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RESEARCH ARTICLE

A STUDY ON THE TEXTURAL CHARACTERISTICS OF ARASALAR RIVER ESTUARY SEDIMENTS OF KARAIKAL, EAST COAST OF INDIA

Ramesh. G*, Ramkumar. T and Mukesh. M.V

Department of Earth Sciences, Annamalai University Annamalainagar, Tamilnadu, India

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ABSTRACT

In the present study the research has been focused on the textural characteristic of the river bottom sediments grain size is the fundamental descriptive measure of the sediments and sedimentary rock large part of information about the sedimentary particles mode of transport and deposition can be obtained from the grain size and the sedimentary environment can be identified by the grain size parameters. This paper determines the average content of clay, silt and sand in the bottom sediments of Arasalar River as well as the sediment statistical parameters. A total of twenty bottom sediments samples were collected during four seasons during the year (2008-09) covering the mouth, estuary and the fresh water zones of the Arasalar river. The result shows that the percentage of sand is more compared with silt and clay during all the four seasons. The concentration of silt and clay is more during summer than the monsoon season which shows the influence of rainwater. During summer season the mean size shows fine sand in dominance, the standard deviation values shows poorly sorted and the skewness indicates strongly fine skewed and the kurtosis value indicates mesokurtic in nature whereas during monsoon season the mean value shows medium sand dominance. The standard deviation indicates poorly sorted in nature and the skewness shows nearly symmetrical and the kurtosis indicates mesokurtic in nature. The difference in the grain sizes may be due to the low energy condition and the influence of rainfall.

INTRODUCTION

An estuary is a partially enclosed body of water along the coast where freshwater from rivers and streams meets and mixes with salt water from the ocean Estuaries and the lands surrounding them are places of transition from land to sea and freshwater to salt water. Although influenced by the tides, they are protected from the full force of ocean waves, winds, and storms by such land forms as barrier islands or peninsulas. In recent times more attention is being paid to estuarine geology owing to the significant role played by the estuaries in the coastal and marine sedimentary system. Estuaries are found along most of the world's coastlines and sedimentary records of estuarine environments have been found in many marginal-marine depositional sequences (Clifton, 1982; Reninson, 1992). In recent years estuaries conceptual models have been introduced to explain differences in the morphology, sedimentary processes, and general sediment distribution (Boyd *et al* , 1992; Dalrymple *et al* , 1992) in order to provide a better basis for global and regional comparison of estuarine systems. Changes in the dynamic properties or river water in the estuarine environment result in the accumulation of fine grained sediment with a high organic matter content, which can, through adsorption processes, play an important role in the transport of heavy metals to the sea floor (water-sediment interface) (Krauskopf, 1956, Burton and Liss, 1976, Jara Marini *et al* , 2008). Thus, the organic substance in estuarine and coastal environment can be regarded as a mixture of terrestrial and marine end members (Mayer, 1985, Dyer 1995). On mixing of fresh water with seawater in the estuary, the increase in salinity and sometimes pH would lead to flocculation of iron oxides, humic substances and other colloidal particles such as clays, which are then deposited together with their adsorbed or co-precipitated as metals (Bryan, 1984). Analysis of grain size distribution provides information about distribution of different size fraction of the sediments which provides the details on hydrodynamic condition prevailing in the region. Further, it is well established that the concentration of finer sediments and its significance to the accumulation of heavy metals. Thus, the present study was aimed to gain a valuable baseline data about the highly productive estuarine and coastal environments from the sedimentological point of view.

Description of The Study Area

The Arasalar estuary is situated at karaikal (Lat 79° 52' E Long 10° 55'N) of Bay of Bengal. The arasalar is a tributary of the river Cauvery, having a total run of 24 km. It enters Karaikal region, a little east of Akalanganni. It forms the natural boundary line separating Niravi Commune from Tirunallar on the north-west and Karaikal on the north east. The Nattar,

Corresponding author:* **Ramesh. G
Department of Earth Sciences, Annamalai University Annamalainagar, India

branching off from Arasalar at Sakkotai in Thanjavur District, runs a distance of 11.2km in a south-easterly direction across Nedungadu and Kottucheri Communes before emptying itself into the sea. The Vanjiar fed by the Arasalar, takes its course along the northern boundary of Tirunallar Commune, drops on a south-easterly curve towards Karaikal Commune and merges with the Arasalar, south-east of Karaikal town after covering a distance of about 9 km. The Nular, also fed by the Arasalar, runs a distance of 13.77 km before it joins Vanjiar northeast of Karaikal town. The study area comprises of estuarine and coastal environment. The estuarine environment from the mouth of the river in downstream to fresh water in upstream direction which extends about 9 km. The coastal environment comprises of beach and near shore from the mouth of river. Totally 20 samples were collected Station 1 is situated nearby mouth of the estuary (marine zone), station 2, 3 and 4 are located estuarine region Station 5 is situated in the fresh water zone.

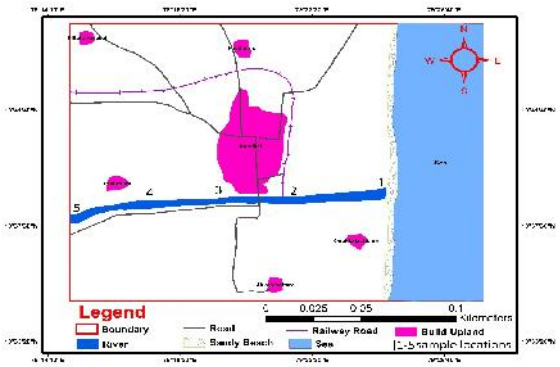

Figure 1 Study area map showing sampling stations

MATERIALS AND METHODS

A total of twenty sediments were collected representing all four seasons during the year 2008-09 covering the estuary, mouth and freshwater zones of arasalar river. The sediment samples were collected by using van veen grab sampler on board hired fishing trawler. Sub-sampling of the sediments was done by taking upper 5cm of the sample from the grab with the help of plastic spatula. Sediment samples were then frozen at 4^0C prior to analysis. Station locations were obtained by the global positioning system (GPS). Sediment samples were then oven dried at 60^0C for further analysis. Sieving technique is applied to separate the grains of various size class fragments

Granulometric Analysis

Textural analysis of the sediments were carried out by the combined method of sieving and pipette analysis after taking known quantity of sample by coning and quartering method. Dry sieving was made at ¼ phi interval for the size range 2500 to 63 µ using Retch digital sieve shaker (AS 200) for 20 minutes. Further, in order to determine the grain size sediments of less than 63µ pipette analysis (Krumbein and Pettijohn, 1938) were done. The results obtained for the samples after sieving and pipette analysis were combined into a single size frequency distribution and cumulative graph were plotted on arithmetic probility sheet Statistical parameters such as Mean size (Mz), Standard deviation (σi), Skewness (Ski) and Kurtosis (KG) were calculated using formula of Folk and Ward (1957) and granulometric classification of sediments were made by method outlined by Shepherd, (1954) and were calculated by using GSSTAT, SEDPLOT programs developed by USGS (United States Geological Survey) (Poppe *et al* , 2004 and Poppe and Eliason, 2008)

Table 1 Textural parameters of the study area

Estuary (2008-2009)				
Station/ Seasons	**Monsoon**	**Post-monsoon**	**Summer**	**Pre-monsoon**
		Mean Size (Phi)		
1	1 55	1 88	2 00	1 84
2	2 07	2 50	2 22	1 07
3	2 11	3 34	4 75	3 28
4	2 32	3 98	4 98	3 57
5	1 21	1 57	1 71	1 99
		Standard deviation(phi)		
1	0 80	0 77	0 88	0 68
2	0 90	1 00	0 90	0 83
3	1 45	0 80	1 32	1 19
4	1 22	1 16	2 05	1 22
5	1 31	0 68	1 86	0 99
		Skewness(phi)		
1	-0 07	-0 20	0 13	-0 02
2	0 10	0 12	0 10	-0 10
3	0 24	0 35	0 44	0 31
4	-0 10	0 37	0 36	0 36
5	0 28	0 10	0 30	0 35
		Kurtosis(phi)		
1	1 40	1 41	1 38	1 39
2	1 11	1 10	0 98	0 95
3	1 90	1 85	1 11	1 09
4	1 02	1 07	0 98	0 92
5	1 10	1 11	0 99	0 90

The phi mean size which represents the average size of the sediments in the grain size spectrum. The phi mean size of the estuary sediments in study area ranged from 1.07φ to 4.98φ. The season and station wise value of phi mean size are shown in Table 1. During the study period (2008-2009) at station - 1, it ranged from 1.55 to 2.00 φ, at stations-2, 3, 4 it ranged from 1.07φ to 2.50 φ, 2.11φ to 4.75φ, 2.32 to 4.98φ respectively. At station - 5, it ranged from 1.21 φ to 1. 99 φ. The occurrence of lower phi mean size noted during the monsoon (2008-2009) at station-2 and during post-monsoon (2009-2010) at station 5 indicates the removal of fines leading the relatively coarser materials in that location. It is noticed that the phi mean size decreases the sediment becomes coarser and if the phi mean size increases the sediment becomes finer. All these indicate that there exists a decrease in grain size in the direction of transport in a river channel. This is mainly due to the differential transport mechanism exists along the river flow as stated by Folk and Ward (1957), Scheidegerg (1961), Allen (1965), Theil (1940), Chauhan (1990), Anthony and Hequette (2007).

The inclusive standard deviation values reflect the energy of depositional environment. The standard deviation of sediments in study area ranged from 0.68 to 2.05φ. During the study period (2008-2009) at station - 1, it ranged from 0.68 to 0.88φ, at stations - 2, 3, 4 and 5, it ranged from 0.83 to 1.00φ, 0.80 to 1.45φ, 2.32 to 4.89φ and 1.21 to 1.99φ respectively. The inclusive standard deviation value was lower at mouth (station-1) and Freshwater zone (station-5) when compared with the estuary. This indicates the Influence of the mean grain size on the sorting nature of the sediments. The standard deviation value indicates the sediments are generally poorly to moderately sorted during the study period. During summer

and post-monsoon seasons the standard deviation value indicates that the sediments are poorly to very poorly sorted in all the stations whereas during pre-monsoon and monsoon seasons the sorting value improves and became sediments moderately well sorted to moderately sorted nature. A relatively better sorting values observed during monsoon and pre-monsoon seasons indicates the removal of finer material leading to a better sorting of sediments. A higher standard deviation value was always noted during monsoon and summer seasons of the study period.

during monsoon and post-monsoon at station 3 and 4. It indicates the sediments are nearly symmetrical nature. It may be due to the mixing of two populations form the different sources. This is similar to the observation of Lee and Grieve (1985) in Keum estuary. In general the skewness approaches to positive in downstream direction of the river, as flow velocity and bed slope trend to decrease and facilitates the deposition of fines. These phenomena have also reported by Folk and Ward (1957) which has been further explained by Friedman (1961) and Martin (1965).

Table 2 Percentage of sand, silt and clay of the study area

Estuary (2008-2009)												
Stations/	**Monsoon**			**Post-monsoon**			**Summer**			**Pre-monsoon**		
Seasons	**Sand %**	**Silt %**	**Clay %**	**Sand %**	**Silt %**	**Clay %**	**Sand %**	**Silt %**	**Clay %**	**Sand %**	**Silt %**	**Clay %**
1	96 35	2 25	1 4	93 78	3 21	3 01	90 45	6 32	3 23	94 04	3 52	2 43
2	77 03	17 29	5 68	70 02	20 77	9 02	78 28	13 52	8 12	70 92	25 83	4 25
3	71 62	20 65	7 73	73 56	15 23	11 21	73 68	15 78	10 54	76 43	18 35	5 22
4	72 32	22 32	5 36	79 76	13 92	6 32	70 32	23 3	6 38	71 03	20 74	8 23
5	83 32	13 25	3 43	90 34	5 62	4 04	92 26	4 06	3 68	88 71	7 21	4 08

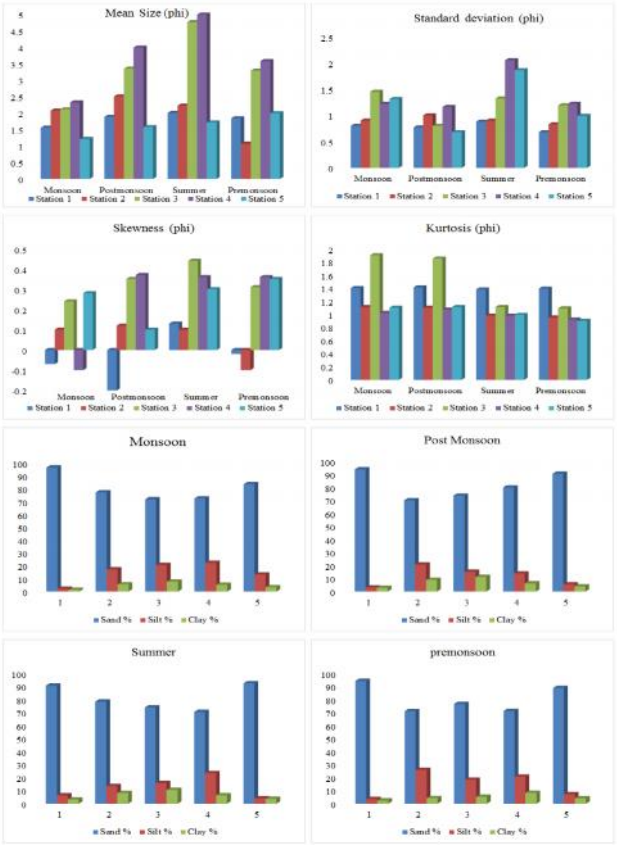

Figure 2 Bar diagramme of structural parameters

Skewness is an important parameter in grain size studies since it is a sensitive indicator of sub population mixing. The value of skewness are shown in Table 1.The skewness value of sediments in study area ranged from -0. 20 to 0.44φ.During the study period (2008-2009), it ranged from -0 20 to 0 13 φ, -0 10 to 1 12 φ, 0 24 to 0 44 φ, -0 10 to 0 37 φ and 0 10 to 0 35 φ at stations - 1, 2, 3, 4 and 5 respectively. A higher skewness value was observed during summer and pre-monsoon at station – 3. The skewness value reveals that most of sediments during study period are symmetrical to very fine skewed. This indicates the presence of considerable amount of finer particles and also estuary conditions are more conducive for the settlement of fines. A lower skewness value was observed

Kurtosis measures the ratio of the sorting in the extremes of the distribution compared with the sorting in the central part. The kurtosis value of the sediments in study area ranged from 0.90 to 1.90φ. The kurtosis values for all the stations were shown in Table .During the study period (2008-2009) at station-1, it ranged from 1.38 to 1.41 φ, at stations - 2, 3 4 it ranged from 0. 95 to 1.11φ, 1. 09 to 1. 90φ, 0.92 to 1.07φ respectively. At station - 5, it ranged from 0.90 to 1.11φ.

Higher kurtosis value was noted during monsoon and post-monsoon at various stations throughout the study. The kurtosis value indicates the sediments are meso to leptokurtic nature. This indicates the concentration of one dominant and other subordinate population. The dominant of fine mode give rise to the leptokurtic nature. Folk and Ward (1957) and Cadigan (1961) while classifying kurtosis, stated that if the central part of the grain size distribution is relatively better sorted that of the average in tail, at distribution is called leptokutic and the unimodal sediments exhibit mesokurtic nature.

During the study period, most of the sediment sample falls in the sand nature and other samples fall in silty sand nature. The silty sand nature are characteristic to the estuary region (stations - 2, 3 and 4). This related to the existence of a relatively low hydraulic energy condition in the estuarine region. The existence of higher sand content at mouth (station - 1) and freshwater zone (station -5) indicates the influence of ebb and flood currents and fresh water input. During premonsoon season, the most of the sediments sample fall in silt sand nature (stations - 2, 3 and 4) when compared to the other seasons. An observation of this kind was made by Pejrup (1988), Mohan and Damodaran (1992) in Vellar estuary

CONCLUSION

The study describes the sedimentary properties of surface sediments in arasalar river estuary, their major inputs and their main transport and depositional processes and main hydrodynamic of the Cauvery river. The study result indicates the grain size analysis of the twenty samples (2008-09). The mean value indicates the dominance of medium sand size particles. The higher phi mean size noted during summer at station - 4, indicated less influence of freshwater flow and relatively calm nature of the coast which favour the settlement of fines and makes the phi mean size to higher side. The

occurrence of lower phi mean size noted during the monsoon at station-2 indicates the removal of fines leading the relatively coarser materials in that location. The standard deviation value indicates that the sediments are poorly to very poorly sorted in all the stations, whereas during premonsoon and monsoon seasons the sorting value improves and became sediments moderately well sorted to moderately sorted nature. A relatively better sorting values observed during monsoon and premonsoon seasons indicates the removal of finer material leading to a better sorting of sediments. The skewness value reveals that most of sediments during study period are symmetrical to very fine skewed. The kurtosis value indicates the sediments are meso to leptokurtic nature. This indicates the concentration of one dominant and other subordinate population. The geology and climatic condition plays a vital role to control the sediment dynamics nature of the arasalar estuary.

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