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Studies on the Sediment Characteristics of Manakudy Estuary, South west coast of India

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Abstract

Kanyakumari District is located on the southern extremity of the Indian Peninsula between lat $8^0 2'$ and $8^0 4'$N and between long $77^0 26'$and $77^0 30'$E .The district receives heavy rains during the South west (June to August) and North east monsoons (October to December). The sediment characteristics were studied in 6 stations namely S1, S2, S3, S4, S5, S6. The grain size ranged from 0.063mm to 0.5mm. The sediment was sandy clay towards river side, but silty clay towards the estuarine side. Organic carbon was lower in S5 and S6. The organic carbon was higher in S2, S3 and S4 because they are located near the mangrove forest on the mudflats. The detritus from the mangrove forest increase the organic carbon content of these stations. Apart from this the sediment fractions are finer; and the finer fraction has affinity for organic carbon.The $CaCO_3$ values were highly fluctuating, due to the presence of Molluscan shells and maximum in S6(34.5%). The sulphur content was uniform in all the stations except S6. The maximum was recorded in S4(1.395%).The coir retting pits along the estuary accounts for H_2S and subsequently the sulphur content of the estuary. The various parameters of surface sediments in the six stations were subjected to two way ANOVA and it was found that they were significantly correlated.

Keywords: Estuary, sediment, organic carbon, calcium carbonate.

Introduction

Estuary sediments are derived from the river watershed and the continental shelf infront of the estuary. Lesser sources are erosion within the estuary, biological activity and eolian transport. The distribution of sediment facies is controlled by interaction between the available sediments, bottom morphology and flow hydrodynamics. Both landward transport of sediments by tidal currents and river inflow supply sediment to an estuary. In river dominated estuaries, equilibrium has been achieved and variation in sediment volume fluctuates with the river flow[1]. Sedimentation in estuaries is within three distinguishable regimes estuarine fluvial, estuarine estuary, estuarine marine. These sequences interfinges with fluvial and marine sediments at the inner and outer limits of the estuary respectively[2]. Dispersal of fine sediment in the marine estuary is controlled by the estuarine circulation pattern. The efficiency of sediment trapping with in the estuary depends on the capacity of an estuary in relation to rate of sedimentation and energy available for transport.

Organic materials derived from decaying mangrove leaves are used as primary food source in sustaining larval and juvenile stocks. Influence of physical, chemical and biological variables on planktonic communities in mangrove waters are more pronounced than the nearshore coastal environment, resulting in seasonal changes of planktonic species composition and densities[3]. Various studies on nutrients and organic carbon in the estuarine sediments have been carried out along the east coast of India[4]. On the west coast, cochin backwaters[5] and the vembanad lake have attracted great attention in this respect. The mangrove habitat is reffered to as an advancing coast, where the land advance toward the sea due to soil sedimentation[6]. Grain size parameters such as mean size (Mz) and standard deviation (SD) reflect the energy conditions of the depositional environment[7]. The difference in size distribution is mainly due to variation in wave energy reaching the point of sampling and extent of turbulence affecting the environment. Sulphur is an essential element in the form of organo sulphur compounds for biological organism. All organisms except animals and protozoans are able to carry out assimilatory sulphate reduction may also be important in salt marsh soils due to the effect of sulphide on plant production. Concentrations of sulphide in marsh soils affect soil redox, metal concentrations and oxygen availability, all of which may feed back to control plant growth[8]. The present study was undertaken to assess the various sediment parameters like sand, silt, clay, organic carbon, $CaCO_3$ and sulphur.

Material and Methods

Description of the study area: The study was carried out at Manakudy estuary (figure-1). Kanyakumari District is located on the southern extremity of the Indian Peninsula between lat $8^0 2'$ and $8^0 4'$N and between long $77^0 26'$and $77^0 30'$E. Pazhayar is one of the main river systems in the District and this river takes

its origin at the Western ghats. From the place of its origin it traverses 23.1km before entering the Arabian Sea through the Manakudy estuary. The Manakudy estuary is the confluence of river Pazhayar and has an area of about 150ha. It is a sand built estuary connected to the Sea during the rainy season. During the period of total occlusion of the river mouth the estuarine water swells due to heavy inflow of water from the head of the estuary and also by the land drainage. During heavy inflow into the estuary the sand bar opens up under the force of gravity. Compared to the expanse of the estuarine area, the bar mouth is relatively small and even during summer months the local people cut open the bar mouth and the estuary has open access to the sea. In order to study the state of health of the Manakudy estuary six stations were selected from the mouth to the head of the estuary. The result of the present investigation are based on the analyses of collection of sediments from the six stations.

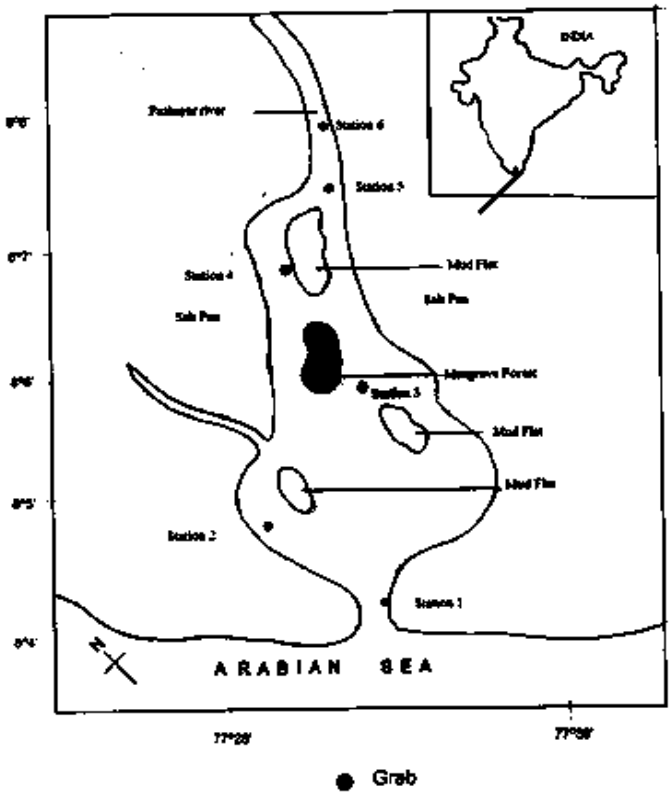

Figure-1
The map showing study area and sampling sites

Station I: This station is situated near the mouth of the estuary almost near the sand bar.

Station II: This station is 2 km away from the station I where the sewage from husk retting factory enters the estuary.

Station III: This station is near the mangrove forest created on the mud flat by the Society for Environment Education and Development (SEED) as a pilot project of a forestation to establish mangrove forests in the manakudy estuary.

Station IV: This station is 2 km away from mangrove forest. Here the sewage from the fisherman settlements and the effluents from the coir retting pits enter the estuary.

Station V: This station is 2 km away from the head of the estuary.

Station VI: This station is at the head of the estuary where in the river pazhayar enters the estuary. There is large scale sand mining in this station and the banks of the river abounds with coconut grooves.

Sample collection and analysis: Surface sediment samples were collected from six stations in Manakudy estuary. The collected sediment samples were air dried and used for estimating sulphur, organic carbon and calcium carbonate. Textural studies on the sediments were performed for sand, silt and clay distribution and grain size analysis. Organic carbon was determined by exothermic heating and oxidation with potassium chromate and concentrated sulphuric acid followed by titration of excess dichromate with 0.5N ferrous ammonium sulphate solution. Sulphur was estimated gravimetrically. Grain size are determined by using different sieves.

Enrichment factor: The enrichment factor (EF) was based on the standardization of a tested element against one. A reference element is the one characterized by low occurrence variability. The most common reference elements are Sc, Mn, Ti, Al and Fe [9-12]. In the present study Al was used as the reference metal using the formula

$$EF = \frac{Cn\ (sample)/\ C\ ref\ (sample}{Bn\ (background)/\ B\ ref\ (background)}$$

Where Cn (sample) is the content of the examined environment. C ref (sample) is the content of the reference element in the examined environment. Bn (background) is the content of the examined elements in the reference environment and B ref (background) is the content of the reference element in the reference environment.

Five contamination categories are recognized on the basis of the enrichment factor[12].

EF<2	Deficiency to minimal enrichment
EF=2-5	Moderate enrichment
EF=5-20	Significant enrichment
EF=20-40	Very high enrichment
EF>40	Extremely high enrichment

Results and Discussion

Sediment Composition: Texture: The amount of different grains of various dimensions were determined using a sieve having different mesh size. The result showed 7 types of grains with dimensions 0.063mm, 0.106mm, 0.15mm, 0.25mm, 0.3mm, 0.355mm and 0.5mm. The relative abundance of grains are given in table-1.

Table- 1
Relative abundance of grains

Grain size (mm)	S1 (%)	S2 (%)	S3 (%)	S4 (%)	S5 (%)	S6 (%)
0.5	13.92	12.88	13.2	7.3	3.34	4.87
0.355	29.47	24.49	25.81	15.74	1.72	19.22
0.3	16.09	13.63	17.31	9.3	2.59	17.98
0.25	18.16	19.32	23.7	24.15	12.23	29.97
0.15	12.94	16.67	12.96	22.75	29.44	21.28
0.106	5.99	8.72	5.72	13.64	32.08	5.46
0.063	3.43	4.29	1.30	7.12	18.6	1.22

Sand, Silt, Clay: The percentage composition of sediments obtained in six stations are shown in table 2. The percentage composition of sand was at the maximum in S6 (91.7%) and minimum in S2 (76.23%). In stations S1, S3 and S5,the composition of sand was almost equal. The percentage of silt showed the maximum in S2 (22%) and minimum in S6 (6.29%). The range was between 6.29% to 22%. The percentage composition of clay in sediment ranged from 1.1% to 2.1%. The maximum percentage was in S4 (2.1%) and minimum was in S1 (1.1%). When the composition of mud (silt clay) was calculated S2 showed the maximum S2 (23.77%) and S6 showed the minimum (8.3%). Based on the percentage of sand and clay S6 can be grouped under sandy clay category.

In estuaries the sand is predominant at the head of the estuary whereas silt and clay are subordinate constituents. The proportion of sand decreases towards the confluence. The admixture of fresh water and saline water reduces the velocity of the transporting agent leading to the deposition of coarser particles such as sand in the head of the estuary with little amount of silt and clay. However in the estuarine mouth, the near shore wave action and tidal action remove the finer particles and allow coarser ones to be deposited[13].

In Manakudy estuary the sediment fraction showed variation and was mostly influenced by monsoon[14]. Nandan et al reported that the bottom sediments were sandy clay in Kadinamkulam estuary during monsoon season. In the cochin mangrove swamps[15], Sunilkumar reported that the substratum was mainly composed of sand with an admixture of silt and clay.

Organic Carbon: The values of organic carbon for different stations are given in table 2. The amount of organic carbon ranged from 1.122% to 8.994%. S2 showed the maximum organic carbon 8.994% followed by S4 (5.622%). The minimum organic carbon content was in S5 (1.122%). The values obtained for organic carbon were comparatively lower than that reported for other Indian estuaries [16-21,]. The higher values of organic carbon in station 4 was due to the coir retting pits located near this station. The relative abundance of organic carbon in stations 3 and 4 might be due to the nearness of mangrove forests. The organic residues from the putrification of mangrove detritus would have settled on the bottom sediments ,[22] Sunilkumar observed an identical condition in the sediments of cochin mangroves and Raghunath et al[23] in shelf sediments off Kasargod. The elevated level may also be due to the influx of land runoff containing a fairly good amount of terrigenous organic matter. The station 5 showed lower organic carbon and it may be due to the nature of sediment[24]. Dora and Roa suggested that a change in the texture of bottom sediments in responsible for the relative decrease in organic carbon in the sediments. One of the feature of organic carbon in the sediments is that its concentration increases as the particle size of the sediment decreases [22,25,].

There was a significant correlation of organic carbon with silt fractions. Similarly clay fractions showed significant correlation with organic carbon. The finer fractions (silt+clay) showed an efficacious relationship with organic carbon, while coarser fractions have no patent kinship. This is clearly evident in Manakudy estuary wherein station 2 showed a percentage of 8.99% organic carbon and the finer fractions (silt+clay) showed 23.77%. Similar results were reported from other estuaries of India[26] have expressed the possibility of greater accumulation of organic matter in the case of clayey silt sediments, which offer larger surface area for the adsorption of organic matter. Raghunath and Murthy[23] also found that organic matter increases with silt percentage and mean grain size and decreases with increase in depth and sand percentage. In Manakudy, the organic carbon observed in different stations is quite in agreement with the widely accepted view of several workers that fine grained sediments generally have higher amounts of organic carbon than coarse grained ones[14,20]. It was observed by a few workers[14,27] that in the areas where organic pollution is high , the total organic carbon often exceeds 5%. In Manakudy estuary the highest value recorded was 8.99% in station 2. This station has a large number of coir retting pits which let in large quantities of organic effluents into the estuary. The average organic carbon in the six stations increases in the order: S5<S6<S3<S1<S4<S2

Calcium Carbonate: The values of calcium carbonate in the six study stations are shown in table 2 and $CaCO_3$ values ranged from 2% to 34.5% .S6 showed the maximum $CaCO_3$ content S6 (34.5%) followed by S5 (28.5%). The minimum values were recorded in S1 (2%). The large quantities of molluscan shell fragments and foraminiferans account for the elevated calcium carbonate content in station 6. Roy et al[28] observed similar

trends in the sediments of Tambraparani delta. The calcium carbonate content in the six stations increases in the order: S1<S3<S4<S2<S5<S6

Sulphur: The values of sulphur in the six stations are shown in table 2. The sulphur content ranged from 0.984% to 0.1395%. The maximum sulphur content was recorded in S4 (1.395%) followed by S2 (1.345%). The minimum was recorded in S6 (0.984%). The average sulphur content in the six stations increases in the order: S6<S1<S3<S5<S2<S4

The higher values of sulphur in S4 was due to the coir retting pits where hydrogen sulphide is released. The hydrogen sulphide formed by most decomposing bacteria is oxidized to sulphate and finally to elemental sulphur. The sulphur removed from the organic phase in the form of elemental sulphur is insoluble and accumulates in sediments[29].

The various parameters of surface sediments in the six stations were subjected to two way ANOVA and it was found that they were significantly correlated[30].

Metal concentration in sediment: Elemental concentration in sediments in six stations of Manakudy estuary was shown in table 4. The values of sodium ranged from 9761 μgg^{-1} to 10900 μgg^{-1}. The maximum in S6 and minimum in S2. The content of potassium ranged from 8100 μgg^{-1} to 9974 μgg^{-1}. The maximum being in S3 and minimum in S1. The content of calcium ranged from 1573 μgg^{-1} to 3882 μgg^{-1}. The maximum being in S1 and minimum in S4. The content of magnesium ranged from 5410 μgg^{-1} to 5126 μgg^{-1}. The maximum being in S4 and minimum in S2. The content of copper ranged from 36.42 μgg^{-1} to 45.86 μgg^{-1}. The maximum being in S2 and minimum in S4.The content of iron ranged from 4380 μgg^{-1} to 4878 μgg^{-1}. The maximum being in S1 and minimum in S6.

Metal enrichment: Enrichment factor: The enrichment factor (EF) for various elements were assessed and the enrichment factor ranged from 0.5 to 1.3 with station 4 showing the lowest value (0.5) and station 1 showing the highest value (1.3). The enrichment factor for samples S1, S2, S3, S4, S5, and S6 are shown in table 3. The results obtained were compared with the five contamination categories as recognized on the basis of the enrichment factor[12].

Table- 2
The sediment parameters in percentage in six stations of Manakudy estuary

Station	Sand	Silt	Clay	SILT + CLAY (FinerFraction)	Sulphur	Organic Carbon	Calcium Carbonate
S1	84.22	14.68	1.1	15.78	10.892	4.498	2
S2	76.23	22	1.77	23.77	13.45	8.994	12
S3	84.26	14.62	1.12	15.74	10.984	3.934	4
S4	81.83	16.07	2.1	18.17	13.957	5.622	4.5
S5	84.89	13.93	1.18	15.11	11.807	1.122	28.5
S6	91.7	6.29	2.01	8.30	9.84	2.248	34.5

Table-3
Two way ANOVA of sediment parameters between the stations of Manakudy estuary

Source of Variation	SS	df	MS	F	P-value	F crit	Remark
Stations	128.8529	5	25.7705	0.5063	0.768	2.71088	NS
Parameters	858.1533	4	214.5383	4.2151	0.0123	2.866	*
Error	1017.9469	20	50.8973	-	-	-	-
Total	2004.9533	29	-	-	-	-	-

*Significant at 5% level

Table-4
Elemental concentration in sediments in six stations of Manakudy estuary

Elements	S1	S2	S3	S4	S5	S6
Na (μgg^{-1})	10472	9791	10768	9561	10900	10900
K (μgg^{-1})	8100	9630	9974	9700	8200	8420
Ca (μgg^{-1})	3882	2442	1670	1573	1620	3200
Mg (μgg^{-1})	5281	5126	5240	5410	5301	5280
Cu (μgg^{-1})	43.63	45.86	37.35	36.42	44.6	45.26
Fe (μgg^{-1})	4878	4787	4561	4400	4563	4380

Table -5
Enrichment factor recorded in six stations in Manakudy estuary

Stations	Enrichment factor
S1	1.3
S2	0.9
S3	1.1
S4	0.5
S5	0.9
S6	1.02

Conclusion

The sediments of Manakudy estuary showed varied texture and sediment types. The substratum was mainly composed of sand with an admixture of silt and clay that slightly varies in different stations. The organic carbon showed an efficacious relationship with silt and in the station 4 near the mangroves there is organic pollution because the organic carbon values are exceed 5%. The calcium carbonate values are moderately elevated due to molluscan and foramineran shells. The sulphur content was high near the coir retting pits. The metal enrichment was minimal and the estuary can be grouped under the uncontaminated category.

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