

## Geochemical Reactivity of Surficial and Core Sediment of a Tropical Mangrove Ecosystem

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**ABSTRACT:** Sediments from the surface, core water and vegetation of tropical mangroves were collected from tropical mangroves, India. Total phosphorus, total nitrogen, organic carbon, protein, carbohydrate and tannin and lignin in these samples were estimated. The C/N and C/P of the leaves present in Mangalavanam, Vypeen, and Nettoor are in good agreement with that of the sediment and this result indicated that the main source of the sediment organic matter is the plant remains. The profile of C/N ratios shows a decrease towards the depth, but lies within that of the oligotrophic lakes and plant tissues and peat. The decay rate of C and N indicated that the main reactivity is in the first 5cm of the sediment, which is subjected to re-suspension and significant bio-turbation. But there existed a uniform decay pattern at 10 cm and 15 cm. In the case of monsoon season and post monsoon season a random character was observed at 15 cm depth, which can be attributed to the effective release of organic matter from that depth zone. To assess the reactivity of the systems, the classic one G model with slight modifications to suit to the system was employed.

**Key words:** Mangroves, Sediments, Core, Organic matter, Reactivity, Ecosystem

### INTRODUCTION

Much of the organic matter in soils, sediments and natural waters are not simply bio-polymeric remains, but rather is a heterogeneous mixture of diagenetically formed polymeric compounds. The global cycles of carbon (Berner, 1982) and oxygen offer a variety of useful perspectives on the extent and mechanisms of sedimentary organic matter burial, as well as intriguing contradictions to explain these variations in the marine environment, we must understand how, why and at what rate the reactivity of organic detritus changes with time. Natural microbial communities tend to sequentially use the organic substrates that are present, with those more easily decomposable being consumed first (Ghosh *et al.*, 1979). In this way humic materials are concentrated as well as formed in the surficial environment. Sedimentary burial of organic matter and pyrite also is essentially the only source of atmospheric oxygen, and intimately links the global cycles of C, S and O over geologic time

(Berner, 1982). Rivers carry about 1 % of terrestrial productivity to the ocean in comparable to the fluxes of particulate and dissolved organic materials. Total organic carbon burial in marine sediments is less than one third of the river discharge. This indicates that riverine POM and DOM are rapidly and extensively mineralised within seawater or surficial marine sediments. The boundary between the land and sea is in the form of abrupt and often spectacular cliffs, but elsewhere, the boundary can take the form of a complex environment of inter-tidal sediments (Tim, 1997). These environments include shingle banks, sandy beaches, mud flats, salt marsh and mangrove communities. The total global area indicates the significance of inter tidal sediments. The total area of intertidal sediments is likely to be similar to that of adjacent salt marshes and mangles. Inter tidal sediments offer an important habitat for wildlife, food and recreation. The very nature of intertidal areas has left them relatively undistributed by

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human activity compared to inland areas. Interacting with the geological and biological environment modulates the chemistry of these systems. The plant detritus together with decomposing belowground plant material and organic carbon associated with imported fine sediment provides the sediments with a rich supply of organic matter. It is the decomposition of this organic matter, which provides one of the unifying biogeochemical concepts in all these intertidal environments. This organic matter is subsequently oxidised by bacteria using a variety of oxidising agents or terminal electron acceptors or TEA which are they reduced, hence the term redox reactions (Tim, 1997). These different TEAs yield different amounts of energy from their reactions with organic carbon, so the microbial community using the highest energy yielding system always dominates, assuming there is significant amount of that TEA present. Thus as long as there is oxygen present, this will always be the oxidising agent used, but once this is exhausted, alternative oxidants are used in a fixed sequence beginning with nitrate (Coleman, 1985). It is for this reason that these inter-tidal sediments can consume large amounts of nitrate very quickly. In many systems nitrate levels are naturally low, but increasing concentrations of nitrate in rivers arising from human activity can mean nitrate is an important electron acceptor in some coastal systems today. Once nitrate is exhausted in the sediments the readily available oxidised iron and manganese are reduced to their more soluble reduced form. Since phosphate in the sediments is usually strongly associated with iron, this iron mobilisation can also result in phosphorus mobilisation (Sundby et al 1992). These reactions involving the important nutrients, nitrate and phosphorus, illustrate the ways in which intertidal sediment processes can influence the productivity of the intertidal ecosystems and potential the adjacent coastal waters. In this paper, we have attempted to identify and quantify the main biogeochemical processes, which take place in mangrove soils at Kochi, in Kerala, India.

The wetlands of Kerala were a large mangrove swamp centuries ago and anthropogenic activities modified the system into settlements, agricultural fields, filtration ponds and prawn culture fields. The Cochin estuary includes a

system of interconnected lagoons, bays and swamps penetrating the main land and enclosing many islands in between, whose total area amounts to approximately 500 km<sup>2</sup>. The backwater around Cochin is located between Lat. 9 52.40'–10 12'N and Long. 76 10'–76 30'E. This estuary is connected with the Arabian Sea by a permanent opening, 450m wide through which tides act within the estuary. The area of investigation and the station locations are depicted in (Fig.1). The stations were fixed so as to compare the complex environmental conditions prevailing in three different mangrove ecosystems. Brief outlines of the characteristics of these stations are described as follows.

This is a patchy mangrove area in the heart of the city of Cochin. This mangrove forest is a small bird sanctuary, located in the heart of the city behind the High Court of Kerala. It is the home of many exotic and rare varieties of migratory birds. This is an almost closed system with a single narrow canal linking to the estuary. Vypeen, the largest single stretch of mangrove in Kerala has an area of approximately 101 ha. This mangrove area is regularly inundated by a semi diurnal rhythm of Cochin barmouth and the tidal waters bring in lot of fish seed of commercially valuable species prawns. The mangrove vegetation consists primarily of *Avicenna* with *Rhizophora* constituting occasional growth. Nettoor is a vanishing mangrove ecosystem. It is facing a major threat of land reclamation for construction of roads, buildings etc. During inter monsoon periods, when the seawater enters inside, prawn is cultivated. This is an open system with maximum human intervention.

## MATERIALS & METHODS

Sediment as well as water samples were collected from the stations at bimonthly intervals from November 1999 to November 2000. Water samples were collected using plastic buckets. In the laboratory, they were filtered through GF/C filter paper along with pre combustion at 500°C. These residues were analysed for particulate organic carbon. Surficial sediment samples were collected using a clean plastic spoon. Core sediment samples were obtained by penetrating a PVC pipe of 10cm diameter. The core samples were cut into sub samples at 5cm intervals. The

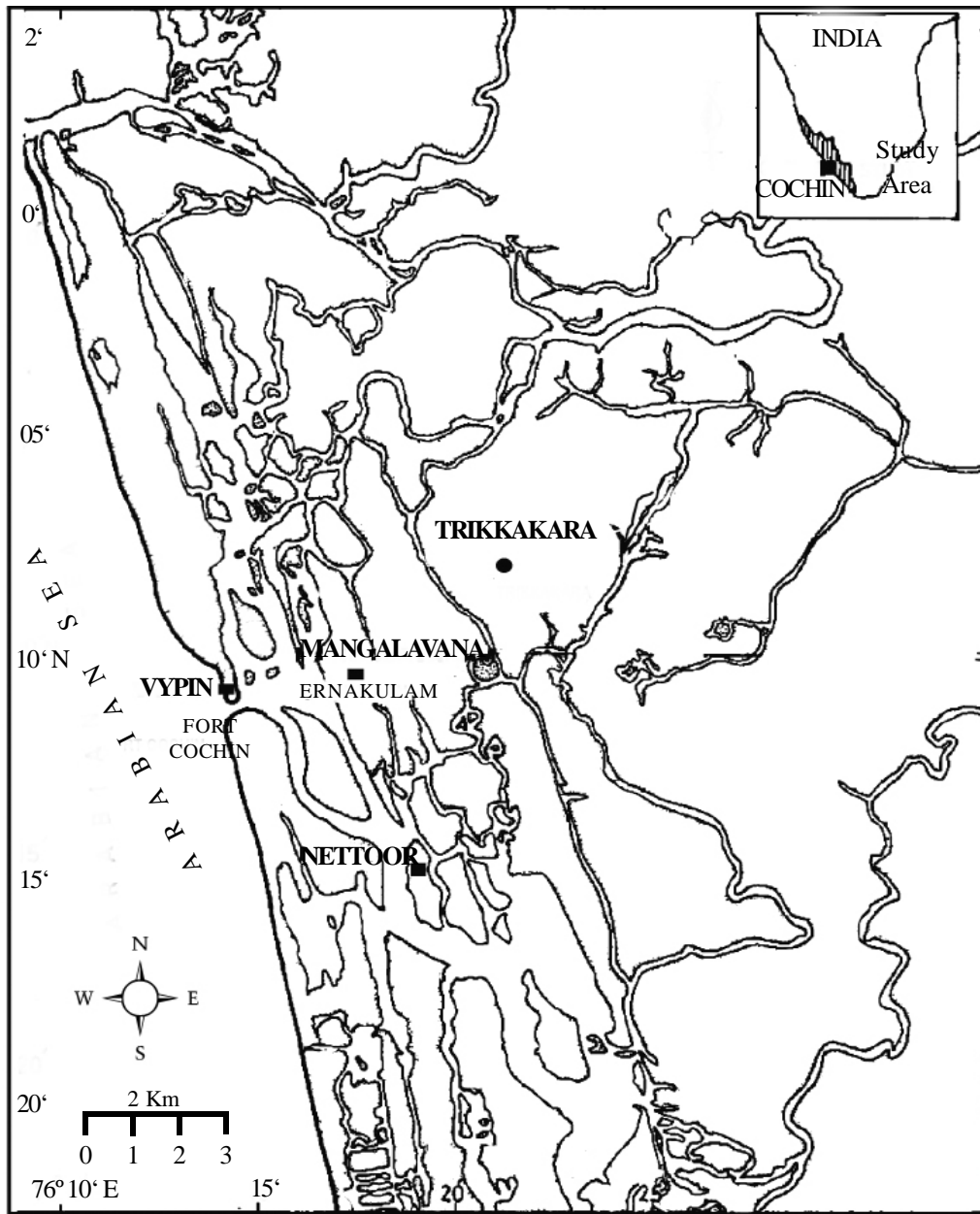


Fig.1. Map of Cochin estuary Showing Locating Location of Sampling Sites

samples were taken in polythene bags and stored deep frozen until analyses. All analyses were done in duplicate. Sediment samples were analyzed for its grain size and total organic carbon. Organic carbon determinations were carried out by the method of Gaudette et al. (1974). Grain size of the sediments was determined by the method of Carvar (1971). The particulate organic carbon was analyzed by the method given in Strickland and

Parsons (1977). The protein from the sediment was extracted by 1N NaOH. A weighed amount of the sample was mixed with the extractant and maintained at 80°C for 30 minutes to dissolve the proteins. After cooling, aliquots were transferred to clean test tubes and 5mL of the coppex reagent were added followed by 0.5 ml of folin - Ciocalteu reagent after 10 minutes. Appropriate blank and standards (bovine albumin) were similarly treated and the analysis was carried out (Nayar, 1992).

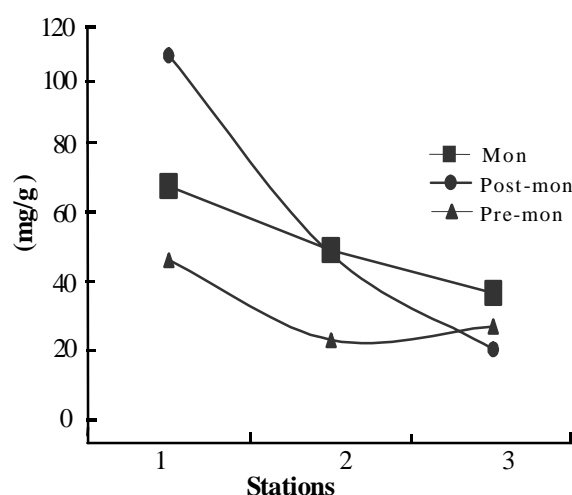
Total carbohydrates from the sediment samples were leached by the hydrolysis of the sample with 1N H<sub>2</sub>SO<sub>4</sub> at 100 °C for 1 h. Cooled and filtered sample aliquots were taken in clean test tubes. Added 1 mL of 5% phenol and 5 mL of concentrated sulphuric acid. Cooled 84.the test tube and measured the optical density (Nayar, 1992). Tannin and lignin from the sediment samples were leached with 0.05M NaOH for 90 minutes and filtered. 5mL aliquots of the filtrate were mixed with 1mL of citrate solution followed by the Tannin - lignin reagent and the carbonate tartarate reagent. The optical density was measured at 765 nm (Nayar, 1992). Total phosphorus was estimated by perchloric acid digestion followed by spectrophotometer analysis (Strickland and Parson 1977) and total nitrogen was estimated using Kjeldhal method and the distilled ammonia was determined by back titration with 0.01 HCl. Leaves of *Avicenna*, *Rhizophora*, *Acanthus* were dried in an oven below 60°C and analyzed for carbon, nitrogen and phosphorus using the above-mentioned methods.

**RESULTS & DISCUSSION**

The seasonal distribution of organic carbon in the surface sediments of three ecosystems is given in (Fig. 2) and (Fig. 3) shows its depth profile in the sediment. Comparatively higher values for carbon were observed in station 1 in all seasons. During all the three seasons, maximum amount was noted in station 1 and minimum in station 3. In the case of core sediments, the amount of carbon gradually decreased towards the depth except in station 3 during post monsoon. The values fluctuated between 38.71 mg/g to 69.61 mg/g in the surface during monsoon. The amount of carbon in the sediments increased in the post monsoon. In this season, the sediments are rich in carbon and the values were in the range of 22.51 mg/g to 107.2 mg/g. Lower values were observed during pre monsoon. The percentage of sand silt and clay are given in the (Tables 1, 2 & 3). respectively. High percentage of clay in the sediment during monsoon and post monsoon also supports the high amount of carbon during these seasons.

The distribution of nitrogen and phosphorus in the surface and core sediments is given in the (Table 4). Lower values were observed in Mangalavanam and higher in Nettoor d during all

seasons. The values observed were in the range of 0.81 mg/g to 4.5 mg/g during monsoon. In the core sediments, the amount gradually decreased in Vypeen. But in system Mangalavanam & Nettoor, higher amount was noted in the 10 cm layer than 5 cm. In the post monsoon, the amount of nitrogen increased in all systems and maximum was noted in Mangalavanam. In this season, the concentration in the 10 cm layer was more than in the 5 cm in all ecosystems. The depth profile during pre monsoon in Mangalavanam showed a gradual decrease, but in Mangalavanam & Nettoor an increase was observed towards 10 cm layer.



**Fig. 2. Distribution of Carbon in the surface sediment (mg/g)**

**Table 1. Sand (%)**

	Pre	Mon	Post
System 1	16.47	23.03	33.06
System 2	16.19	2.84	39.32
System 3	63.41	91.87	85.13

**Table 2. Silt (%)**

	Pre	Mon	Post
System 1	38.62	32.98	16.56
System 2	44.12	47.56	24.65
System 3	8.53	1.32	6.72

**Table 3. Clay %**

	Pre	Mon	Post
System 1	44.77	43.56	49.83
System 2	40.81	49.13	34.81
System 3	27.92	6.31	7.57

**Table 4. Distribution of nitrogen and phosphorus in the surface and core sediments**

System 1

Depth (cm)	Total N (mg/g)			Total P (mg/g)		
	Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon
0	4.5	9.39	7.4	0.89	11.17	9.5
5	4.9	2.6	6.5	0.48	0.5	0.48
10	7.1	4.3	3.5	0.1	0.25	0.1
15	3.6	0.98	2.6	ND	ND	ND

System 2

Depth (cm)	Total N (mg/g)			Total P (mg/g)		
	Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon
0	4.5	9.39	7.4	0.89	11.17	9.5
5	4.9	2.6	6.5	0.48	0.5	0.48
10	7.1	4.3	3.5	0.1	0.25	0.1
15	3.6	0.98	2.6	ND	ND	ND

System 3

Depth (cm)	Total N (mg/g)			Total P (mg/g)		
	Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon
0	0.81	2.18	3.33	0.66	0.26	0.98
5	0.49	0.71	0.67	0.16	ND	0.51
10	1.88	1.03	1.12	0.46	0.93	ND
15	ND	1.17	1.12	ND	ND	0.11

The seasonal variation of protein in the surface and in the core is given in the (Figs. 4 & 5). During monsoon maximum amount of protein was noted in Vypeen and minimum in Nettoor. The values were in the range of 0.2 mg/g to 1.24 mg/g. Gradual decrease towards the depth up to 15cm was observed in system 3. But in Mangalavanam & Vypeen an increase was noted in the 10cm layer and then a decrease. In the pre monsoon, maximum amount was observed in the surface in Mangalavanam & Nettoor, but in Vypeen maximum was noted in the 15cm layer. There was a gradual decrease in Mangalavanam but in Vypeen & Nettoor an increase was noted at 10cm depth.

The seasonal variations of carbohydrates in the surface and core sediments are given in (Figs. 6 & 7). Maximum amount of carbohydrates was observed in all ecosystems during post monsoon.

During this season, the values were in the range of 7.86 mg/g to 7.5 mg/g. The highest amount was noted in Nettoor and the lowest in Mangalavanam. A gradual decrease towards depth was noted in Mangalavanam. But in Vypeen and Nettoor an increase was observed in 10 cm layer. During monsoon, highest concentration was noted in Vypeen and the lowest in Nettoor. The values were in the range of 1.55 mg/g to 51 mg/g. In Nettoor, a gradual increase was noted towards the depth and reached a maximum at 15 cm depth. There was a gradual decrease towards depth in Mangalavanam but in Vypeen an increase was noted at 10 cm. In the pre monsoon season maximum concentration was observed in Vypeen and minimum in Nettoor. Towards the depth, a gradual decrease was noted in mangalavanam, but an increase at 10 cm was noted in Vypeen and Nettoor.

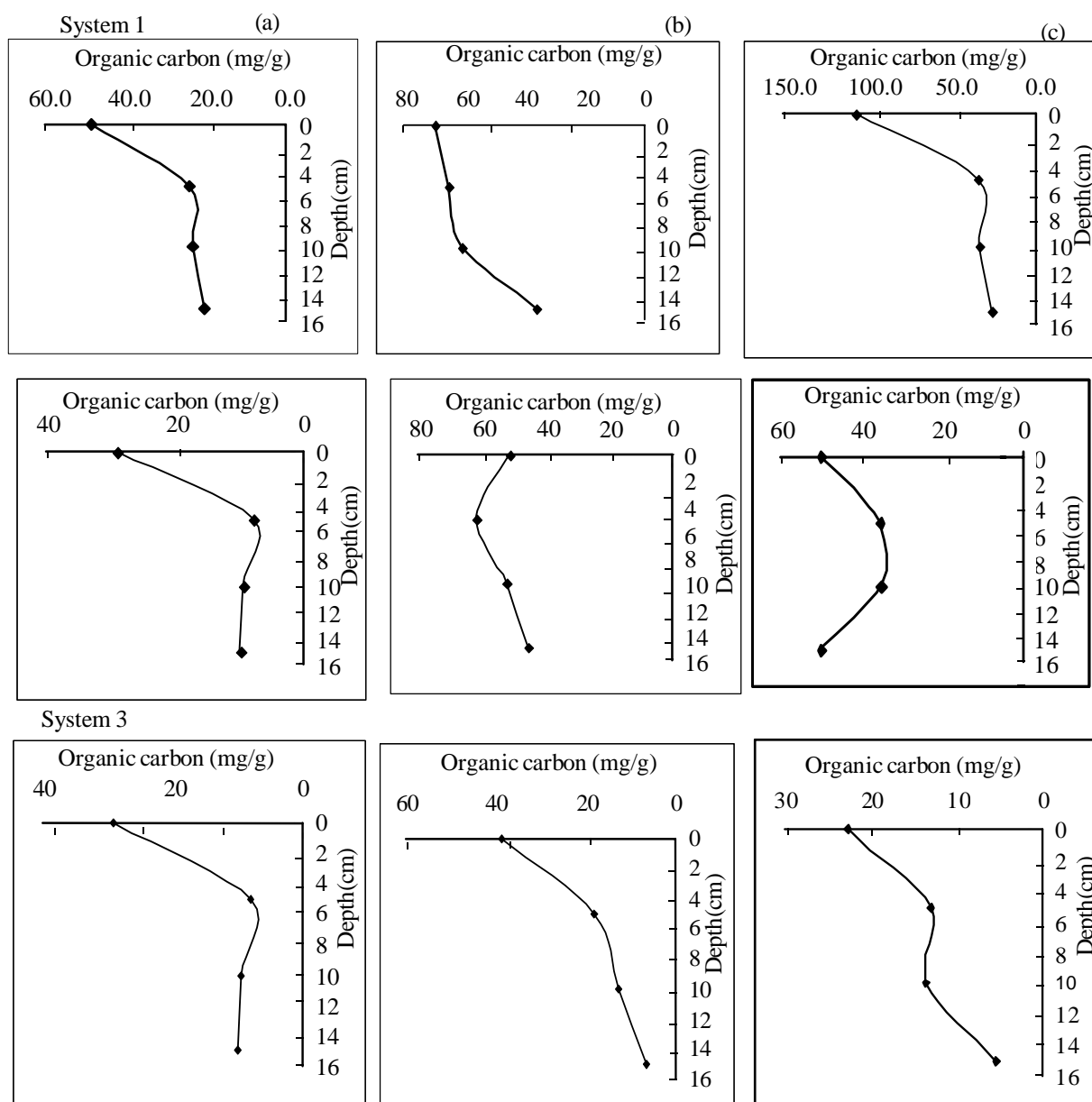


Fig. 3. Depth profile of Organic carbon in the sediment during three seasons a) Pre-monsoon b) Monsoon c) Post-monsoon

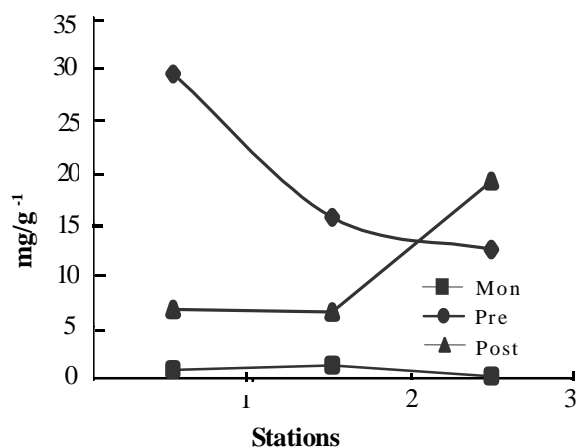


Fig. 4. Distribution of Protein in the surface sediment (mg/g)

Figures 8 & 9 show the seasonal distribution of Tannin and lignin in the surface and core. Maximum amount of tannin and lignin was noted during pre monsoon in all ecosystems. The values were in the range of 3.45 mg/g-7.15 mg/g. Highest was observed in Mangalavanam and the lowest in Nettoor. A gradual decrease was noted up to 10cm depth and then an increase at the lowest layer in all systems. In the monsoon, the values were in the range 0.97 mg/g -3.95 mg/g. Maximum was observed in Mangalavanam and minimum in Vypeen. There was a decrease towards the depth in Mangalavanam. But in Vypeen & Nettoor, the same trend was observed

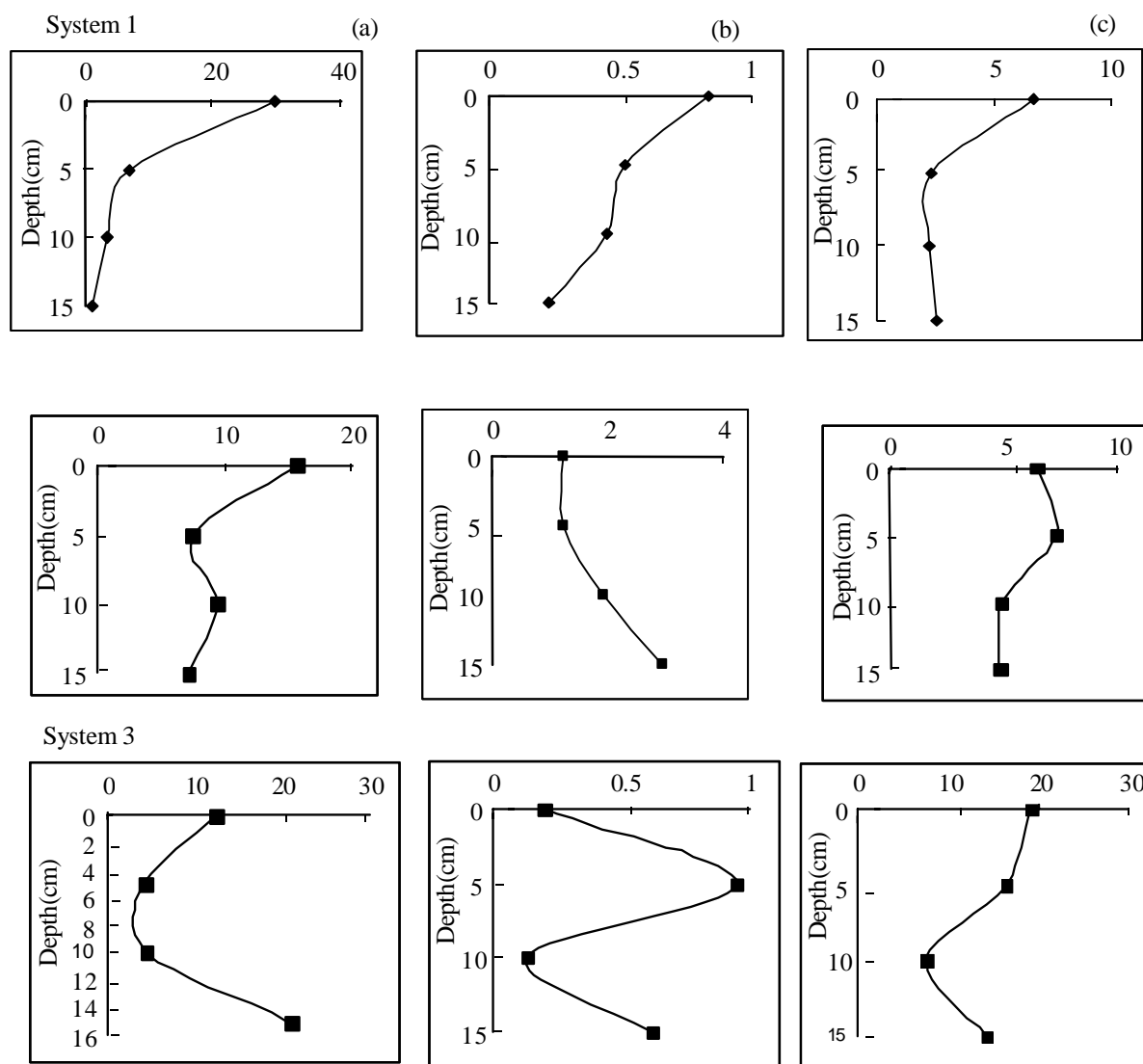


Fig. 5. Depth Profiles of Protein during different season (a) Pre-monsoon (b) Monsoon (c) Post-monsoon

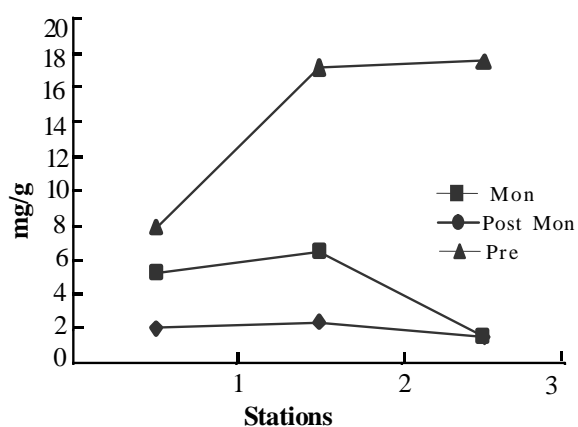


Fig. 6. Distribution of Carbohydrates in the surface sediment (mg/g)

in this season also. Comparatively lower amount was observed during this season in all stations. The values fluctuated between 0.56 mg/g - 1.71 mg/g with a maximum in Mangalavanam and minimum in Nettoor. In the Vypeen, the concentration of tannin & lignin increased towards the depth and reached a maximum at 15cm. But in Mangalavanam, a gradual increase was increase was noted up to 10cm and then a decrease. Similar trend was observed in Nettoor also. The C/N and C/P ratios of the sediment and the leaves are given in the (Tables 5, 6 and 7). The C/N and C/P of the leaves in these ecosystems are in good agreement with that of the sediment. Slight variations are noted in the pre-monsoon, which could be due to the mineralisation of organic matter in the

sediments. The observed value in Mangalavanam is in close agreement with that in Cochin Back waters (Table 5). The profile of C/N ratios show

values a decrease towards the depth, but lies within that of the oligotrophic lakes and plant tissues and peat.

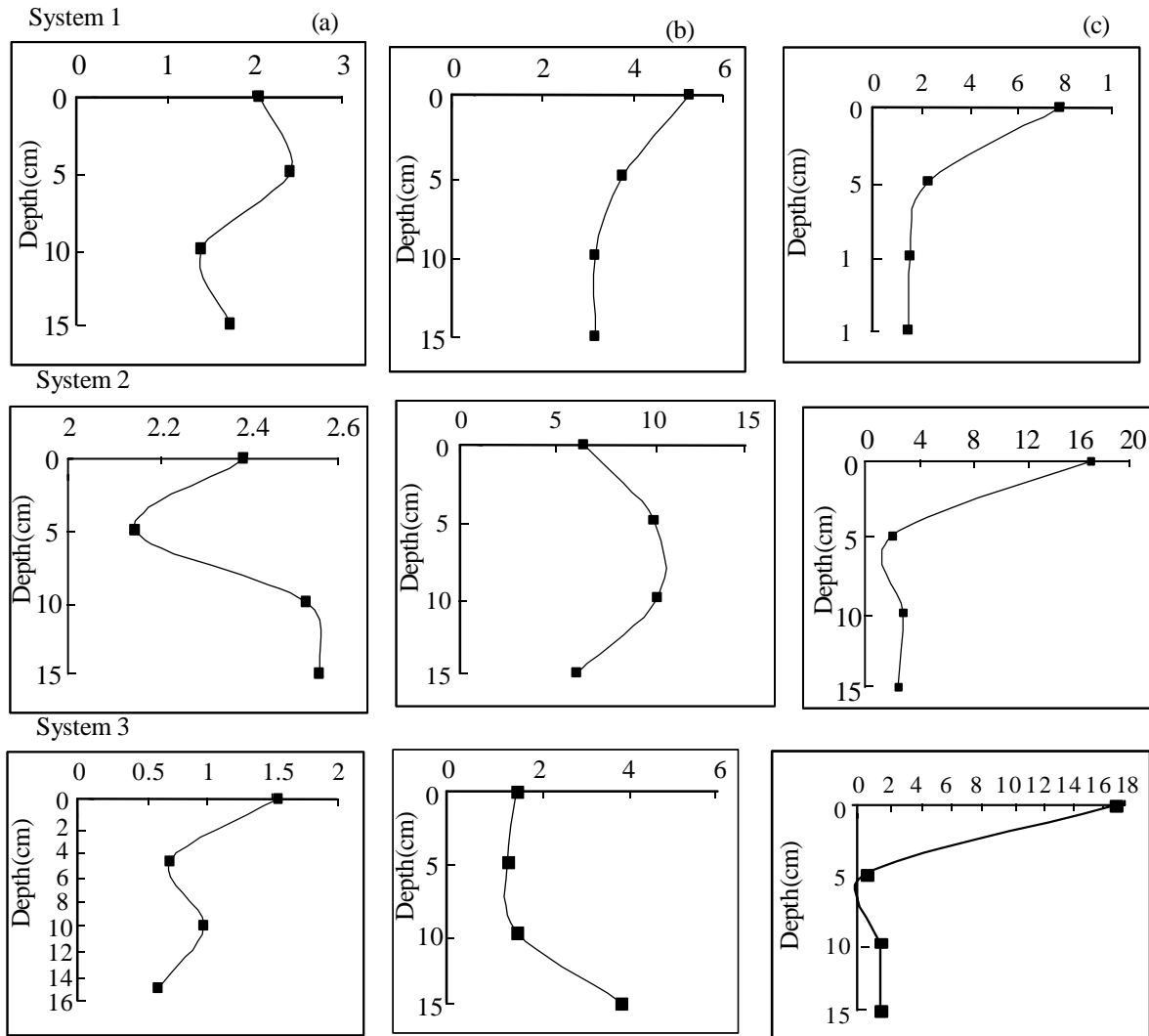


Fig. 7. Depth Profiles of Carbohydrates during different season (a) Pre- monsoon (b) Monsoon (c) Post- monsoon

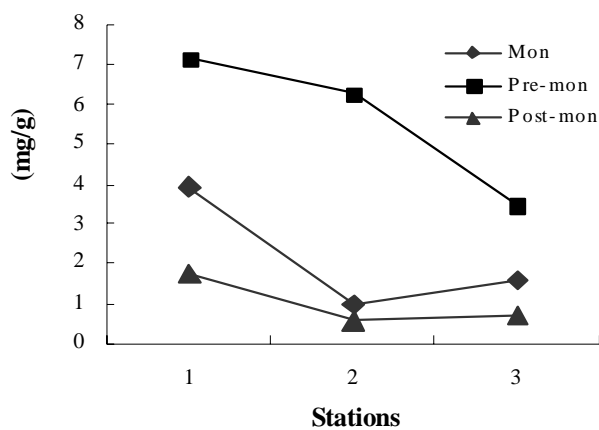


Fig. 8. Distribution of Tannin and lignin in the surface sediment (mg/g)



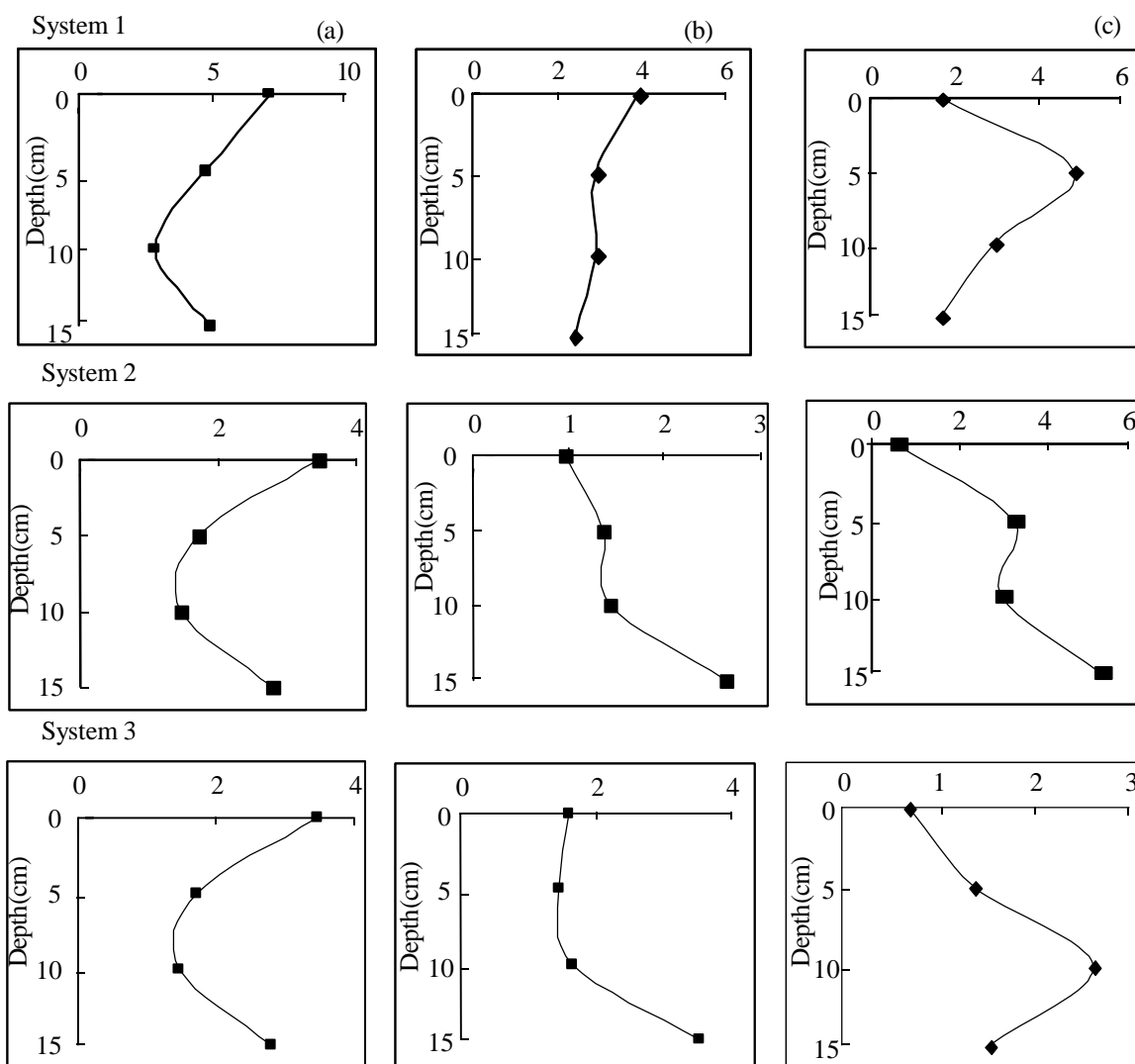


Fig. 9. Depth profiles of tannin & lignin during different seasons  
 (a) Pre-Monsoon (b) Monsoon (c) Post-monsoon

Table 5. C/N, C/P and N/P ratios in the sediments and leaves of system I

System 1			System 2			System 3		
C/N			C/P			N/P		
Mon	Post- mon	Pre-mon	Mon	Post-mon	Pre-mon	Mon	Post-mon	Pre-mon
15.6	11.42	6.52	78.21	9.6	5.08	5.01	0.84064	0.78
13.3	13.27	3.72	135.42	69.0	50.42	10.21	5.2	13.54
8.5	7.81	6.66	607.00	134.4	233.00	71.10	17.2	35.00
10.0	26.94	7.85	ND	ND	ND	ND	ND	ND

Leaf	C/N	C/P	N/P
Mav	11.57	143.85	12.43
Mac	9.38	93.37	9.95
Mrh	15.30	138.35	9.04

Mav-Avicennia in system I, Mac-Acanthus in system I, Mrh-Rhizophora in System I

**Table 6 . C/N, C/P and N/P ratios in the sediments and leaves of system II**

C/N			C/P			N/P		
Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon
12.17	11.31	6.56	ND	58.14	30.36	ND	5.14	5.14
13.78	31.05	8.04	27.44	5.99	ND	1.99	0.19	0.19
14.51	15.54	3.81	23.64	76.37	14.62	1.63	4.91	4.91
15.92	20.14	5.39	6.40	110.98	46.58	0.40	5.51	5.51

Leaf	C/N	C/P	N/P
Vav	9.32	128.28	13.76
Vac	6.99	95.94	13.73
Vrh	17.18	205.66	11.97

Vav-Avicennia in system 2, Vac-Acanthus in system 2, Vrh -Rhizopora in system 2

**Table 7. C/N, C/P and N/P ratios in the sediments and leaves of system III**

C/N			C/P			N/P		
Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon	Mon	Post- mon	Pre-mon
47.79	10.33	8.76	58.65	86.58	29.78	1.23	8.38	3.40
36.98	18.31	12.01	113.25	ND	15.78	3.06	ND	1.31
6.65	13.11	8.48	27.17	14.52	ND	4.09	1.11	ND
ND	4.67	8.84	ND	ND	90	ND	ND	10.18

Leaf	C/N	C/P	N/P
Nav	21.04	305.46	14.52
Nac	14.60	180.61	12.37
Nrh	20.52	221.04	10.77

Nav-Avicennia in system 3, Nac-Acanthus in system 3, Nrh - Rhizopora in system 3

In Vypeen also, the value is in good agreement with that of leaves (Table 6). This indicated the main source of the sediment organic matter is the plant remains. The vertical distribution in the core indicated a regular decrease up to 10cm and then an increase, which shows that sediments are becoming poor in nitrogen. Towards the depth, the amount of phosphorus decreased. Indicating preferential phosphorus removal occurs prior to deposition and burial of the organic matter. In the Nettoor, the value is high (Table 7), but is in agreement that of plant remains and peat (Waksmann, 1933; Brenner *et al.*, 1978). The high value indicated poor protein in sediments than in

leaves. Comparative values of C/N, C/P, and N/P ratios from a various investigations are given in (Table 8). The decay rate of C and N indicate that the main reactivity is in the first 5cm. It has already been mentioned that the first 5cm is subjected to re suspension and significant bioturbation. Moreover the availability of the molecular oxygen due to the depth characteristics of the overlying water also may be a reason for the enhanced reactivity the decay ratio at 10 and 15cm are comparable to each other suggesting a uniform decay pattern. The 15cm data in the case of monsoon and post monsoon exhibit a random character, which can be attributed to the effective

**Table 8. Comparative values of C/N, C/P, and N/P ratios from a variety of investigations**

Region	Ratios	References
India:	C/P 2.25:1 to 37.5:1	Sankaranarayanan
-Cochin Backwaters	C/N 2.3: 1 to 16.9:1 N/P 1.2:1 to 4.07:1	& Panampunnayil (1979)
-Cochin Backwaters	C/P 22.6:1 to 60.4:1	Qasim &
-Cochin wetland Sediments	C/N 5:1 to 10.5:1 C/P 15.37:1 to 36.77:1 C/N 1.22:1 to 5.27:1 N/P 3.69:1 to 17.23:1	Sankaranarayanan (1972) Lizen Mathews (2000)
-Natural Plankton	N/P 13.8:1	Sen Gupta <i>et al.</i> (1976)
-Culture Plankton	N/P 18.2:1	
-Sediments of Mandovi Estuary, Goa	C/P 1.53:1 to 38.5:1 C/N 0.21:1 to 2.0:1 N/P 2.92:1 to 37.51:1	Nasolkar <i>et al.</i> (1996)
USA (California):		
-Sediments of Catalina	N/P 5.8:1(average)	Rittenberg <i>et al.</i> (1955)
-Sediments of Santa Barbara	N/P 3.3:1(average)	
-Sediments of Santa Monica	N/P 1.4:1(average)	
Pacific ocean:		
-Completely oxidized Sediments	C/N 2.2:1 to 5.0:1	Muller (1977)
Arabian Sea:		
-Shelf Sediments	C/N 2.48:1 to 37.5:1 C/P 1.0:1 to 8.0:1	Bhosle <i>et al.</i> (1977)
Archipelago Region	C/P 42 N/P 72	Tallberg (1999)

release of organic matter from that depth zone. It is to be noted that attempts to differentiate between the sediment and pore water contributions haven't been done here prima (Table 8). Comparative values of C/N, C/P, and N/P ratios from a variety of investigations. rily because the intention was to identify the actual amount of organic carbon and nitrogen (the total available organic carbon) and also the sediment characteristics. Semi solid or colloidal nature shown by the sediments didn't permit the clear separation of pore water from the sediment. Studies to identify the pore water contribution in this geochemical zone are in vogue.

As it can be seen from the data, the refractive substances including Tannin and lignin constitute the major fraction of the organic matter in the sediment. Even though no attempt has been made to isolate the reactive organic component or matter from the total content, the observed values of the tannin and lignin indicate a substantial accumulating tendency of the refractory substances. This would definitely contribute or modify the reactivity

calculations and the randomness observed in the geochemical reactivity in fact supports this argument. To assess the reactivity of the systems, the classic one G model (Bernier, 1989) with slight modifications to suit to the system was employed here; the equation quoted by Colombo *et al.* (1996) is given as:

$$G_z = G_u + (G_s - G_u) e^{-\lambda z}$$

Where  $G_z$  is the concentration of organic matter at a specified depth  $Z$ ,  $G_u$  is the concentration of uncreative organic matter, i.e. the bottom of the core,  $G_s - G_u$  is the concentration of reactive organic matter, with  $G_s$  as the concentration in the top 0-3 cm and  $\lambda$  is the attenuation factor.

$$\lambda = \omega/2Db - [(\omega/2Db)^2 + k/Db]^{1/2}$$

Where  $Db$  is the biological mixing coefficient,  $\omega$  is the sedimentation rate and  $k$  is the apparent first order decay of the species in question. The values of  $G_s$  and  $G_u$  were obtained from the profiles. The model was applied to the data assuming constant  $Db, \omega$  and  $k$ . While adopting

the model to the present study, the biological mixing coefficient is replaced by the average flushing time. In the present systems, the tidal action is the major contributor to the flushing processes. So the average time for a tidal cycle has been taken as the flushing time. As it has already been mentioned, the first 5 cm of the sediment is considered as the surface sediment, which will be subjected to maximum diagenetic processes. This part of the sediment in fact takes part in the geological processes like sediment re-suspension and also to the bioturbation. So the decay constant was evaluated from the ratio of organic carbon in the surface and 5cm depth of the sediment (Table 9). The decay constant is given as:

$$\text{Decay constant} = G5-G0/G0$$

Due to the low depth characteristics of the over lying water and the shallowness of the water

column, a direct estimation of the sedimentation rate is impossible in the present systems. As the sedimentation rate is proportional to the POC flux in the present calculations, the POC flux /area has been utilized to replace the sedimentation rate in the equation. The values corresponding to these parameters are subject to modifications due to the seasonal contributions. The attenuation factor was so calculated independently for the three seasons. The amount of organic carbon, nitrogen, carbohydrate, protein at different depths of the sediment was calculated using the attenuation factor. The calculated results are given in (Tables 10, 11 & 12). The comparison of these values indicates that in all the ecosystems, the observed value at low depth is in good agreement with the calculated value. But this agreement is observed only for the pre -monsoon period in the case of 15 cm depth.

**Table 9. Decay Ratio of sediments in three systems**

	dc15/dc10			dn15/dn10		
	Premon	Mon	Post	Premon	Mon	Post
System 1	0.88	0.59	0.79	0.74	0.51	0.23
System 2	1.11	0.87	1.42	0.78	0.79	1.10
System 3	1.04	0.51	0.40	1.00	Nd	1.14

**Table 10. Comparison of Calculated & Observed value of various organic compounds in system 1**

	10		15	
	Cal	Obs	Cal	Obs
Carbon				
Mon	61.78	52.25	61.80	45.37
Pre	26.14	28.88	26.14	28.88
Post	35.69	26.02	35.83	49.94
Nitrogen				
Mon	4.48	3.6	4.48	2.85
Pre	3.25	6.83	3.25	5.36
Post	1.20	2.26	1.24	2.48
Carbohydrates				
Mon	10.25	10.39	10.261	6.13
Pre	2.1498	2.53	2.1498	2.56
Post	2.11	2.93	20.901	2.53
Protein				
Pre	7.40	9.45	7.40	7.04
Mon	1.23	1.93	2.03	2.96
Post	7.21	4.92	6.41	4.81
	Attenuation factor (y)			
	pre	0.00001		
	post	-0.0002		
	mon	0.001		

**Table 11. Comparison of Calculated & Observed value of various organic compounds in system 2**

<b>Carbon</b>	<b>obs</b>	<b>cal</b>	<b>obs</b>	<b>cal</b>
Post	13.5	13.03	5.46	13.04
Pre	9.5	8.10	9.90	8.12
Mon	12.5	18.23	6.40	18.29
<b>Nitrogen</b>				
Post	1.03	0.71	1.17	0.72
Pre	1.12	0.68	1.12	0.69
Mon	1.88	0.49	ND	0.49
<b>Carbohydrate</b>				
Post	1.52	0.71	1.62	0.74
Pre	0.98	0.72	0.62	0.72
Mon	1.54	1.36	3.86	1.36
<b>Protein</b>				
Post	7.53	16.33	14.29	16.33
Pre	4.51	4.37	21.09	4.38
Mon	0.13	0.95	0.62	0.95
<b>Attenuation factor (y)</b>				
Post		-0.0003		
Pre		-0.00023		
Mon		-0.00056		

**Table 12. Comparison of Calculated & Observed value of various organic compounds in system 3**

	<b>10</b>		<b>15</b>	
<b>Carbon</b>	<b>Obs</b>	<b>Cal</b>	<b>Obs</b>	<b>Cal</b>
Post	33.60	45.18	26.40	46.32
Pre	23.30	25.28	20.40	25.15
Mon	60.70	55.69	36.10	60.14
<b>Nitrogen</b>				
Post	4.30	9.99	0.98	6.18
Pre	3.50	6.85	2.60	7.03
Mon	7.11	4.86	3.60	4.84
<b>Carbohydrates</b>				
Post	1.62	4.52	1.5	5.26
Pre	1.42	2.26	1.74	2.21
Mon	3.18	3.95	3.18	4.01
<b>Protein</b>				
Post	2.26	4.03	2.52	4.62
Pre	3.55	17.06	1.04	20.29
Mon	0.45	0.55	0.23	0.56
<b>Attenuation factor (y)</b>				
		-0.06		
		-0.05		
		-0.01		

## CONCLUSION

The monsoon and post monsoon observed values considerably vary with calculated value. The difference may be due to the difference in the affect of the seasons at depths. The close agreement between the observed and calculated approved the considerations put forth for the computation of the data. Significant seasonal contribute to the OC in the different depths of the sediment was reported in earlier work (Klump *et al.*, 1980). Here also, no concrete explanation is offered except that the ecosystem characteristics above the sediment are significantly different for three reasons due to difference in the amount of water sweeping into the sediments (Alongi, 2002).

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