

ORGANIC CARBON IN THE SEDIMENTS OF THE LOWER REACHES OF PERIAR RIVER

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ABSTRACT

Sediments are indicators of the quality of water overlying them and hence, useful in the assessment of environmental pollution. Temporal and spatial variations in sediment characteristics and organic carbon content from 9 stations in the lower reaches of Periyar river an area in Cochin Backwater which is polluted from different sources were studied for one year during 1981. Variations in colour and texture of sediments were brought about by changes in the grain size and state of oxidation of organic matter. The colour of the sediment varied from greyish black at stations 1 and 2, brownish at station 3, black at stations 4 to 8 and reddish at station 9.

Organic carbon and sediment texture showed a direct relationship at all stations except at station 9 where organic carbon content showed an irregular pattern. Overall range of organic carbon content was between 1.19 and 29.6 mg.g⁻¹. The mean organic carbon of the stations ranged between 6.8 mg.g⁻¹ (station 5) and 20.8 mg.g⁻¹ (station 9). On the whole temporal variations were considerable with high values at station 9 and low values at station 5. Fluctuations were more at stations 6,7 and 8.

INTRODUCTION

The nature and extent of fluctuation in the composition of sediments can indicate the extent of stress on shallow aquatic environments. The sediments in the estuaries indicate the balance between the erosional and depositional forces of the ecosystem. The supply and source of these materials and the sites of deposition mainly depend on the type of estuaries, river discharge, currents, wave action and tidal regime. Organic carbon content in the sediments of the estuarine riverine system is of considerable interest as a potential food for the benthic fauna. Generally the state of preservation depends partly on its texture as well as microbial and redox potential of the sediment.

The present study pertains to the sediment characteristics and organic carbon content of the lower reaches of Periyar where a number of industries dump their wastes and further downstream large scale coconut husk retting is carried out. The sediment characteristics and organic matter content of the backwater system

have been reported on many occasions (Murthy and Veerayya, 1972a; Gopalakrishnapillai, 1978; Sankaranarayanan and Panampunnayil, 1979; Remani *et al.* 1980; Remani *et al.* 1981; Aravindakshnan *et al.* 1992.) A detailed systematic survey of this region has not been done so far and hence this study was undertaken.

MATERIAL AND METHODS

Sediment samples were collected with a van Veen grab (area 0.05 m²) during January - December 1981, covering nine stations from barmouth to 21 kms upstream in the northern limb of Cochin backwater where several chemical industries discharge their effluents (Fig.I). The grain size analysis of the sediment was done by pipette method (Krumbein and Petti John, 1936) and of organic carbon estimation by wet digestion method (El Wakeel and Riley, 1957). Organic carbon values are given on dry weight basis.

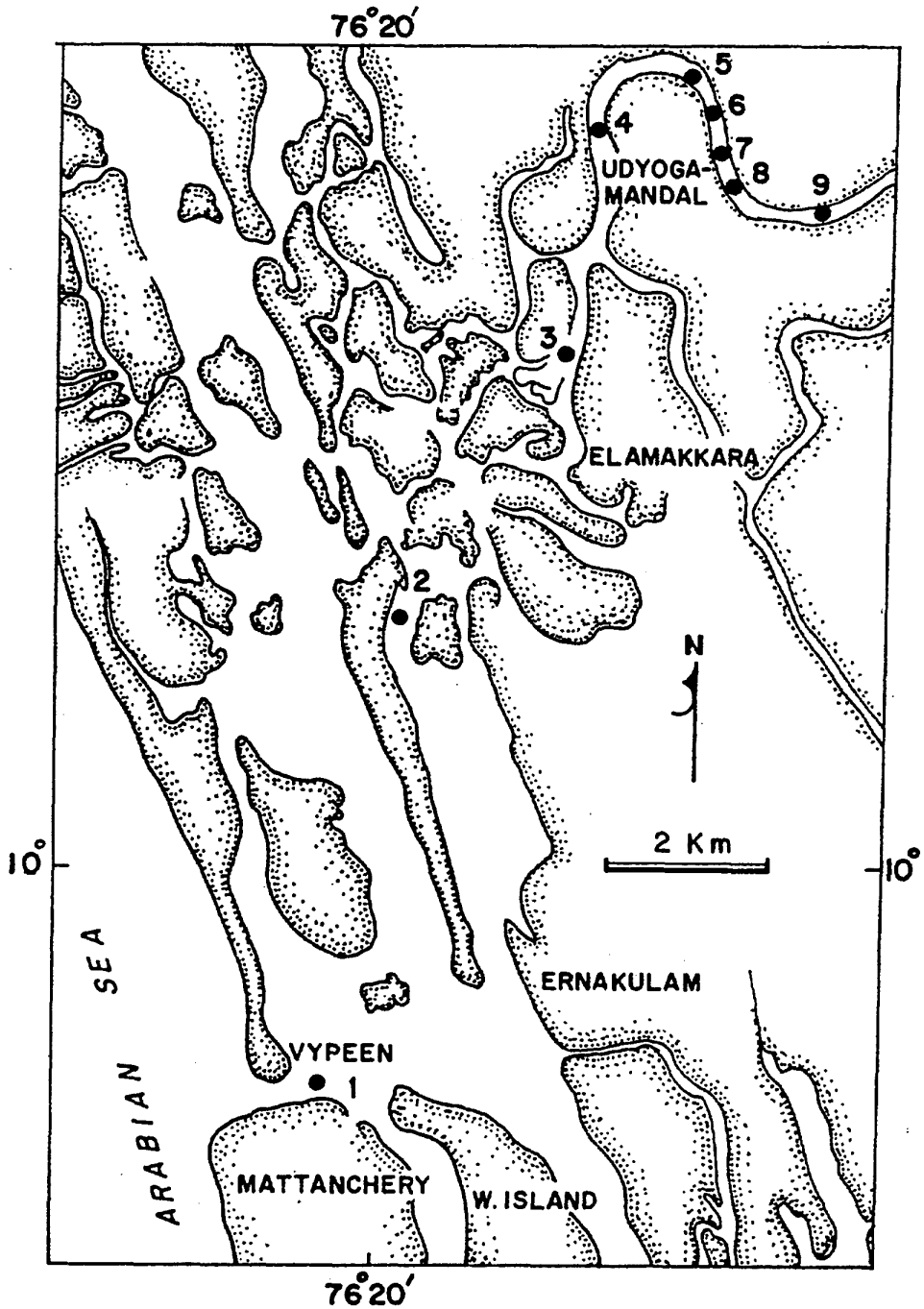


Fig. 1 : Station locations

RESULTS AND DISCUSSION

Spatial and temporal variations in the texture and organic carbon content of the sediments at various stations are depicted in Table I, Figs. 2 & 3. The colour of the sediment varied from greyish black at stations 1 & 2 to brownish at station 3, black at station 4 to 8, reddish at station 9. Stations 1 & 2 were predominantly clayey, whereas stations 4 to 6, were dominated by a sandy bottom with a percentage varied from 60 to 99% and stations 7 & 8 had a silty bottom varying in composition from 45 to 72%. The substratum at station 9 widely varied from sand to silt.

were considerably high. Higher values usually prevailed at station 9, and lower values occurred at station 5. Fluctuations were more at stations 6 to 8, probably due to intermittent organic loads. Stations 3 and 4 showed an increase in value upto postmonsoon. The reddish brown colour of the sediment at station 9 indicated the oxidised condition whereas the light grey sediment indicated the presence of terrigenous matter (Hashmi *et al.* 1978 and Remani *et al.* 1981). The sediments at the effluent discharge sites (stations 6 to 8) were black in colour and malodorous akin to the green and black mud of the coconut retting ground and stagnant basin (Kuencn, 1950; Hymes, 1966 and Remari *et*

Table I: Sediment texture at stations 1 - 9 during different months.

Months	1	2	3	4	5	6	7	8	9
Jan.	B	B	G	G	G	A	F	F	G
Mar.	D	D	G	G	G	G	A	A	G
Apr.	D	B	G	G	E	G	F	F	E
May	D	F	C	G	E	G	F	B	F
Jun.	D	F	F	G	G	G	F	F	C
Jul.	D	D	F	A	G	F	A	F	C
Aug.	D	F	E	E	G	F	E	D	E
Sept.	D	F	F	G	G	G	F	E	E
Oct.	D	F	C	G	G	G	F	E	C
Nov.	D	B	B	C	G	F	D	B	E
Dec.	C	D	G	G	G	E	F	G	E

A = Sandy silt;

B = Sandy clay;

C = Silty sand;

D = Silty clay;

E = Clayey sand;

F = Clayey silt;

G = Sandy.

Considerable spatial and temporal variations in organic carbon were noticed depending on the type of sediment. Spatial variations showed a fluctuating trend during premonsoon period. During the southwest monsoon (June to Sept), the values showed an increasing trend from stations 1 to 4. A low average value (6.8 mg.g^{-1}) was noted at station 5 and the highest (29.6 mg.g^{-1}) at station 9.

In general temporal and spatial variations

al. 1981). The stations 1 to 2 near the estuarine mouth had predominantly clayey bottom. Textural characteristics of the sediments of Ashtamudi estuary varied markedly over the course of an year at all stations (Nair *et al.* 1984). Available data from our surveys of estuarine regions along southwest coast also showed a seasonal cycle in texture and organic content of the sediment. The semipermeable sediments rich in clay and silt tend to hold interstitial water that has no direct relation with the

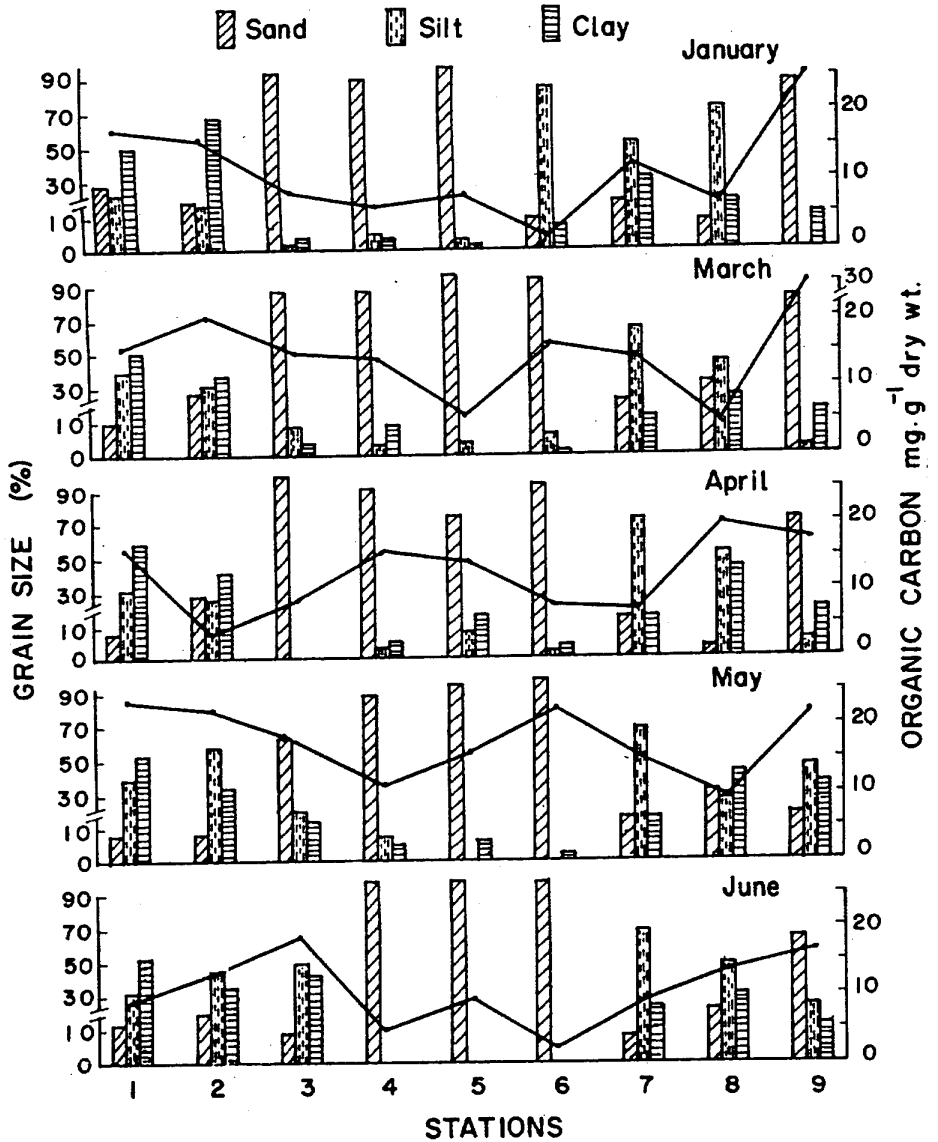


Fig. 2 : Grain size and distribution of organic carbon at different stations from January to June

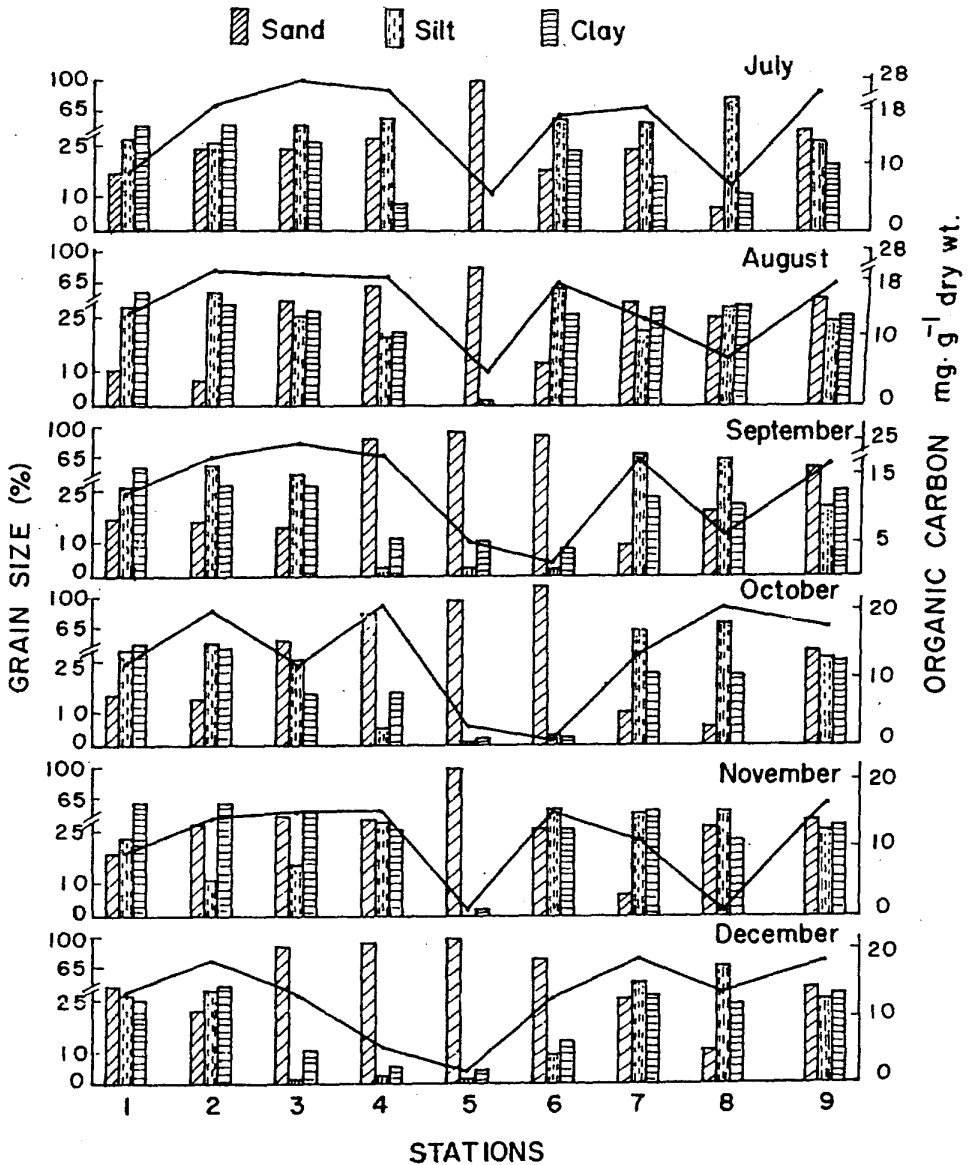


Fig. 3 : Grain size and distribution of organic carbon at different stations from July to December

prevailing tidal regime, as has been observed by Shirodkar and Sen Gupta (1985). This strongly suggests a physico-chemical regime in the sedimentary environment that is out of phase with that of overlying water. The present study also showed salinity values of the interstitial water varying from that of overlying water which fluctuated between 0.21 to 28.0‰ depending on the nature of the sediments. Shirodkar and Sen Gupta (1985) have observed reduced conditions in coastal and estuarine sediments during October to May and oxidised condition in June and September. The colour of the sediment at stations 1 & 2 of the study agrees well with this statement.

The organic carbon content during the study was found to vary between 1.19 & 29.6 mg.g⁻¹ affecting considerably the pH of the sediment indicating the release of acidic compounds by break down of organic matter. This is in conformation with the observations of Shirodkar and Sen Gupta (1985).

High organic carbon noticed at station 1 during premonsoon may be the result of dredging activities. Land runoff and terrigenous sources contributed to monsoonal increase of organic carbon content. Nair *et al.* (1984) recorded high values of organic matter in the sediments of Ashtamudi estuary as a result of effluent discharge from Punaloor Paper Mills. Chandran (1987) noticed no conspicuous tidal variations in organic carbon content in Vellar estuary and the values varied between 0.28 & 24.8 mg.g⁻¹ which agrees with the present values. Saraladevi *et al.* (1979) have attributed the termination of the phytoplankton bloom as a factor for the very high carbon content. High oxygen content, high temperature and shallowness of the system seems to favour the oxidation of organic matter in sediments (Murthy and Veerayya, 1972).

Estuaries in general are highly productive and the available data on Cochin backwaters shows that it is highly productive (Russel, 1960 and Qasim *et al.* 1969).

Benthic production is of importance in assessing the fishery resources of an area. Distribution of bottom fauna has direct relationship with the type of bottom and physical nature and extraneous inputs may drastically alter the number and type of species (Sandens, 1959). Variations in the abundance, distribution and density of benthic population in this region have been studied (Saraladevi and Venugopal, 1989). A clear cut relationship is discernible between the sediment characteristics and bottom fauna.

In the present study stations 1 and 2 where the substratum was silty clay with high organic carbon content supported abundant and diverse fauna. Stations 3 to 6 with sandy bottom and low organic carbon content showed a healthy population of bivalve mainly constituted by *Villorita cyprinoides*. Stations 7 and 8 where substratum was clay and silty however showed a different pattern of benthic distribution. Station 7 down stream of effluent discharge site had high biomass mainly constituted by caprellid polychaetes which can tolerate the existing stress condition. Station 8, the effluent discharge site had very poor biomass and density. Station 9 upstream of effluent discharge site had a more sandy bottom and supported a dense and healthy benthic population.

The higher retention of organic matter on fine grained material is known (Russel, 1960). The texture and content of organic matter widely varied in the study region. However, a broad generalisation can still be attempted. Station 9 in this scheme is referred to as an end member free from industrial inputs. Stations 8 to 5 are in the vicinity of effluent discharge site. Station 4 is designated as transition zone since it experiences condition between limnetic and estuarine depending on the monsoonal regime. Stations 3 & 2 are true estuarine stations and station 1 is saline end member. This proposed categorisation is relevant especially during lean river flow. The monsoonal deluge masks it. The seasons tend to telescope into each other and is variable over years.

While station 1 had relatively higher organic content, stations 8 to 5 showed only sporadic higher levels. Concurrent observation on organic carbon of seston have shown that this area is rich in autochthonous material (Saraladevi, 1989). This however does not seem to translate itself to higher organic content of sediments. The benthic consumers being sparse, a net export of organic matter downstream is suggested (Saraladevi and Venugopal, 1989). The nature of substrate (Table I, Figs. 2 & 3) apart from the prevailing physico-chemical conditions also do not seem to be conducive to the enrichment of the bottom. In the area described as transition zone previous workers have noted a build up of material such as heavy metals (Venugopal *et al.* 1982) and nutrients. Sankaranarayanna *et al.* (1986) and Saraladevi *et al.* (1991) have noted a cradling effect caused by the tides that can encourage net deposition of material. The present data does not corroborate these. This is quite surprising in view of the additional organic loading from agricultural sources in this area. The saline end member (station 1) being a recipient of other inputs like sewer discharge and dredge spoils sustained high values are explainable. Thus the composition of sediment being the prime factor in its capacity, to hold organic matter, the role of prevailing physico-chemical conditions especially man made alterations deserve attention.

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REFERENCES

- Aravindakshan, P.N., Balasubramanian, T., Lalithambika Devi, C.B., Chandrasekharan Nair, K.K., Gopalakrishnan, T.C., Jayalakshmy, K.V. and Krishnankutty, M. 1991. Benthos and substratum characteristics of Prawn Culture fields in and around Cochin Backwaters, *J.Mar.biol. Ass. India*, 34 (1&2) : 203-217.
- Chandran, R. 1987. Hydrobiological studies in the gradient zone of the Vellar Estuary IV. Benthic fauna. *Mahasagar - Bull. Nat. Inst. Oceanogr.*, 20 (1) : 1-13.
- El Wakeel, S.K. and Riley, J.P. 1957. Determination of organic carbon in marine mud. *J.Cons. Perm. Int. Explor. Mer.*, 22: 180- 183.
- Gopalakrishnapillai, N. 1978. Macrobenthos of a tropical estuary Ph.D. Thesis. *Univ. Cochin*.
- Hashimi, N.H., Kidwai, R.M. and Nair, R.R. 1978. Grain size and coarse fraction studies of sediments between Vengurla and Mangalore on the Western Continental Shelf of India. *Indian J. mar. Sci.*, 7: 231-238.
- Hynes, H.N.B. 1966. *The Biology of Polluted waters*. Liverpool University Press, 202 pp.
- Krumbein and Petti John, F.J. 1938. *Manual of Sedimentary Petrography* Appleton Century Crofts, New York, 549 pp.
- Kuonen, P.H. 1950. *Marine Geology*. John Wiley and Sons, New York, 568.
- Murthy, P.S.N and Veeryya, N. 1972. Studies on the sediments of Vembanad Lake Kerala state: Part I. Distribution of organic matter. *Indian J.Mar. Sci.*, 1: 45-51.
- Nair, N.B., Abdul Aziz, P.K. Arunchalam, M. Krishnakumar, K. and Dharmaraj, K. 1984. Ecology of Indian Estuaries Part X. Distribution of total Phosphorus, total Nitrogen, and total Potassium in the sediments of Ashtamudi estuary. *Mahasagar-Bull. Nat. Inst. Oceanogr.*, 17(10):35-39.
- Qasim, S.Z., Wellershan, S.S., Bhattathiri, P.M.A. and Abidi, S.A.H. 1969. Organic matter in a tropical estuary *J.exp. mar. Biol. Ecol.*, 2 : 87-103.

- Remani, K.N., Venugopal, P., Sarala Devi, K. and Unnithan, R.V.** 1980. Sediments of Cochin backwaters in relation to pollution. *Indian J. Mar. Sci.*, **9** :111-114.
- Remani, K.N., Venugopal, P., Sarala Devi, K. and Unnithan, R.V.** 1981 Sediments of a retting yard. *Indian J. Mar.Sci.*, **10**:41-44.
- Russel, E.J.** 1950. *Soil Conditions and Plant Growth*. Longmans Green and Co. New York.
- Sanders, H.L.** 1958. Benthic studies in Buzards. Bay Animal - Sediment relationships. *Limnol. Oceanogr.*, **3** : 245-258.
- Sankaranarayanan, V.N and Panampunnayil, S.U.** 1979. Studies on organic carbon, nitrogen and phosphorus in sediments of the Cochin backwaters. *Indian J. Mar.Sci.*, **8** : 27-30.
- Sankaranarayanan, V.N., Udaya Varma, P., Balachandran, K.K., Arbaham Pylee and Thresiamma Joseph.** 1986. Estuarine characteristics of the lower reaches of the river Periyar. *Indian J.Mar.Sci.*, **15**: 166-170.
- Saraladevi, K.** 1989. Temporal and spatial variations in particulate matter particulate organic carbon and attenuation coefficient in Cochinbackwaters. *Indian J. Mar. Sci.*, **18** (4) 242- 245.
- Saraladevi, K., Sankaranarayanan, V.N. and Venugaopal, P.** 1991. Distribution of nutrients in the Periyar river estuary. *Indian J. Mar. Sci.*, **20**(1) : 49-54.
- Saraladevi, K. and Venugopal, P.** 1989. Benthos of Cochin backwaters receiving Industrial effluents. *Indian J. Mar. Sci.*, **18** (3), 165-169.
- Saraladevi, K., Venugopal, P., Remani, K.N, Lalitha, S. and Unnithan, R.V.** 1979. Hydrographic features and water quality of Cochin backwaters in relation to industrial pollution. *Indian J. Mar. Sci.*, **8**: 141-145.
- Shirodkar, P.V. and Sen Gupta, R.** 1985. Chemistry and behaviour of calcium and magnesium in interstitial waters of sediments from the coastal and estuarine regions of Mandovi river along the Westcoast of India. *Indian J. Mar. Sci.*, **14** (4) : 196-201.
- Venugopal, P., Remani, K.N., Sarala Devi, K. and Unnithan, R.V.** 1982. Trace metal levels in the sediments of Cochin Backwaters. *Mahasagar - Bull. Natn. Inst. Oceanogr.*, **15** (4): 205-214.