Dedicated to

Loving Memory of My Father

ECO-BIOLOGICAL STUDIES OF MANGROVE, *RHIZOPHORA* SPECIES

DISSERTATION SUBMITTED BY

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C E R T I F I C A T E

This is to certify that this Dissertation is a bonafide record of work carried out by Kum. Preetha. P.M. under my supervision and that no part thereof has been presented before for any other degree.

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CONTENTS

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PREFACE

The occurence of mangrove forests is a characterestic feature of tropical intertidal zone. Dominated by many species of trees or shrubs, which have the ability to grow in saline or brackishwater, these plants exhibit a number of features that allow them to withstand the wide fluctuations of various factors in these ecosystems.

The mangrove areas found in estuarine and coastal regions are a source of organic detritus. The specialized root system of these plants, trap the sediments in the muddy or silty substrata and serve as store house of nutrients. Therefore these eccosystems are usually inhabited by a number of organisms and consume the nutrient-rich detritus. The mangroves enrich the productivity of the surrounding water bodies, which in turn leads to a dense population of secondary and teritiary consumers. It also serves as a breeding and nursery ground for many finfishes and shellfishes.

The role of mangroves in the maintenance of coastline, and prevention of soil erosion has attracted much attention. Their root system helps to prevent the erosion, and such accreted areas gradually become regions of high production. Due to these characterestic features, the mangrove ecosystem are increasingly used as a suitable site for aquaculture practices.

The mangroves have provided a significant source of fuel and fodder. But exploitation of mangrove forests for various uses have lead to the destruction of the habitat . Therefore many countries are attempting to optimise the use of their mangrove resources without endagering them.

To know more about the mangrove ecosystem from an aquaculture and conservation point of view detailed studies on the ecology and biology of different communities are necessary. Some of the mangrove communities in the Cochin estuarine area has been studied previously. However, observations on the mangrove, Rhizophora sp. has not formed a subject of elaborate study. Therefore an attempt has been made here to understand the ecological and biological aspects of mangrove areas dominated by Rhizophora in the Cochin area.

Ecological studies include the determination of various hydrophysical parameters of the water and soil. Biological observations were restricted to floral phenology, litter production and experiments on decomposition of leaves and germination of propagules in the field itself.

A C K N O W L E D G M E N T S

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INTRODUCTION

Vannucci (1989) defines mangrove as a word, which is a collective noun designating an ecosystem formed by a very special association of plants and animals that live in the intertidal area of low lying tropical coasts, estuaries, deltas, backwaters and lagoons. Following early work on mangroves (Watson 1928, Mac Nae 1968) the importance has shifted to the study of their distribution, ecology, decomposition of leaves, characteristics of sediments, productivity, fisheries and as a site for aquaculture.

The mangrove vegetation of India is estimated to be 3,55,500 ha with 1,15,200 ha in the Andaman and Nicobar Islands and only a vestige of less than 100 ha in the Kerala backwaters (Blasco 1975). The east coast including Andaman and Nicobar islands, contributes about 82% while west coast has only 18% (Untawale 1985). Mall *et al* (1985) found the ratio between mangrove coastline to total coastaline in peninsular India to be 8:100, which was less than the ratio found in Australia, Venezula and Penisular Malasia.

Rajagopalan *et al* (1986) in an appraisal of the mangrove ecosystem in the Cochin backwater, found them to be formative, mostly developing on small reclaimed or natural Islands, with the dominant vegetation constituted by species of *Acanthus*, Excoecaria, Clerodendrum, Aegiceias, Avicennia and Rhizophora. A moderate soil salinity, tidal inundation, low redox potential and fine grained soil with silt and clay were found to be favourable to the colonization of Acanthus ilicifolius in Cochin area (Muralidharan 1984). The rhizosphere microflora of the same species was studied by Mini Raman (1986). Meenakshy (1985) found Avicennia officinalis to germinate best in salinities lesser than 15‰. Josileen Jose (1989) observed the total litter production from a Bruguiera spp dominated ecosystem at Cochin to be 76.30 t/ha/yr. Inclusion of Rhizophora mucronata leaves at 15% of the feed, both in green and decomposed form enhance the growth of juveniles of P. indicus (Sally Anne Thomas 1985).

Mangrove areas contribute significantly to fish production by 1) sustaining a fishery 2) as a suitable site for culture and 3) by providing breeding and nursery ground for many finfishes and shellfishes. Robertson et al (1990) observed species belonging to the families Engraulidae, Ambassidae, Leiognathidae, Clupeidae and Atherinidae to dominate the mangrove fish communities in Queensland , Australia. A preliminary study on the fishery resources of the mangrove swamps of Sundarbans showed a production of 2,500 metric tonnes/ year (Chakrabarti 1984). Chong et al (1990) found a coastal mangrove community in Malaysia to comprise of 63-99% of juvenile fish and 100% of juvenile prawns. Fisheries and aquaculture significance of mangrove swamps with special reference to Indo-West-Pacific region has been explained by Macintosh (1982). Rajguru et al (1988) found that the mangrove waters at Pitchavaram serve as nursery grounds for juvenile of marine flat fishes. Post larval and juvenile P. merguiensis, use mangrove estuary as a nursery area (Vance et al 1990). The importance of mangroves to coastal fishery and the need for its conservation has been highlighted by Achuthankutty (1990).

Lopez-Portillo et al (1989) Studied the variation in physiognomy in relation to salinity in two different geomorphic habitats. Tidal dynamics, precipitation events and nitrification were identified as major control factors affecting the hydrochemistry of a mangrove tidal creek by Ovalle et al (1990). Boto and Robertson (1990) examined the nitrogen fixation rates of sediments, algal mats, decomposing logs and algal - covered proproots of a tropical mangrove forest and found low to moderate fixation. The responses of mangrove R. mucronata to high salinity is medicated primarily through low osmotic potentials and not by salinity per se (Naidoo 1986).

The sediments of mangrove areas are unique due to the high detrital and organic matter content which contribute to the productivity of mangrove ecosystems. Saxena et al (1988) estimated the sulphate - reducing bacteria from sediment samples of mangrove swamps and found that the counts decreased with depth. Soil salinity in a South African mangrove swamp showed distinct seasonal trends, being lower during hot, wet summer and two-three fold higher during cool, dry winter (Naidoo 1989). Leichtfried (1990) studied the distribution and food quality of organic matter (POM) in reef and mangrove sediments and found that in comparable sediments POM quantities and qualities are similar regardless of the geographical distribution. Alongi (1990) studied the effect of mangrove detrital out welling on nutrient regeneration and oxygen fluxes in coastal sediments of the Central Great Burrier reef lagoon, and observed that a high concentration of organic carbon and total nitrogen were recorded from the station receiving the greatest quantities of mangrove litter.

Detritus from Seagrass, epiphytes or phytoplankton are the major contributors of reduced carbon in an estuarine ecosystem, while mangrove makes only a localized low contribution to the food chain (Fleming et al 1990).

Ecological conditions like temperature have strong influence on some species of mangroves for flowering and fruiting (Mulik and Bhosale 1989). Jimenez (1988) found the seedling density of R. racemosa to fluctuate according to the season and the crop production, while Tamai and Lampa (1988) observed that initial seedlings establishment is not strongly affected by light condition and soil texture. Smith (1987) concluded that the species zonation patterns observed in intertidal mangrove areas cannot be explained by physiological adaptations alone and factors such as propagule dispersal, competition and predation on propagules may also be important. Significant effect of nitrogen source and concentration, as well as of salinity on nitrogen content, biomass accumulation and photosynthetic leaf area of Bruguiera gymnorrhiza was observed by Naidoo (1990). Litterfall measured in two mangrove communities showed that stem material generally made a small contribution to total litter but the estimated total litter production for a year was a significant input to these communities (Steink and Ward 1988). Flores-Verdugo et al (1990) investigated the mangrove ecology, aquatic primary production and fish community dynamics in the Teacapa-Aqua Brava lagoon - estuarine system. In the Cananeia lagoon estuarine system near the latitudinal limit for mangroves, primary production exhibits pronounced seasonal pulses, heterotrophic process lag photosynthetic production and are partially driven by particulate matter inputs (Schaffer-Novelli et al. 1990).

The degradation of mangroves by various agencies has been the focus of attention and efficient management measures have been suggested. Vernberg (1984) highlights the ecological value of the mangroves and presents examples of the impact of human on mangroves. He suggests that well designed mangrove management practices must be developed so that short-term economic gains do not destroy the potential for a long-term, renewable, sustainable economic growth. Untawale (1985) states that in the absence of a national plan like land use plan as well as conservation and utilization strategy, the mangrove along the Indian Coasts have been reduced to an alarming stage, particularly along the west coast of India.

The foregoing brief review on the recent work carried out on the ecology and biology of mangroves, underlines the importance of mangroves and the need for its conservation. With this view, the present work attempts to understand the various factors both ecological and biological which control a *Rhizophora* dominated community in the Cochin area.

MATERIALS AND METHODS

Identification:

The mangrove tree Rhizophora mucronata was identified based on its morphological characters such as long aerial roots, which raise the main trunk above the level of its origin, presence of leaf-scars on the terete branches, and entire leaves dotted black beneath and bright green above (Blatter 1905).

Study Sites:

R. mucronata, selected for the study is a dominant mangrove vegetation and commonly grows in Islands of Cochin estuarine system. After a preliminary survey 3 stations were fixed.

Station - 1: Murukkumpadam.

The area fixed for the study is near Murukkumpadam boatjetty, on the western side of Vypeen - Munambam road. The predominant vegetation is R. mucronata, along with Bruguiera cylindrica, Acanthus ilicifolius and Avicennia officinalis. The tidal flow of this area is weak.

Station - 2: Puduveypu.

Puduveypu is situated about 2 km north of Murukkumpadam. The study site is near Puduveypu fishery station of Kerala Agricultural University. R. mucronata dominates but Brugiuera and Acanthus ilicifolius is also seen. The tidal action

Plate 1. R. mucronata at Murukkumpadam showing the proproots.

Plate 2. The R. mucronata dominated mangrove at Puduveypu.

Plate 3. The mangrove at the fringe of a prawn culture pond Narakkal and its closer view (below).

is more here when compared to first station.

Station - 3: Narakkal

Narakkal is 4 km north of Puduveypu. A site adjacent to the Narakkal centre of CIBA was chosen for collecting field data. Rhizophora mucronata forms a fringe on the northern edge of an about 0.2 acre prawn culture pond. The tidal action is high at this station due to proximity to the main canal.

The study was conducted from May to October, 1991. Water and sediment samples were collected fortnightly from these sites.

ECOLOGICAL PARAMETERS

Surface water was collected in 250 ml plastic bottles and its temperature was noted and sediment was stored in polythene bags which was made air tight. Water samples for dissolved oxygen estimation were collected in 100 ml glass bottles care being taken to avoid air bubbles and fixed in the field itself. The water parameters estimated were pH, salinity, dissolved oxygen and nutrients. The sediment was dried at 70°C and analysed for pH, organic carbon, available phospharous and cation exchange capacity. The analysis of the sample was carried out as follows:

A. WATER:

a. pH: is measured in a digital ECIL pH meter.

b. Salinity: Mohr-Knudse method (Strickland and Parson, 1968) using silver nitrate and potassium dichromate as indicator was followed.

c. Dissolved oxygen: The dissolved oxygen content is estimated by the modified Winkler technique (Strickland and Parson, 1968).

For estimating the nutrients, the methods outlined by Strickland and Parson (1968) and Parson et al (1984) was followed and spectro-photometric measurements were taken on a ECIL Spectrophotometer

d. Nitrate: A modified method of Mullin and Riley (1955) in which nitrate was determined after reduction in darkness by the buffer reagent (obtained by mixing phenol solution and sodium hydroxide) and the reducing agent (a mixture of hydrazine sulphate and copper sulphate). The reaction was stopped after 20 hrs by addition of 2 ml of acetone. 1 ml of sulphanilamide and 1 ml NNED was added and the pink colour developed was read at 543 nm.

e. Nitrite: The determination of nitrite is based on the classical Griess's reaction, in which the nitrite ion at pH 1.5-2.0 is diazotized with sulphanilamide, resulting in a diazo compound, which in turn is coupled with N-(1-napthyl) - ethylenediamine to form a highly coloured azo dye with an absorption maxima at 543 nm that is measured spectrophotometrically.

f. Ammonia: Sea water is treated in an alkalanine citrate medium with sodium hypochlorite and phenol in the presence of sodium nitroprusside which act as a catalyzer. The blue indophenol colour formed with ammonia is measured spectrophotometrically at 640 nm.

g. Reactive phospharous: The phosphate in water is allowed to react with ammonium molybdate, forming a complex heteropoly acid. This acid is reduced by ascorbic acid, to a blue-coloured complex, the light absorption of which is measured in a spectrophotometer by using a 660 nm filter. Normally this reduction is slow, but by adding a catalyst - antimonyl tartrate - the reduction proceeds swiftly.

h. Reactive Silicate: The determination of dissolved silicon compounds in natural water is based on the formation of a yellow silicomolybdic acid, when a more or less acidic sample is treated with a molybdate reagent. Since both of the yellow silicomolybdic acid isomers are rather weak in colour, they are reduced to intensely coloured blue complexes. A mixture of metol and sulphate was used as reducing agent.

i. Chlorophyll: A known volume of mangrove water is filtered on Whatman filter paper of 4.7 cm and 0.45 μ pore size. Pigments are extracted from the filter in 90% acetone and their concentration is estimated spectrophotometrically at range of 665, 645 and 630 nm for Chl.a Chl.b and Chl.c respectively.

The Chl.a values were multiplied by a factor of 17.3 to estimate the productivity in mg/cubm (Cushing 1958).

B. SEDIMENT: Sediment was analysed following methods of Jackson (1973)

a. Grain Size analysis: Grain size of sediment was carried out by the pippete method.

b. pH: is estimated by a ECIL digital pH meter. 10 gm of soil is weighed in to 50 ml beaker and 10 ml of deionized water is added. The mixture is stirred intermittingly for about one hour and pH is determined.

c. Organic Carbon: Organic carbon was determined by rapid titration method; with diphenylamine as an indicator.

d. Organic matter: Organic matter of sample is calculated directly by multiplying the value of organic carbon obtained by a factor 1.724.

e. Total nitrogen: 20% of organic carbon obtained is considered as total nitrogen.

The concentration of the various parameters was calculated based on its optical density. Standard graphs were used.

BIOLOGICAL PARAMETERS

(a) Phenology: The percentage of shoots, buds at different stages, full flowers, fruits and mature seedlings during different months were observed.

(b) Litter: Mangrove Litter was collected from a fixed quadrant of 1 Sq.m. Litter accumulated was collected fortnightly sorted, washed, dried and weighed.

(c) Decomposition experiment of leaves: Mature leaves of *R. murcronata* were collected, measured and wet weight taken. After drying them in the oven at 70°C to constant weight, 10 gm was placed in litter bags of 10 x 15 cm made of nylon mosquito net. The bags were kept immersed in brackish water collected from Murukkumpadam. The rate of decomposition was estimated by removing the contents of the bag, on to a petridish, dried at room temperature for 20 mts and weight noted.

(d) <u>Germination experiment of propagules</u>:

10 mature propagules collected from mother plant, when pericarp becomes dark green to brown in colour, was planted in 3 x 1 m area at Puduveypu station, which was indundated at high tides. The percentage of survival and growth were observed.

RESULTS

ECOLOGICAL PARAMETERS

A. WATER

1. Temperature : The fortnightly variation was more or less similar in all the station with low values during second half of June which increased and reached a peak in the second half of August (Fig I). The values at Murukkumpadam was low during most of the period and recorded values lower than the other two stations. The change was significant ($P<0.05$) between stations and between the months ($P<0.01$). (Table : 1, 2, 3., ANOVA table : I, A).

2. p^H : p^H values showed a maximum concentrations from June second week to the last week of September. A sharp decline was observed in June first week at all stations. There was no significant variation among the stations, However significant ($P<0.01$) variation was observed between months. (Fig - 2, Table: 1, 2, 3, ANOVA table : I, C).

3. Salinity : With the onset of monsson in the latter half of May, salinity declined in all the stations and remained at less than 10 pp t throughout. The change was significant between the months ($P<0.01$). (Fig - 3, Table : 1, 2, 3

4. Dissolved Oxygen : Narakkal showes a maximum dissolved oxygen content than other stations during the initial months and a declain was observed during the second week of July,

Table 1: Values observed from water samples for various hydrographical parameters at Murukkumpadam.

Month	Week	Temperature (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrate (µg at/l)	Nitrite (µg at/l)	Ammonia (µg at/l)	Phosphate (µg at/l)	Silicate (µg at/l)
MAY	I	33.0	31.7	2.6	7.21	1.30	0.56	110.0	10.4	20.0
	III	32.0	20.3	4.2	7.77	0.70	0.82	82.4	10.9	12.4
JUNE	I	30.0	6.9	4.8	6.82	0.04	1.30	30.6	19.8	70.0
	III	27.0	4.9	3.4	8.12	0.12	1.32	29.6	19.0	10.2
JULY	I	28.0	1.4	3.9	8.28	0.52	1.20	30.1	26.7	10.1
	III	27.0	3.3	5.7	8.26	0.05	0.30	11.5	6.1	48.1
AUGUST	I	28.0	2.3	1.8	8.22	0.56	0.31	21.4	26.0	23
	III	28.0	1.7	7.8	8,78	0.42	0.80	30.6	13.3	9.7
SEPTEMBER	I	30.5	5.7	2.9	8.61	0.30	0.44	10.1	29.6	8.1
	III	29.3	9.3	1.3	8.41	0.34	0.30	90.2	27.2	7.2
OCTOBER	I	31.0	5.9	6.4	7.83	0.22	1.20	17.8	17.2	8.4

Table 2: Values observed from water samples for various hydrographical parameters at Puduveypu.

Month	Week	Temperature (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrate (µg at/l)	Nitrite (µg at./l)	Ammonia (µg at./l)	Phosphate (µg at/l)	Silicate (µg at./l)
MAY	I	34.5	28.6	2.0	6.75	0.25	0.29	30.1	15.5	150.00
	III	34.0	26.8	3.6	7.95	0.02	0.35	17.3	14.3	115.00
JUNE	I	31.5	9.8	3.9	6.17	0.05	0.29	90.8	16.5	100.30
	III	27.8	3.8	4.3	8.29	0.11	0.33	70.4	13.3	58.00
JULY	I	29.5	2.3	4.0	8.52	0.31	1.00	60.1	23.1	29.05
	III	28.3	3.8	2.7	8.51	0.14	0.50	46.0	24.9	31.05
AUGUST	I	28.5	3.3	3.0	8.39	0.53	1.50	120.5	18.4	2.01
	III	31.0	2.8	7.4	8.48	1.43	1.70	96.0	14.4	18.05
SEPTEMBER	I	30.2	7.5	5.7	8.23	0.13	1.82	29.0	22.4	37.05
	III	28.3	8.7	4.4	8.04	0.13	1.36	10.2	21.5	33.2
OCTOBER	I	34	6.9	4.9	8.02	0.12	0.92	25.0	16.4	24.5

Table 3: Values observed from water samples for various hydrographical parameters at Narakkal.

Month	Week	Temperature (°C)	Salinity (‰)	Dissolved oxygen (ml/l)	pH	Nitrate (µg at./l)	Nitrite (µg at./l)	Ammonia (µg at./l)	Phosphate (µ g at/l	Silicate (µg at/l)
MAY	I	35.5	17.6	8.40	7.22	0.84	0.24	70.1	6.4	35.20
	III	33.2	14.2	8.20	7.34	0.92	0.27	72.0	6.2	30.4
JUNE	I	33.0	6.7	7.20	6.07	1.02	0.29	40.6	5.0	47.80
	III	28.5	5.4	7.65	8.04	1.14	0.31	20.1	6.1	55.20
JULY	I	30.0	2.6	6.21	8.44	0.54	1.30	10.9	6.1	30.03
	III	30.0	5.1	2.48	8.42	0.32	0.10	1.3	1.8	17.05
AUGUST	I	31.0	2.8	6.70	8.61	0.54	1.70	2.5	6.1	13.05
	III	34.5	2.2	6.60	8.63	0.10	0.25	6.0	3.2	22.05
SEPTEMBER	I	32.0	3.8	6.40	8.52	0.12	0.82	9.0	9.2	29.05
	III	28.0	12.0	3.20	8.67	0.24	1.20	80.6	8.4	18.20
OCTOBER	I	30.8	4.7	3.12	8.12	0.53	1.26	70.2	10.2	16.40

Fig. 1 : Fortnightly variations in water temperature at Stations I to III.

Fig. 2 : Fortnightly variations in water p^H at Stations I to III.

Fig.1. Temperature

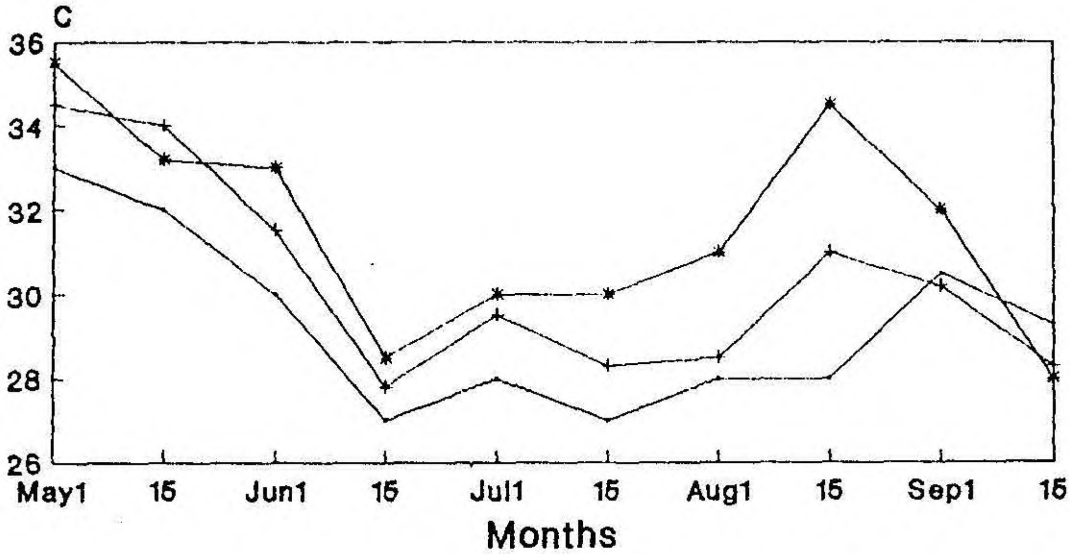


Fig.2. pH

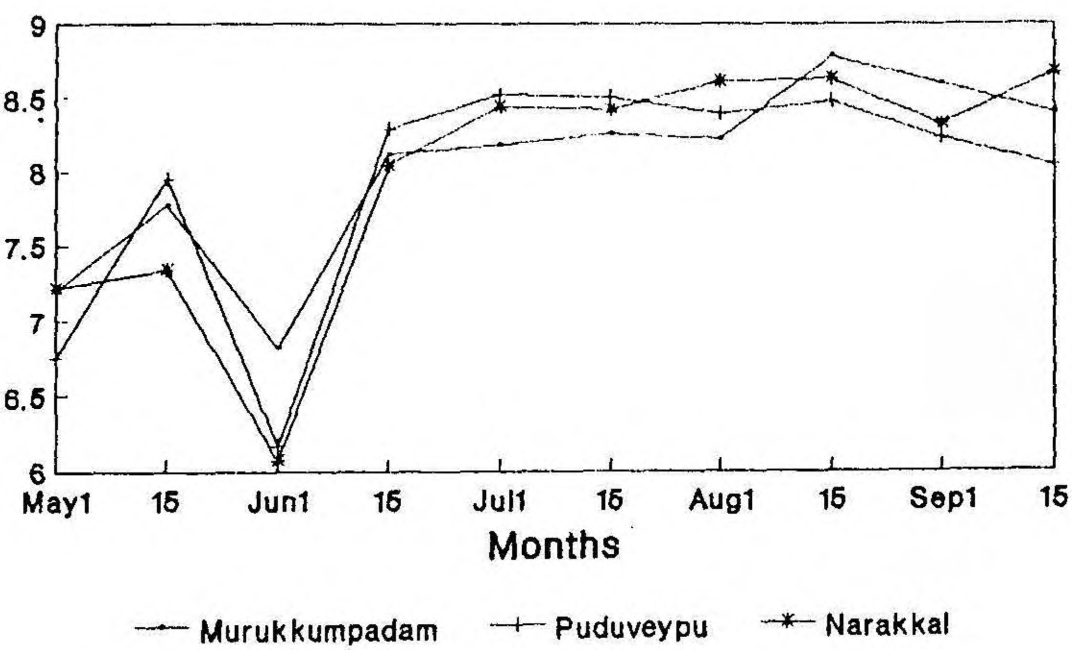


Fig. 3 : Fortnightly variations in water salinity at Stations I to III.

Fig. 4 : Fortnightly variations in Dissolved oxygen at Stations I to III.

Fig.3. Salinity

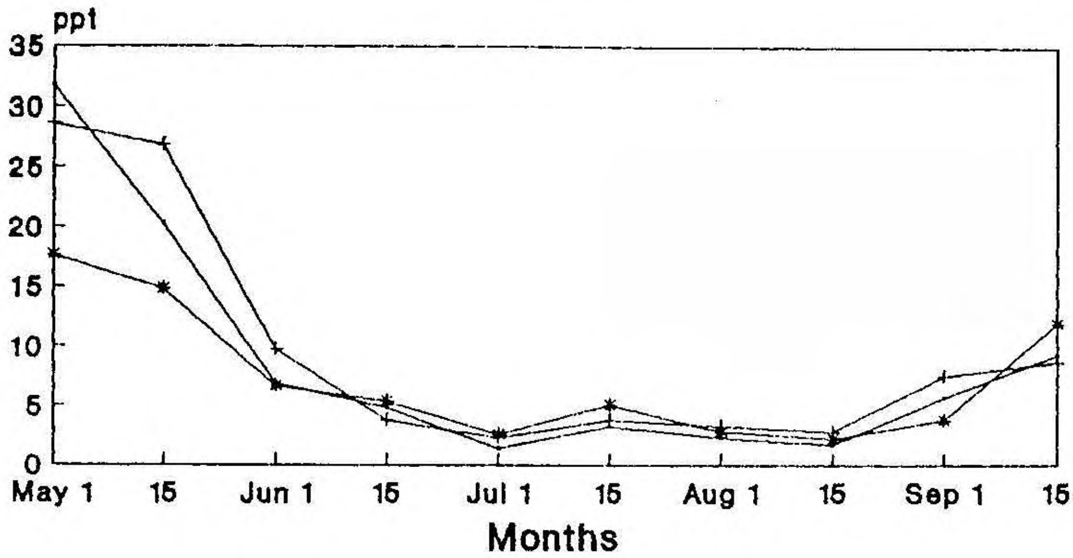
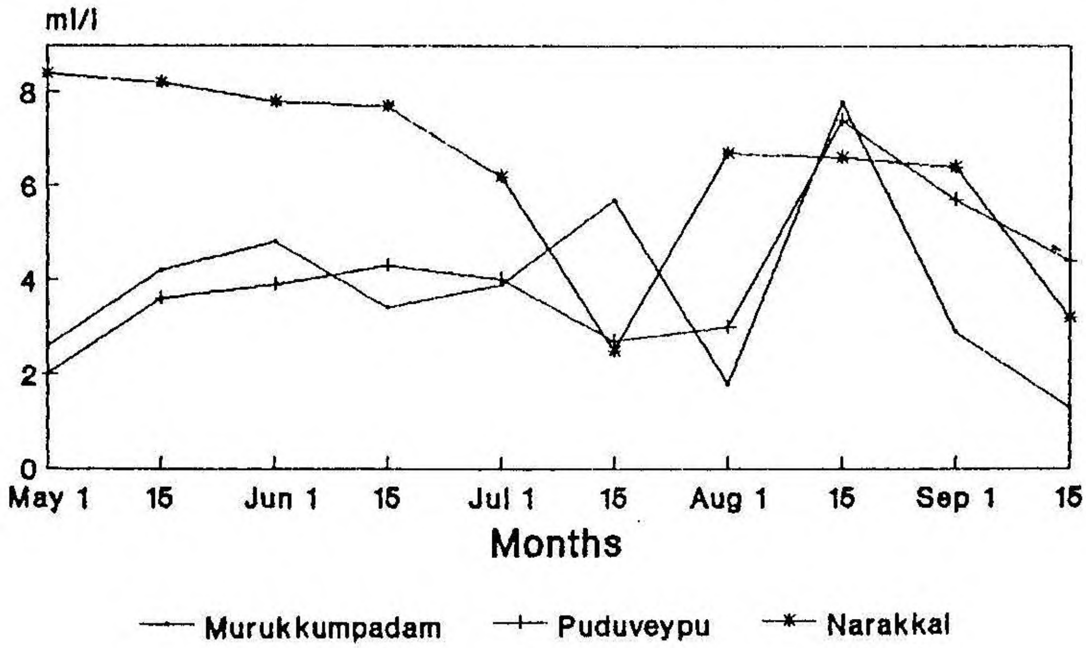


Fig.4. Dissolved Oxygen



The variations at the other two stations were almost similar. Significant differences between the months was observed. However the variations among the stations were not significant. (Fig - 4, table : 1,2,3)(ANOVA table : I, D)

5. Nitrate : A gradual increase is observed at Narakkal during the first two months. But thereafter it reduced and remained low for rest of the period. On the other hand at Murukkumpadam a sharp decline was observed in the initial period and here also it continue to remain at a low concentration. At Puduveypu the concentration was low with a peak in August second week. The change was siginficant between months ($P < 0.05$) (Fig - 5, table : 1,2,3)(ANOVA table: II, A)

6. Nitrite : From all the 3 stations the nitrite concentration was recorded shows an alternate increasing and decreasing trend from June 3rd week to July 3rd week; with a peak at August Ist week. There was not significant variation among the station or months during the study period. (Fig - 6, table : 1,2,3)(ANOVA table : II, B)

7. Ammonia : At Narakkal the concentration of Ammonia showed a gradual decrease from May Ist week to July second week. Thereafter it slightly increase up to September second week. At Murukkumpadam and Puduveypu station a peak was observed in June 3rd week and August Ist week. No significant variation among the station or month was observed. (Fig - 7, table : 1,2,3)(ANOVA table : II, E)

Fig. 5 : Fortnightly variations in Nitrate at Stations I to III.

Fig. 6 : Fortnightly variations in nitrite at Stations I to III.

Fig. 7 : Fortnightly variation in ammonia at Stations I to III.

Fig.5. Nitrate

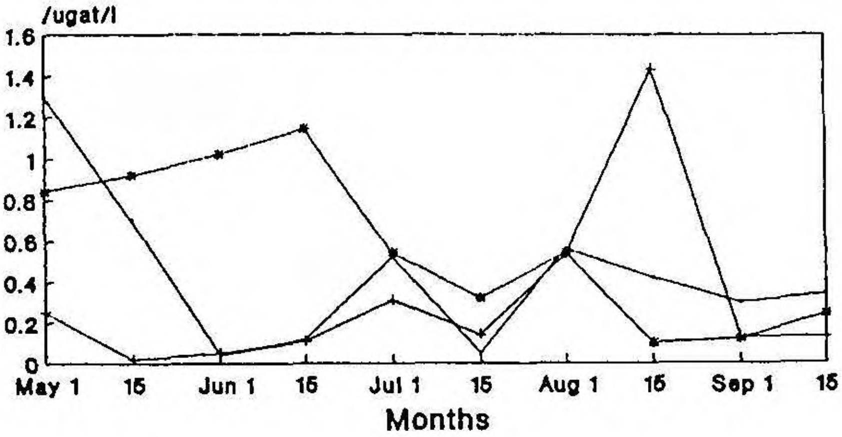


Fig.6. Nitrite

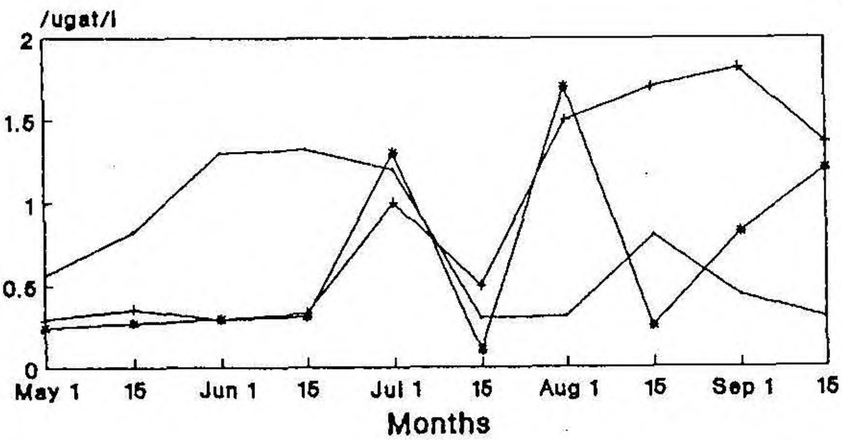
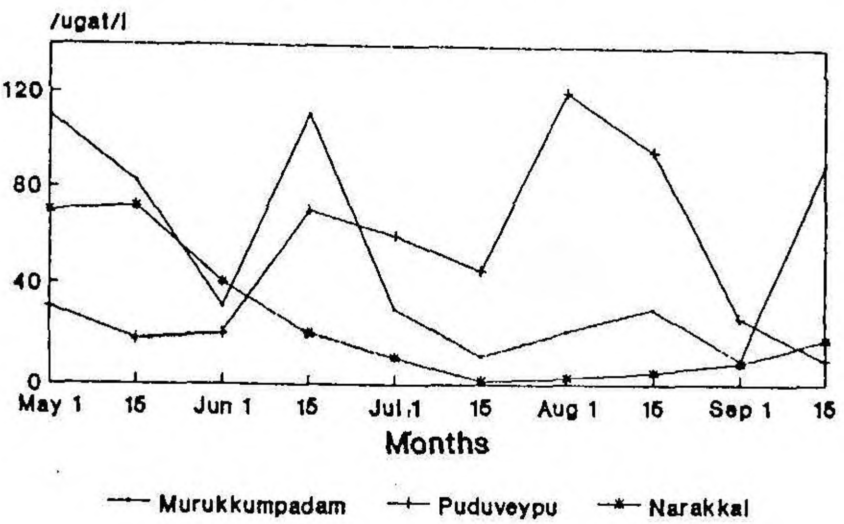


Fig.7. Ammonia



8. Phosphate : Fortnightly variations was more or less similar (low values) at Murukkumpadam and Puduveypu. There is a sharp decline observed in July second week at Murukkumpadam. At Narakkal the concentration was low during most of the period and recorded values lower than the other two stations. The change was significant ($P < 0.01$) between station and between the months ($P < 0.05$). (Fig - 8, table : 1,2,3 ANOVA, II C)

9. Silicate : A decline in silicate concentration was observed at 3 stations due to the onsent of monsoon which remains in same range throughout the period. A significant differences between the months for all the 3 stations was observed ($P < 0.01$). However the variation among the month also significant ($P < 0.01$)(Fig - 9, table : 1,2,3 ANOVA table: II D)

10. Chlorophyll : Chl.a the significant factor used for productivity was high in all the station in the month of September. However at Murukkumpadam (fig - 10 a) the values of Chl b were marginally greater than chl.a during September. (Fig - 10, table :4; Productivity - Fig: 19, Table: 10).

SOIL

11. Grain Size Analysis : The grain size analysis of sediment shows sand as the major constituents; followed by clay and silt. The percentage of sand, clay and silt was as follows.

Fig. 8 : Fortnightly variations in Phosphate-Phosphorus at Stations I to III.

Fig. 9 : Fortnightly variations in Silicate-Silicon at Stations I to III.

Fig.8. Phosphate

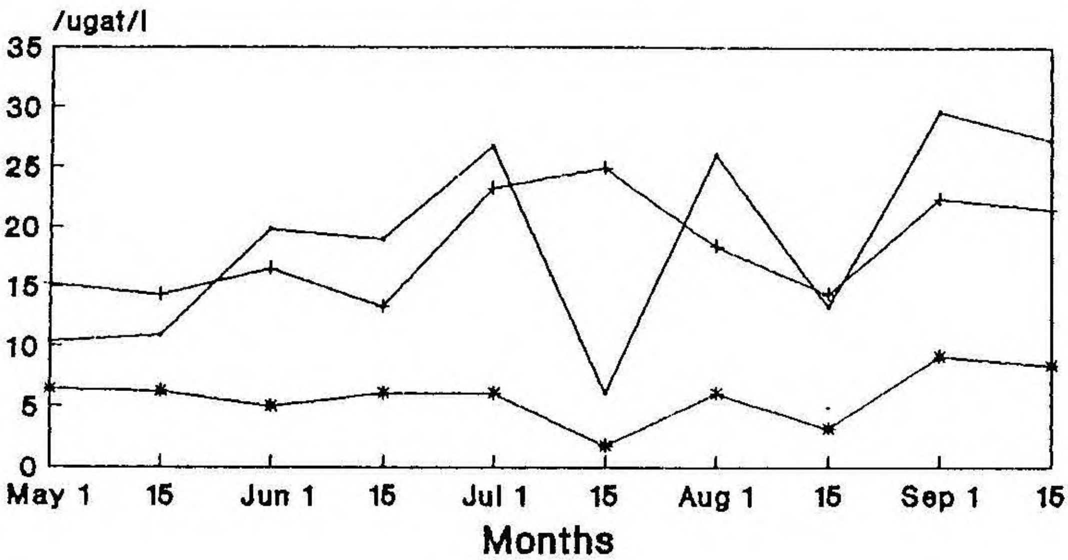


Fig.9. Silicate

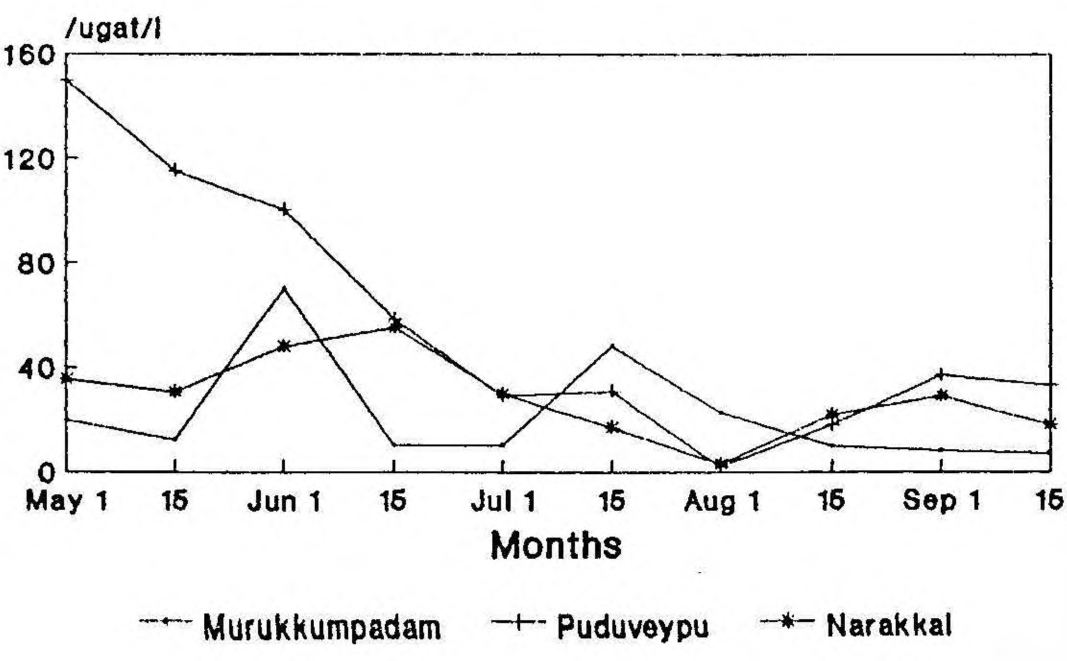


Table 4: Chlorophyll values observed at the three stations during different months.

STATION		MAY	JUNE	JULY	AUGUST	SEPTEMBER
A						
Chlorophyll	(a)	8.812	4.65	11.76	25.02	43.65
(mg/m^3)	(b)	2.389	12.59	9.26	14.5	47.53
	(c)	11.562	7.06	6.79	7.63	21.86
B						
Chlorophyll	(a)	5.091	12.42	22.19	17.05	37.95
(mg/m^3)	(b)	5.672	13.15	21.69	14.56	22.48
	(c)	14.981	21.51	8.09	6.59	21.57
C						
Chlorophyll	(a)	15.85	23.99	12.79	9.53	84.3
(mg/m^3)	(b)	14.69	23.71	10.82	8.23	29.67
	(c)	10.44	37.36	5.87	7.89	12.84

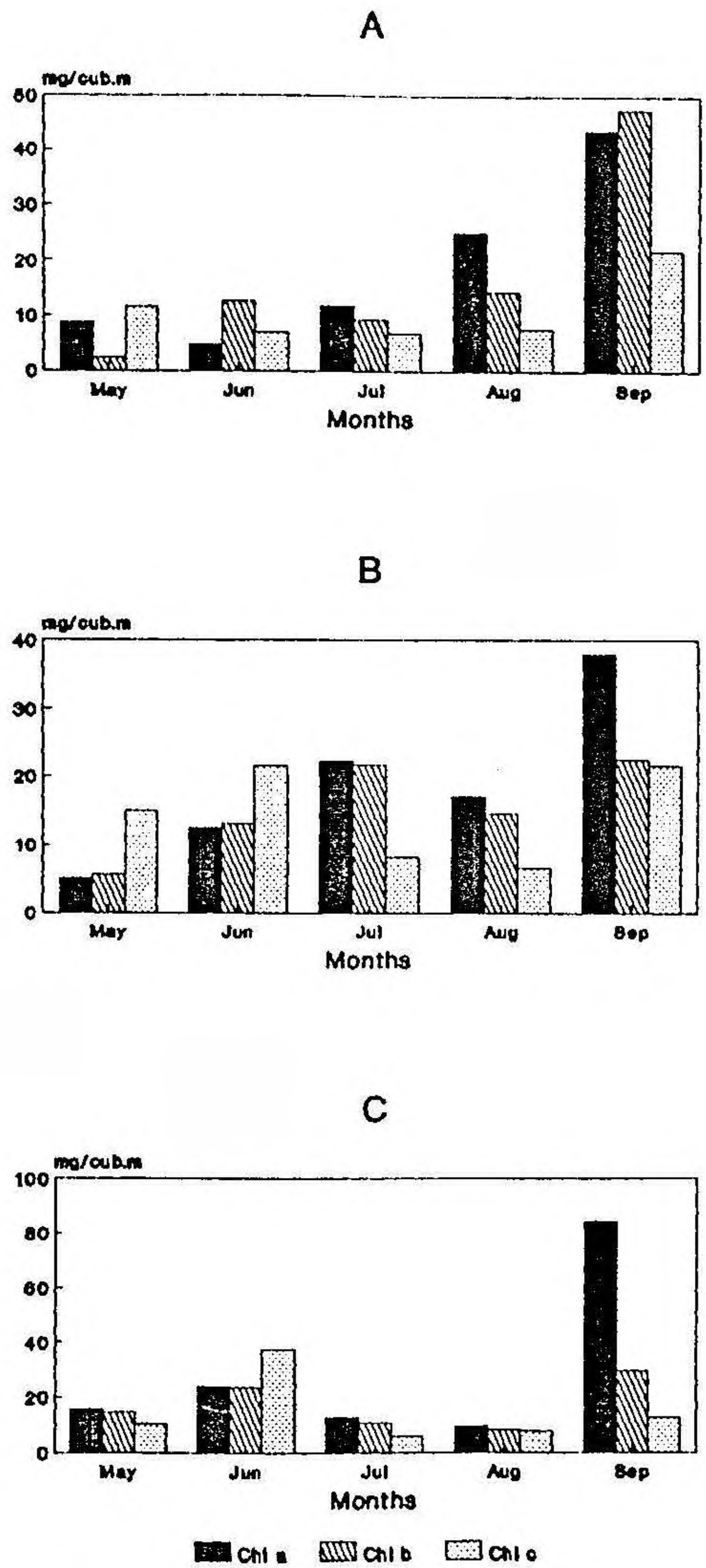


Fig.10. Variations in Chl a, b, c.

A. Murukkumpadam
B. Puduveypu.
C. Narakkal.

Table 5 : Grain size analysis of sediments collected from the different stations.

STATIONS	Sand (%)	Clay (%)	Silt (%)
MURUKKUMPADAM	76.4%	19.8%	3.8%
PUDUVYPEEN	84.2%	13.8%	2%
NARAKKAL	78.2%	13.8%	8%

Fig. 17 : Grain size analysis of Sediment shows different composition.

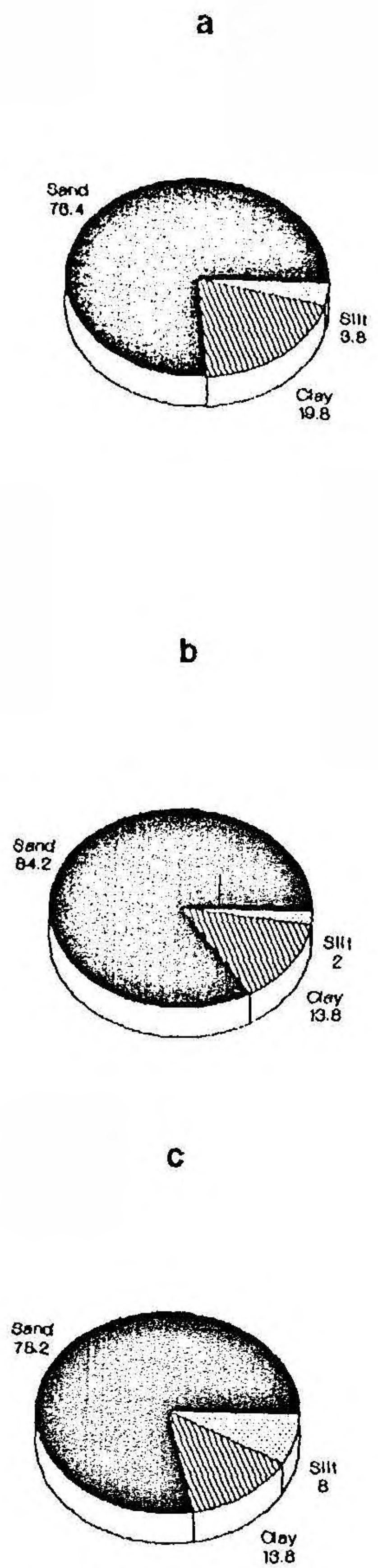


Fig.17. Grainsize analysis
a. Murukkumpadam
b. Puduveypu
c. Narakkal

	Sand	Clay	Silt
Murukkumpadam	78.4%	19.8%	8.8%
Puduveypu	84.2%	13.8%	2%
Narakkal	78.2%	10.8%	8%

12. p^H: Except for a sharp declain in the p^H during the first week of June, the p^H values in all the all stations remaind above 8. (Fig - 11, table : 6,7,8; ANOVA table: III A)

13. Organic Carbon:

At Narakkal concentration of organic carbon should much lower values than the other two stations. At Puduveypu and Murukkumpadam a peak value was observed during June 3rd week and a decline occure in August Ist week. The significant variation among the station ($P<0.01$) and months ($P<0.01$) was observed during the period.(Fig - 12 table: 6,7,8. ANOVA table : III B)

14. Organic matter and Total nitrogen:

As the values are computed from the estimation of Organic Carbon they follow a similar pattern to that of organic carbon.(Fig. 13,14, table : 6,7,8; ANOVA table : III C)

15. Available Phosphorous :

Murukkumpadam station shows more concentration than the other 2 stations Narakkal and Puduveypu had a smilar range during the observation period. But a peak value was recorded in July Ist week at all 3 stations. The change was significant at stations and months ($P<0.01$)
(Fig - 15, table : 6,7,8; ANOVA table : III E)

Table 6 : Sediment parameters observed at Murukkumpadam.

MONTH	Week	pH	Organic Carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available phosphate µg/g	Cation Exchange Capacity meq/100gm
MAY	I	8.01	2.34	4.03	0.468	64.6	20
	III	8,05	2.32	3.90	0.464	62.6	22
JUNE	I	7.92	2.61	4.49	0.522	68.5	18
	III	8.03	4.32	7.44	0.864	73.2	22
JULY	I	7.42	2.03	3.46	0.406	76.0	20
	III	7.23	2.03	3.50	0.406	67.4	21
AUGUST	I	7.39	0.99	1.706	0.198	43.6	22
	III	7.28	1.48	2.55	0.296	34.2	19
SEPTEMBER	I	7.22	0.41	0.70	0.082	21.2	20
	III	7.12	0.72	1.24	0.144	18.7	22
OCTOBER	I	7.19	1.21	2.08	0.242	15.3	21

Table 7 : Sediment parameters observed at Puduveypu.

MONTH	Week	pH	Organic carbon (%)	Organic matter (%)	Total Nitrogen (%)	Available Phosphorous (µg/gm)	Cation Exchange Capacity meq/100gm
MAY	I	8.00	1.98	3.41	0.396	14.0	16
	III	8,08	1.92	3.31	0.384	18.9	18
JUNE	I	7.95	2.31	3.98	0.468	26.6	10
	III	7.82	4.17	7.18	0.834	34.6	14
JULY	I	7.80	4.32	7.44	0.864	40.4	17
	III	7.67	4.34	7.48	0.868	20.2	20
AUGUST	I	7.85	1.05	1.81	0.21	11.6	23
	III	7.25	1.53	2.67	0.309	18.2	22
SEPTEMBER	I	6.53	1.84	3.18	0.369	22.6	14
	III	7.12	1.91	3.29	0.382	18.9	18
OCTOBER	I	7.08	1.62	2.79	0.324	15.6	22

Table 8: Sediment parameters observed at Narakkal.

MONTH	Week	pH	Organic carbon (%)	Organic matter (%)	Total Nitrogen	Available Phosphate µg/gm	Cation Exchange Capacity meq/100gm
MAY	I	8.21	1.25	2.16	0.025	22.6	19
	III	7.52	1.28	2.20	0.256	23.3	20
JUNE	I	7.69	0.78	1.34	0.156	30.1	26
	III	7.53	0.84	1.44	0.168	34.2	23
JULY	I	7.95	1.80	3.10	0.36	39.2	25
	III	7.90	1.42	2.44	0.284	42.3	24
AUGUST	I	7.40	0.780	1.34	0.156	37.4	23
	III	6.82	1.55	2.67	0.31	32.2	22
SEPTEMBER	I	6.88	1.68	2.77	0.312	32.0	22
	II	6.91	1.72	2.96	0.344	27.8	20
OCTOBER	I	7.03	1.78	3.06	0.356	20.4	21

Fig. 11 : Fortnightly variations in p^H of Sediment at Stations I to III.

Fig. 12 : Fortnightly variations in Organic Carbon of Sediment at Stations I to III.

Fig.11. Soil pH

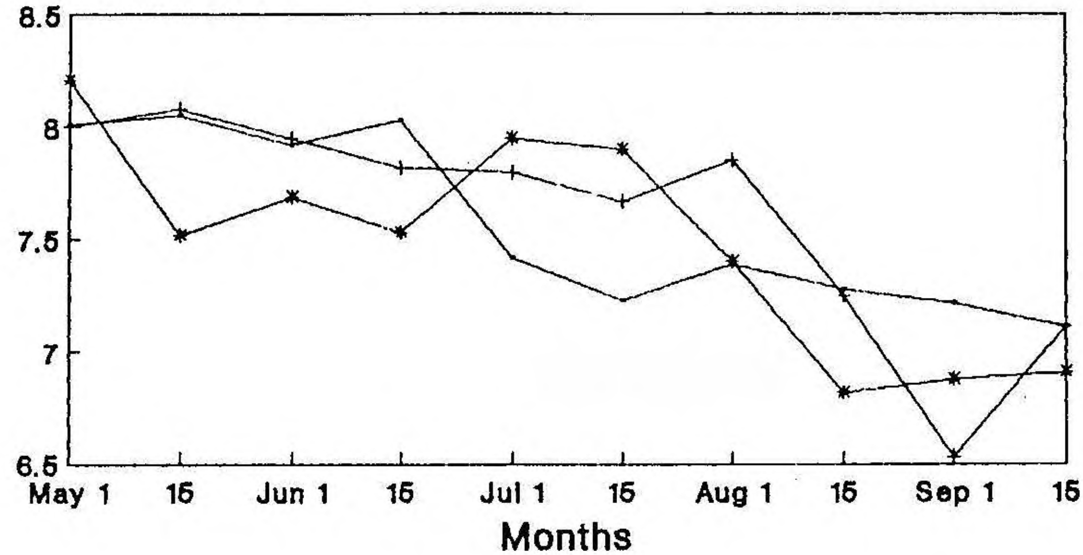


Fig.12. Organic Carbon

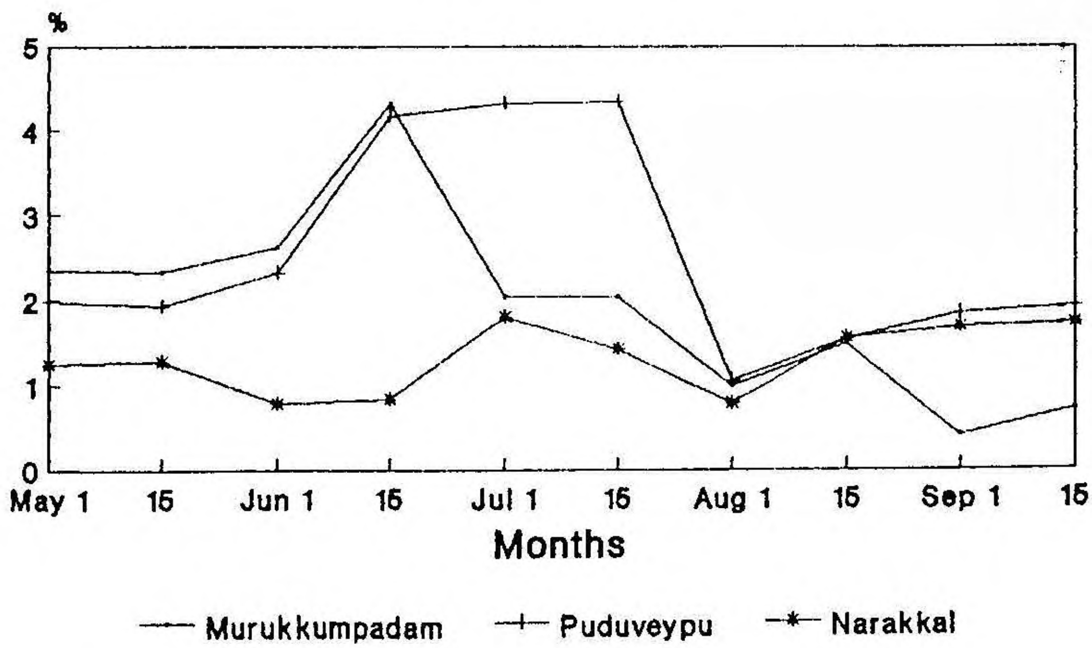


Fig. 13 : Fortnightly variations in organic matter of Sediment at Stations I to III.

Fig. 14 : Fortnightly variations in Total nitrogen of Sediment at Stations I to III.

Fig.13. Organic Matter

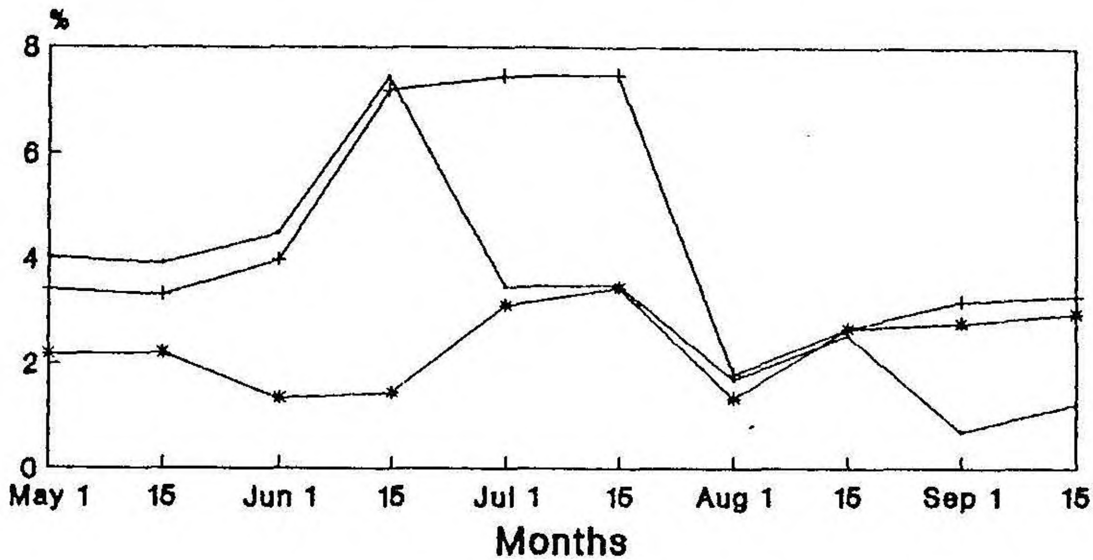


Fig.14. Total Nitrogen

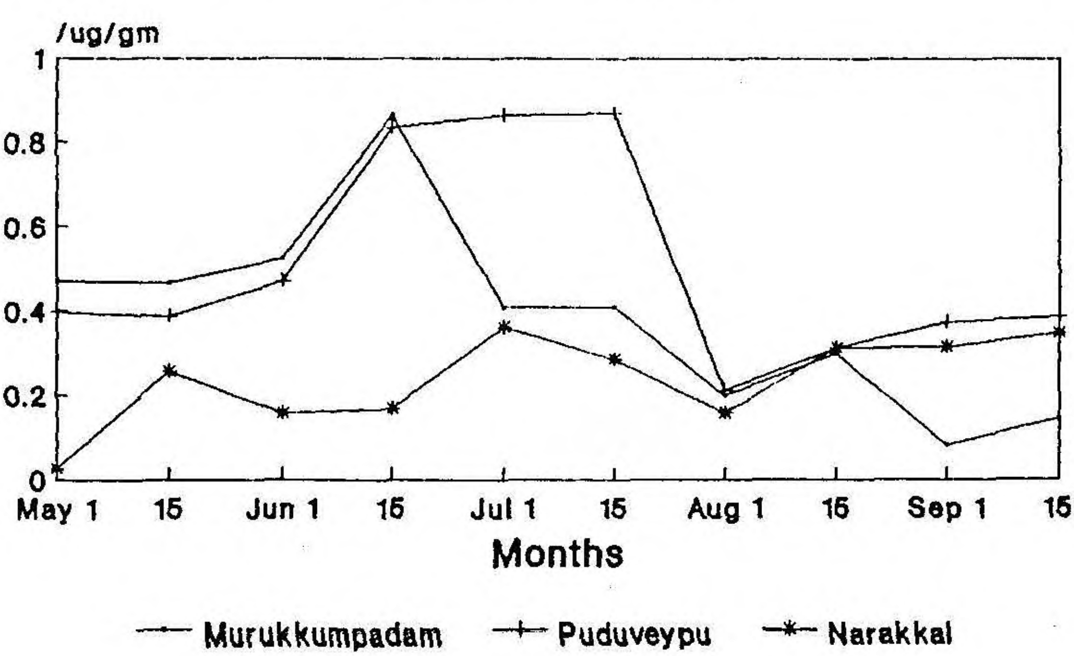


Fig. 15 : Fortnightly variations in available phosphorus of Sediment at Stations I to III.

Fig. 16 : Fortnightly variations in Cation exchange capacity of Sediment at Stations I to III.

Fig.15. Available Phosphate

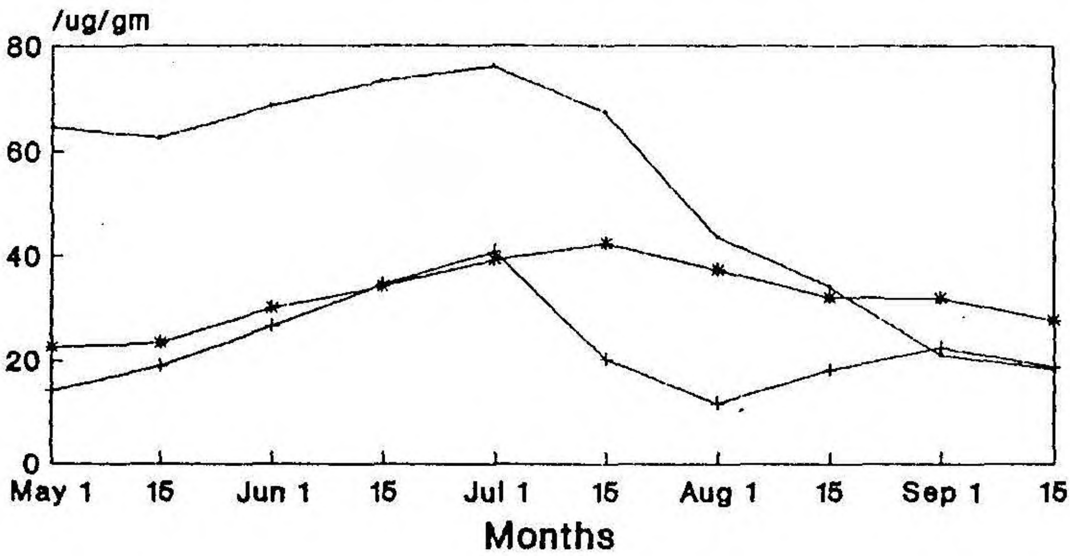
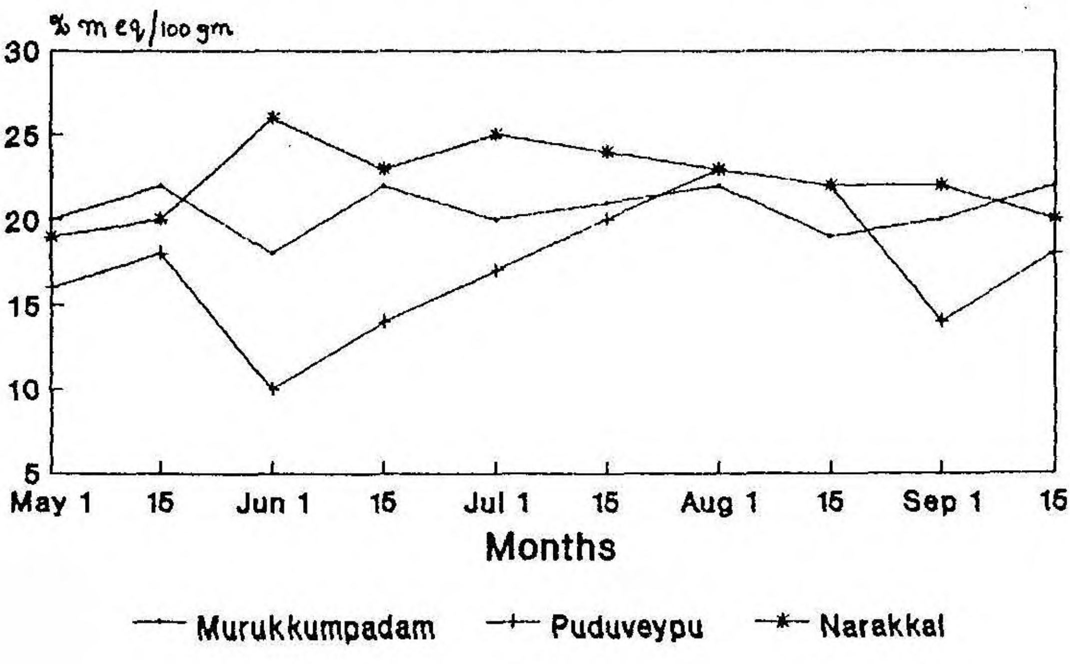


Fig.16. Cation Exchange Capacity



16. Cation exchange capacity:

At Narakkal the CEC of soil indicate a steady level during the study period. At Puduveypu station, an increasing trend was observed from June Ist week to August Ist week. A peak value recorded in June Ist week at Murukkumpadam, thereafter it is almost same range as Narakkal. The change was significant ($P<0.01$) between stations and between the months ($P<0.05$) (Fig - 16 table : 6,7,8, ANOVA table : III F)

BIOLOGICAL PARAMETERS

Floral Phenology :

The flower buds were observed in August - December and maximum number of flowers were observed during November - December and the propagule starts its appearence during March - April. The propagules grow to a size of 24 cm to 36 cm and maximum number of propagule drop off during July - August, though falling starts in June itself.

Litter :

The total litter production during the study period is shown in table 12. A maximum litter fall was observed during the month of July. With the contribution from fruits accounting for 90% of total litter. During the 5 month period the percentage contribution by twigs, fruits and leaves were 12.9, 63.6, 23.5 respectively. Fruits had a maximum fall during July. The total litter production during the study period was 357 gm/m^2/5 month. (Fig - 18 table : 9)

Table 9 : Observed litter fall for the different components at Puduveypu.

	Twigs gm/mt	Fruits gm/m^2	Leaves gm/m^2	Total gm/m^2
May	24	-	52	76
June	7	66	10	83
July	5	106	6	117
Aug	2	55	6	63
Sept	8	-	10	18
Total	46	227	84	357

Table 10: Productivity calculated from Chl. a values for the three stations.

Stations	May	June	July	August	September
Murukkumpadam	152.45	80.45	203.45	432.85	755.15
Puduveypu	88.07	214.87	383.89	294.97	656.54
Narakkal	274.20	415.02	221.27	164.87	1458.39

Fig.18. **Litter Fall**

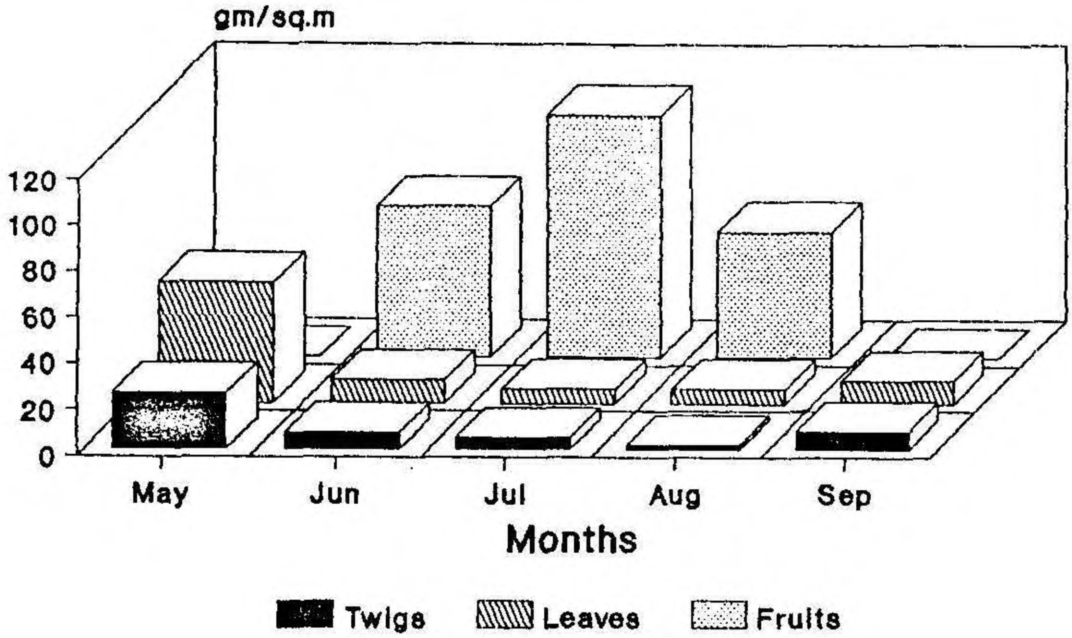
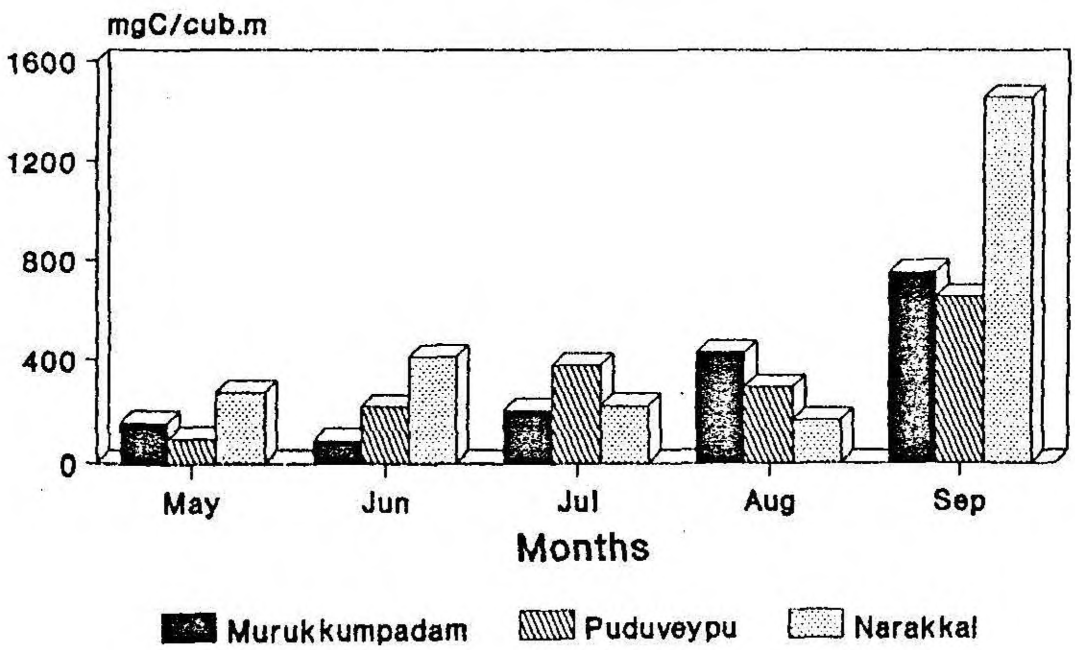


Fig.19. **Productivity**



Decomposition experiment of Leaves:

The experiment conducted in the laboratory, the rate of decomposition of Rhizophora leaves was low during the first 28 days. Thereafter, the decomposition rate has become rapid. 39% of total weight was reduced during the period of study (49 days). A linear relationship between days and loss of weight gave an equation

$y = 10.295 - 0.088\ x$

$r = -0.98$

Expected days for 50% decomposition is calculated to be 60 days. (Fig: 20).

Germination experiment:

For the experimental purpose 20 matured propagules (seed) were planted in 3 x 1 m area at Puduveypu station. Out of these, 16 were survived, 4 of them got decayed due to the influence of flood and predators such as crabs & other micro organisms. After plantation a continuous observation were made and noticed the appearence of the 1st leaf & its growth rate were measured (leaf length and breadth) (Table 11). The present observation indicates that about 4 months time it took to reach a 4 leaves stage. Through this experiment the growth rate were found very slow, it may be due to the effect of several factors such as tidal variation and monsoonal fluctuation in temperature & salinity and other biological factors. Table : 11

Fig.20. Decomposition

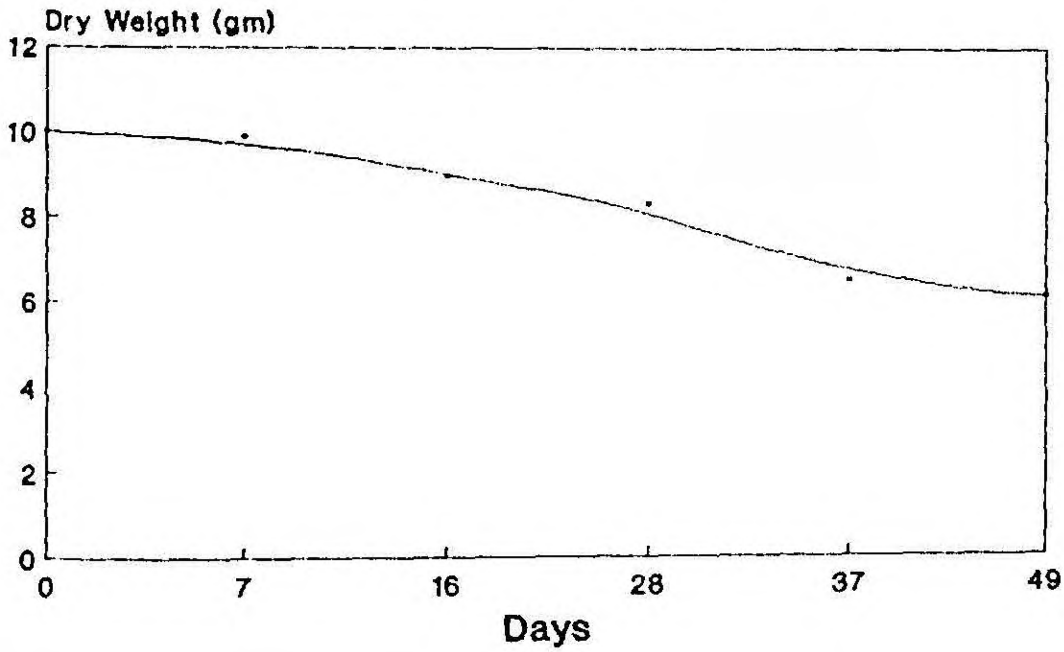


Table 11 : Results on the germination experiment on *R. mucronata* propagules.

No. of days after planting	Number of leaves	Increase in length	Increase in breadth
0	0		
5	Root developed		
17	Primordia		
36	1st leaf	0.23 mm	0.17 mm
64	IInd "	0.3 mm	0.2 mm
100	IIIrd "	0.43 mm	0.23 mm
139	IVth "	0.47 mm	0.26 mm

Plate 6. Propagule of R. mucronata (Centre one, top) and the various stages of its development (below).

Plate 4. The flower buds of R. mucronata at Narakkal.

Plate 5. Five leaved stage of a young R. mucronata

Rainfall data

The monthly rainfall data recorded from April 1991 to October 1991 were: 71, 80, 1492, 541, 433, 54 and 49 mm for the respective months, with the peak in June.

ANOVA TABLE 1

	Source	df	SS	MS	F	Remarks
A.	STATION	2	26.252	13.126	4.305	SIG (5%)
	MONTHS	4	87.355	21.839	7.162	HI.SIG(1%)
	INTERACTION	8	13.168	1.646	0.540	
	CELLTOTALS	14	126.775	9.055	2.970	
	ERROR	15	45.736	3.049	1.000	
	TOTAL	29	172.512			
B.	STATION	2	65.360	32.680	2.219	N.S.
	MONTH	4	2058.095	514.524	34.940	Hi.SIG(1%)
	INTERACTION	8	241.392	30.174	2.049	
	CELLTOTALS	14	2364.848	168.918	11.471	
	ERROR	15	220.886	14.726	1.000	
	TOTAL	29	2585.733			
C.	STATION	2	0.072	0.036	0.087	N.S.
	MONTH	4	0.438	2.360	5.685	Hi.SIG(1%)
	INTERACTION	8	0.566	0.071	0.170	
	CELLTOTALS	14	10.076	0.720	1.734	
	ERROR	15	6.225	0.415	1.000	
	TOTAL	29	16.301			
D.	STATION	2	38.738	19.369	6.067	SIG(5%)
	MONTH	4	11.365	2.841	0.890	N.S.
	INTERACTION	8	32.135	4.017	1.258	
	CELLTOTALS	14	82.238	5.874	1.840	
	ERROR	15	47.885	3.192	1.000	
	TOTAL	29	130.123			

Two way ANOVA with multiple equal observations/cell for water.
A. Temperature B. Salinity C. pH D. Dissolved oxygen.

ANOVA TAVLE II.

	Source	df	SS	MS	F	Remarks
A.	STATION	2	0.368	0.180	3.029	N.S.
	MONTH	4	0.887	0.222	3.736	SIG(5%)
	INTERACTION	8	2.405	0.301	5.064	
	CELLTOTALS	14	3.652	0.261	4.394	
	ERROR	15	0.891	0.059	1.000	
	TOTAL	29	4.542			
B.	STATION	2	0.356	0.178	0.995	N.S.
	MONTH	4	1.558	0.389	2.175	N.S.
	INTERACTION	8	3.762	0.470	2.627	
	CELLTOTALS	14	5.676	0.405	2.265	
	ERROR	15	2.686	0.179	1.000	
	TOTAL	29	8.362			
C.	STATION	2	1095.932	547.966	25.181	Hi SIG(1%)
	MONTH	4	268.012	67.003	3.079	SIG (5%)
	INTERACTION	8	235.744	29.468	1.354	
	CELLTOTALS	14	1599.688	114.263	5.251	
	ERROR	15	326.410	21.761	1.000	
	TOTAL	29	1926.098			
D.	STATION	2	7082.285	3541.143	11.456	Hi SIG(1%)
	MONTH	4	10990.316	2747.579	8.886	Hi SIG(1%)
	INTERACTION	8	11210.938	1401.367	4.534	
	CELLTOTALS	14	29283.539	2091.681	6.767	
	ERROR	15	4636.547	309.103	1.000	
	TOTAL	29	33920.086			
E.	STATION	2	3792.000	1096.000	2.668	N.S.
	MONTH	4	5752.484	1438.121	2.024	N.S.
	INTERACTION	8	20026.133	2503.267	3.523	
	CELLTOTALS	14	29570.617	2112.187	2.972	
	ERROR	15	10659.250	710.617	1.000	
	TOTAL	29	40229.867			

Two way ANOVA with multiple equal observations/cell for water.
A. Nitrate, B. Nitrite, C. Phosphate D. Silicate, E. Ammonia.

ANOVA TABLE III.

	Source	df	SS	MS	F	Remarks
A.	STATION	2	0.083	0.041	0.748	N.S.
	MONTH	4	3.975	0.994	17.939	Hi.SIG(1%)
	INTERACTION	8	0.803	0.100	1.812	
	CELLTOTALS	14	4.861	0.347	6.268	
	ERROR	15	0.831	0.055	1.000	
	TOTAL	29	5.692			
B.	STATION	2	7.540	3.770	14.664	Hi.SIG(1%)
	MONTH	4	9.932	2.483	9.658	Hi.SIG(1%)
	INTERACTION	8	12.912	1.614	6.278	
	CELLTOTALS	14	30.384	2.170	8.442	
	ERROR	15	3.856	0.257	1.000	
	TOTAL	29	34.240			
C.	STATION	2	22.749	11.374	14.853	Hi.SIG(1%)
	MONTH	4	29.544	7.386	9.645	Hi.SIG(1%)
	INTERACTION	8	37.825	4.728	6.174	
	CELLTOTALS	14	90.118	6.437	8.406	
	ERROR	15	11.487	0.766	1.000	
	TOTAL	29	101.605			
D.	STATION	2	0.369	0.185	15.439	Hi.SIG(1%)
	MONTH	4	0.417	0.104	8.720	Hi.SIG(1%)
	INTERACTION	8	0.518	0.065	5.413	
	CELLTOTALS	14	1.303	0.093	7.790	
	ERROR	15	0.179	0.012	1.000	
	TOTAL	29	1.483			
E.	STATION	2	13431.961	6715.980	25.786	Hi.SIG(1%)
	MONTH	4	12856.000	3214.000	12.342	Hi. SIG(1%)
	INTERACTION	8	13973.313	1746.664	6.707	
	CELLTOTALS	14	40261.273	2875.805	11.043	
	ERROR	15	3906.313	260.421	1.000	
	TOTAL	29	44167.586			
F.	STATION	2	139.466	69.733	21.729	Hi.SIG(1%)
	MONTH	4	43.200	10.800	3.375	SIG (5%)
	INTERACTION	8	113.200	14.150	3.422	
	CELLTOTALS	14	295.866	21.133	6.604	
	ERROR	15	48.000	3.200	1.000	
	TOTAL	29	343.866			

Two way ANOVA with multiple equal observation/cell for sediment.

A. pH B. Organic carbon C. Organic matter D. Total nitrogen
E. Available phosphorus F. Cation exchange capacity.

DISCUSSION

A study of the eco-biological conditions of the mangrove Rhizophora species has been the principle objective of this presentation. In general the mangrove communities are discontinously distributed in the Cochin estuarine system, as indicated by Rajagopalan et al (1986). The habitats dominated by Rhizophora were fixed at Murukkumpadam, Puduveypu and Narakkal as observation stations for this work.

The tidal amplitude in the Cochin estuarine system is weak (less than I meter). The mangroves exhibit some kind of zonation depending on the soil, salinity and tidal inundation classes to different sets of mangrove species (Watson, 1928), and Rhizophora mucronata was included by him in inundation Class I, i.e. the mangrove floor reached by all tides. Macnae (1968) has opined that complete zonation will be found only in the areas having considerable intertidal range.

Physical and chemical factor of the soil are important factors governing the structure and distribution of mangrove species.

Organic Carbon and hence organic matter and total nitrogen was found to be low at Narakkal when compared to the other stations. This may be due to a greater water exchange because of its proximity to the main canal. Twilly (1985) found that the export of organic carbon is associated with increased tidal amplitude. Nasser (1986) observed the concentration of organic carbon in the seasonal ponds of Vypeen Island to be greater than those of the perennial ponds and attributed it to decaying organic manure and the detritus resulting from the growing paddy. The values observed in the present study is lower than those reported by him. This may be due to the tidal exchange and hence export while there is no letting in of water into seasonal ponds during the paddy growing season. But the values of the present study compares well with the observations of Alongi (1990).

The grain size analysis of soil revealed sand as the major constituents and the percentage of clay was more than 10 at all 3 stations. However this fractions vary, spatially at Puduveypu were at a Bruguiera site, Josileen Jose (1989) reported greater percentage of silt and clay.

The soil p^H varried from 6.53 to 8.21 in all the stations. The lowest value of 6.53 was recorded at Puduveypu in the 3rd week of September. During that month the Narakkal station also recorded low p^H. This however is within the normal range of coastal soil p^H (Blasco 1975).

The estimates of organic matter varried from 0.70 to 7.48% . These had close relation with the monthly observation values for the organic carbon content. The average organic matter content was higher than that in the Godavary estuary (Naidoo 1968).

The cation exchange capacity (CEC) at different stations are varied. The highest reading was observed at Narakkal in June, and the lowest at Puduveypu in the same month. The two way ANOVA with multiple equal observation/cell showd that the change in CEC of Sediment was significant between stations and between months.

The percentage of nitrogen was low in the pre-monsoon month but recovered to peak values during June-July and dropped to lower values in the immediat post-monsoon month. A smilar trend of increasing values of nitrogen percentage in the sediments of seasonal and perinial ponds of Cochin area was observed by Nasser (1986). But compared to the values of 1.2 to 4.2% observed by him, the % of nitrogen in Rhizophora soil is lower.

The available phospherous in the three stations ranged from 11.6 to 76 ug/gm and showed wide variation during different months. Mortimer (1971) reported that progressive decline in the dissolved oxygen at the water sediment interface was accompanied by transfer of phosphorous to the overlying water. In the present study also the inverse relationship between high dissolved oxygen and low phosphorous content was observed in the month of August and September. Stirling and Wormald (1977) reported that reductions in salinity enhance phosphate adsorption. In general salinity drops drastically in the mangrove waters during June to August.

The monthly variations of hydrological parameters in the mangrove waters showed general fluctuation typical of an estuarine system which is influenced by rain fall during monsoon, river run off, and recovery of essential parameters during post monsoon months.

Uncles et al., (1990) observed that the ecological conditions of mangrove systems and its associated coastal waters and fisheries is influenced by stratification caused by slow currents and weak tidal mixing. Added to this the density gradiants caused by the changes in salinity affect the longitudinal transport of salts, nutrients and dissolved and suspended particulate material. The ecosystems studied has a strong influence of both varied salinites and tidal amplitudes. This strong stratification in salinity makes the nutrients measurement and budgets inconclusive (Wattayakorn et al., 1990).

An understanding of the mechanisms which effects the stratification in mangrove estuaries, its development, magnitude and erosion is therefore of importance to nutrient-flux studies and predictive capabilities (Uncles et al 1990). Ridd et al (1990) while analysing the longitudinal diffusion in mangrove-fringed tidal creeks observed that mangrove swamp systems are extremely efficient at dispersing contaminants or nutrients to the near-shore zone. Further Wolanski et al (1990) say that coastal waters are constantly exchanged and moved back and forth between the coastal boundary and the mangrove swamp which ensure a strong dynamic link between mangroves and coastal waters.

In mangrove swamps, primary productivity can be attributed to several sources, the mangrove trees themselves, from their associated attached macrophytic vegetation and alage, from free-floating macrophytic vegetation and from phytoplankton or benthic microalgae (John and Lawson 1990). Productivity calculated from phytoplankton without taking in to account respiration and other losses were 335, 490 and 500 mg C/m^3/day at Murukkumpadam, Puduveypu and Narakkal respectively. This is comparable with the values for phytoplankton production at Ghana by pouly (1975). and also by Kwei (1981). Flores - Verdugo et al., (1990) found that the mean annual net aquatic productivity to be 410 mg C/m^3/ day at Teacapan - Aqua Brava estuarine system. However productivity from phytoplankton probably represents only a small fraction of the total primary production of mangol (John and Lawson 1990). Therefore, the total gross production from the present study would work out to 1.20 1.76 1.80 tonne C/ha/annum from the three sites. Kathiresan and Kannan (1985) compared the photosynthetic productivity in 3 species of Rhizophora and found that R mucronata showed intermiediate production in terms of dry matter production.

The total litter production at Puduveypu is estimated to be 8.568 tonnes/ha/year of which 12.7, 23.5 and 63.6% is contributed by twig, leaves, and fruits respectively. Japer (1989) explained the 'disappearence' of leaf litter as due to tidal export, macro-feeder activity and microbial activity. Gong and Ong (1990) estimated that 50% of leaf litter production could be attributed to tidal export. If it is assumed that a same percentage is removed from Puduveypu than the tidal export of leaf litter works out to be 2.76 Kg/ha/day. This is lower than the values reported by Robertson (1986) and Gong and Ong (1990). Gong and Ong (1990) cautions that the dynamics of leaf litter is dependent on several factors and suggest that tidal export becomes increasingly important with the amount of inundation. Puduveypu, from where the data on litter production was collected was submerged during the period of study with tidal influence. Gong and Ong (1990) used a lower figure of 50% export for twig litter and 0% export for fruit litter after taking in to account the predation of fruits by crabs and a large percentage of fruit (propagale) taking root. Using these percentages the twig litter export from Puduveypu would be 1.51 Kg/ha/day. This as in the case of leaf litter, is also lower than the values by Robertson (1986) and Gong and Ong (1990). However, the values of Josileen Jose (1989) for the total litter production from a Bruguiera spp dominated ecosystem at Cochin is much higher than that obtained in the present study.

Decomposition of marine macrophytes and mangroves is characterised by an initial leaching of soluble organic and inorganic compounds with subsequent colonization of bacteria, fungi and protozoans which utilize the labile substance and initiate the breakdown of plant material resulting finally in physical and biological fragmentation (Tam *et al.*, 1990). The decay coefficient or rate loss (percentage loss/day) calculated for *R. mucronata* was 0.80. This is lower than the values reported for *Avicennia marine* and *Kandelia candel* but higher than that of *A. Corniculatam* (Tam et al., 1990). They explain that decay rates are not only related to species, but also to different environmental conditions under which investigations are conducted. Although care was taken to maintain field conditions in the litter bag experiments in the present case, can not be expected as a true state of actual litter breakdown in the field but rather as an indication of potential breakdown. Also the time required for loss of half the initial dry weight of immersed leaves were longer for R. mucronata (60 days) than A marina (13-16 days), R. Stylosa (17-18 days) (Angsupanich et al., 1989).

The ecological and biological studies of Rhizophora dominated mangrove system at Cochin threw some preliminary light on the role of various nutrients in these ecosystems, the influence of tide and the related environmental aspects.

The mangroves of the Vypeen Island in the Cochin estuarine system is vulnerably situated, sand wiched between the Arabian Sea in the west and an urban area on this east. According to Margalef (1963) this would lead to exploitation of the 'immature' mangrove ecosystem with its low energy requirements. These mangroves support the fishery both in the Cochin backwaters and the continental shelf area of Cochin. The management and conversation of mangroves around Cochin gains importance because the intense human pressure on coastal mangrove which may have repercussions for the productivity of marine fisheries, as pointed out by John and Lawson (1990) may be of an unexpected and deleterious nature.

SUMMARY

Eco-biological studies of mangroves were carried out in Rhizophora species dominated ecosystem, such as Murukkumpadam, Puduveypu and Narakkal (near to a tidal canal) during the period May to September 1991.

Observations on hydrological parameters of the water such as salinity, dissolved oxygen, water temperature, p^H, nutrients (nitrate, nitrite, phosphate, silicate) concentration and chlorophil contents were collected fortnightly from the three ecosystems. The variation in temperature was $27^\circ C$ to $35.5^\circ C$ and high values were recorded during the month of May. The p^H values in all the three ecosystem ranged from 6.07 to 8.78 indicating more alkaline nature of the environment. Salinity showed variations and it ranged from 1.7 to 31.7‰ at Murukkumpadam, 2.3 to 28.6‰ at Puduveypu and 2.2 to 17.6‰ at Narakkal. Dissolved oxygen concentration in the water was maximum at Narakkal when compared to that in the Murukkumpadam and Puduveypu station. The nutrient concentration at all the station showed a different trend in different stations during the study period. Nitrate concentration at Narakkal showes an increasing trend during the first two months, thereafter it reduced and become less. But at Murukkumpadam a sharp decline was observed in the initial period. Then it remains at a low concentration. At Puduveypu the concentration was

low with a peak in August second week. Ammonia reading were high in June 3rd week and August Ist week at Murukkumpadam and Puduveypu. Fortnightly variation of phosphate concentration was more or less similar (low values) at all the stations. Silicate concentration showed a significant differences between the months for all the 3 stations at a 1% level.

Sedimentological parameters studied were grain size composition, and nutrient parameters such as organic carbon, Organic matter, Total nitrogen, available phosphorous, and cation exchange capacity. The sediment in the three ecosystem was found to be sandy in nature. At Narakkal concentration of Organic carbon showed much lower values than the other two stations. But available phosphorous content was more at Murukkumpadam than Puduveypu and Narakkal.

During the study period, the monthly rainfall data recorded from April 1991 to October 1991 were 71, 80, 1492, 541, 433, 54 and 49 mm for the respective months, with the peak in June. The rainfall was found to be an important factor for the change in ecological condition.

The Biological parameters such as floral phenology, litter production, decomposition experiment of leaves and germination experiment of propagule were carried out. The flower buds were observed in August-December. A maximum litter fall was observed during the month of July, due to the shedding of fruits during these period. Decomposition rate of leaves was low in the laboratory condition during the first 28 days of experiments, thereafter, which has become rapid. The germination experiment showed that it needs about 4 months to reach a 4 leaf stage.

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