes for the enrichment of particulate organic matter in the mangrove environs.

It is generally believed that coastal wetlands including marshes and mangroves export large quantities of dissolved inorganic nutrients (eg. nitrate, nitrite, phosphate and silicate) to the adjacent estuarine or coastal waters through tidal movement (Woodwell and Whitney, 1977; Bacon, 1981).

A fluctuating pattern of nitrate concentration (9.2 to 27.3 μM) was conspicuous at the two stations (Fig. 9). The mean seasonal concentration ranged from 14.9 to 26.56 μM and a similar range was reported from the Pitchavaram mangroves (Kannan and Krishnamurthy, 1985) and Pitchavaram and Kodiakkarai mangrove waters (Natarajan, 1987). The observed low concentration of nitrate during the summer season could be due to the utilization of this nutrient by phytoplankton and cessation of fresh water flow as opined by Kannan and Kannan (1996).

Nitrite concentration varied from 0.96 to 6.90 μM (Fig. 10). In general, higher values were recorded during the monsoon season (station 1) and post monsoon season (station 2). This could be due to biological causes like the activity of ' nitrogen-cycle' bacteria, excretion of nitrogenous compounds by plankton and decay of vegetation (Sundararaj and Krishnamurthy, 1975), in addition to fresh water input. Nitrite values were higher in Muthupet mangroves as compared to the mangrove environment of Kodiakkarai (Mohanraju and Natarajan, 1992). This could be to the fact that activity of bacterial reduction of nitrite and oxidation of ammonia by nitrifying bacteria should have been more in Muthupet than in other mangrove environs.

In general, the inorganic phosphate concentration registered peak values during the monsoon seasons at both the stations and the values ranged from 1.6 to 28.9 μM (Fig. 11). The seasonal mean concentration of PO_4 was

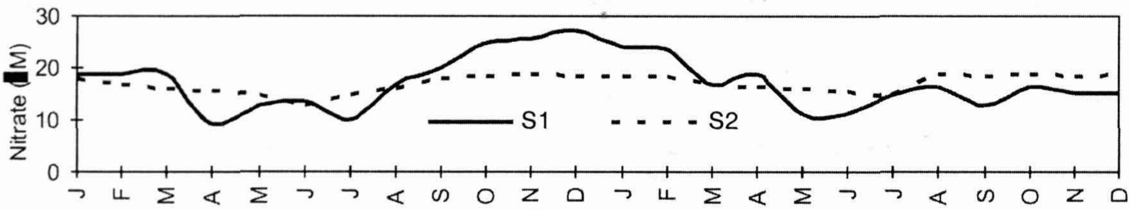

Fig.9. Variations in nitrate

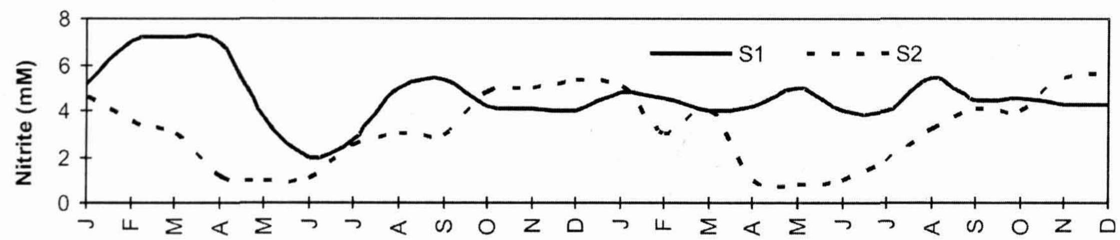

Fig.10. Variations in nitrite

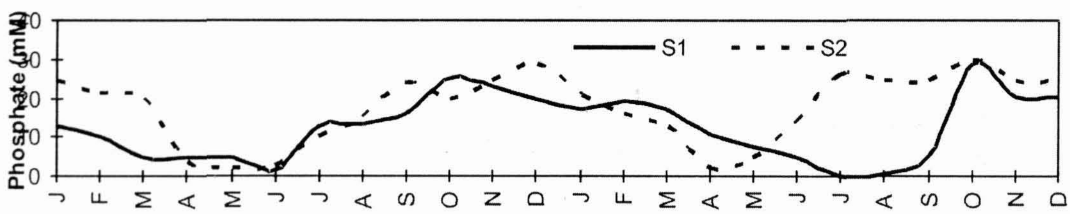

Fig.11. Variations in phosphate

maximal during the monsoon season and minimal during the summer season at both the stations. Increased concentrations of phosphate observed during the monsoon season in the mangrove waters was mainly due to land run off. Slightly lower values of phosphate during the summer season could be due to the utilization of phosphate by phytoplankton, which showed higher photosynthetic activity during this season as evidenced by higher values of primary production as suggested by Kannan and Krishnamurthy (1985). They have also stated that an increase in phosphate level during the monsoon season and a decrease during the summer season coincide with lower and higher primary production values respectively in Pitchavaram Mangroves.

Concentration of PO_4 recorded in the Muthupettai Mangrove waters is higher than that of the mangrove swamps of Kakinada coast (Selvam *et al.*, 1992). Higher values observed in the present study might be due to various reasons viz. transport of phosphate by bubbles rising to the surface, decomposition of particulate organic matter, excretion by plankton and horizontal and vertical transport of water advection.

Reactive silicate concentration varied from 7.9 to 128.6 μM (Fig. 12) while the seasonal concentration ranged between 13.6 and 121.07 μM. Among the two stations, station 1 recorded higher levels of silicate. This range of values is comparable to the values recorded in Pitchavaram 50 to 275 $\mu g\ l^{-1}$ by Kannan and Vasantha, 1992). Silicate maximum was noticed at station 1 where salinity was minimum as this station is situated away from the sea where salinity is measurably reduced by the nutrients laden fresh waters from the Koraiyar river. Lower silicate and higher salinity values were recorded at station 2 which is closer to the sea.

Phytoplankton chlorophyll *a* concentration varied from 0.03 to 3.76 mg m^{-3} (Fig. 13). The chlorophyll *a* concentration showed uniformity in its seasonal distribution at both the stations. However, close appraisal of the values indicated slightly higher concentration at station 2. Seasonal variation in chlorophyll *a* was well marked with primary peaks during summer and premonsoon seasons, coinciding with higher population densities of phytoplankton.

Monthly TSM concentration ranged from 0.13 to 1.65 mg l^{-1} (Fig. 14) while the seasonal mean concentration ranged from 0.18 to 1.40 mg l^{-1} and was generally

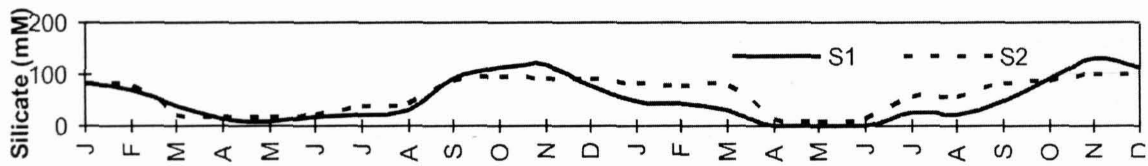

Fig.12. Variations in silicate

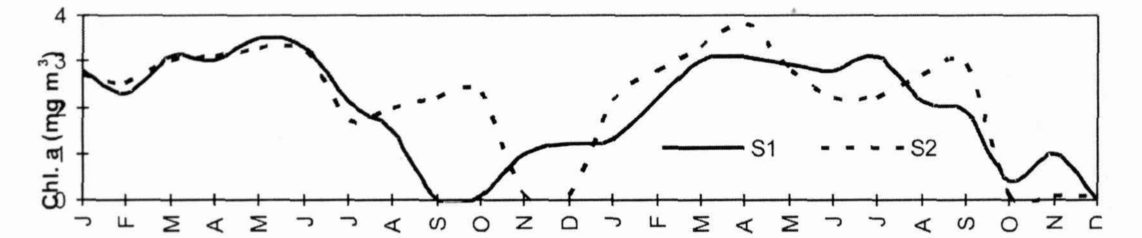

Fig.13. Variations in chlorophyll *a*

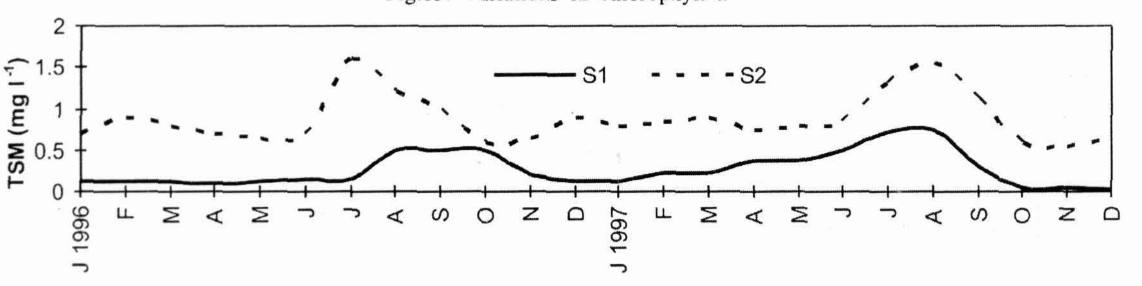

Fig.14. Variations in total suspended matter

higher during the premonsoon season. The level of total suspended matter recorded in the present study is very low when compared to the other mangrove waters where mangrove and terrestrial detritus is present in enormous quantities.

In general, POC and nutrients concentrations were influenced by many parameters at the two stations. Station 1 receives copious fresh water flow during the monsoon season, where the tidal influence is less as it is located away from lagoonal mouth. Further, at station1, fresh water plants such as *Ceratophyllum*, *Vallisneria*, etc., flourish well during the monsoon season. Thus, station 1 partly acts as a freshwater habitat in a year during the monsoon period. But at station 2, which is closer to mouth, though it has monsoonal influence, the ebb tides maintain the brackish water nature.

Analysis of the variance employed between the two stations showed significant variations in salinity, dissolved oxygen, particulate organic carbon, nitrite and total suspended matter of the mangrove waters. All these are key factors which determine the distribution of biota in the marine environment. Their seasonal variations would definitely cause temporal variations in the distribution of both flora and fauna, as depicted clearly in previous studies (Kannan, 1981; Natarajan, 1987; Selvam *et al.*, 1992 and Rajendran, 1997).

Thus in the present study on the water quality of the Muthupet Mangrove biotope showed marked seasonal variations in the physical, chemical and biological characteristics which revealed the typical mangrove environmental condition. Terrestrial run off and monsoonal input mostly altered the turbidity and salinity of the water column. Dissolved oxygen concentration recorded was slightly higher while Particulate Organic Carbon (POC) and Total Suspended Matter (TSM) showed lesser values as compared to other Indian mangrove environs.

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