Assessment of Granulometry and Environment of Deposition of Coastal Sediments from Kollam beach to Marattadi, Kerala, India

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Abstract: ***The textural characteristics of beach sediments mainly depend on the shore processes. The present study focuses on the sediment characterization and environment of deposition of beach sediments from Kollam to Marattadi, along the west coast of Kerala, India. Sediment samples were collected at finer intervals from the littoral zone and the textural characteristics were analyzed in the laboratory. Most of the samples from Kollam to Thirumullavaram deposit by beach process and those from Thirumullavaram to Marattadi deposit by riverine processes.***

Keywords: Mean, Skewness, Kurtosis, Standard deviation, Sediments, Environment of deposition**.**

1. Introduction

Beaches are sedimentary bodies situated at the land–sea interface and are made up of non-cohesive particles of mainly sand size, even though coarser sediments (such as shingles) are dominant in some specific settings [1]. Beaches show a high spatial and temporal variability in terms of morphology, sedimentary balance, source of sediments and erosional/depositional characters. Each beach comprises of several specific emerged and submerged sub-domains with distinct particle behavior and related morphology. Littoral sedimentation is mainly controlled by marine hydrodynamics [2]. Waves and currents are the transport agents which play the most significant role in controlling sediment migration and deposition, which in turn depend on, wind conditions. Heavier and coarser sediment particles are transported as bed load by rolling and dragging while the lighter and finer particles are transported in suspension. Intermediate grains which are too heavy to remain permanently suspended, are taken in suspension by the approaching wave and then resettled. Each particle is reworked by successive waves, which results in good sorting and roundness of sand grains on beaches.

2. Study Area and Methodology

The study area is located along the coastal tract of nearly 10 km, from Kollam to Marattadi, Kollam district, Kerala, India. Kollam coast is characterized by its exotic back water at Thangasseri, where Kollam port is located. The wave activity in this area is highly varying and is highest during monsoon season. Kallada river, originating from Western Ghats, contributes a major part of sediments to the sea through Ashtamudi lake and Marattadi estuary, which is located north of the study area. The area is reported to have moderate wave energy level [3, 4]. The beaches are manually erected by seawalls considering its high erosive nature. Laterite is exposed along the coast of the study area. The major rock types in the hinter land area are khondalite suits including garnet-sillimanite gneisses, garnetiferous leptinite, garnet biotite gneiss, charnockite and Tertiary sediments along the coastal strips [5].

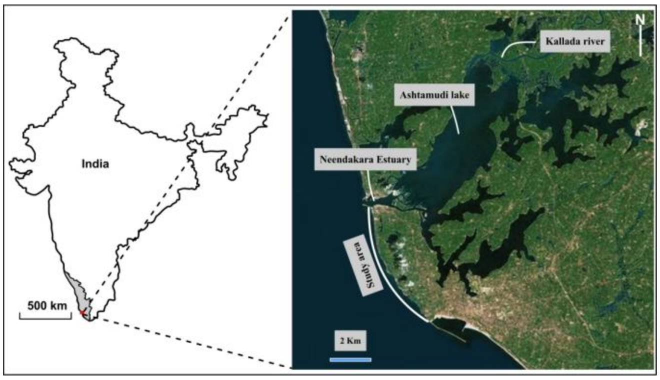

Figure 1: Google Earth imagery of the study area

Beach sand samples were collected from Kollam to Thirumullavaram along a single traverse line, running parallel to the shore. The samples were collected from the intertidal zone during the low tide period at a regular interval of about 250 m distance. About one Kilogram of sediment samples was collected from each sampling point. The top sediment layer of an approximate thickness of 10 cm was removed before collecting sediment samples below the removed layer [6]. The samples were carefully packed in polythene bags and labeled. The samples were brought to the laboratory for textural analysis. 100 gram of representative samples were fractioned by coning and quartering method and were cleaned with distilled water. The organic matter such as calcareous shells in the sediment samples were removed by treating the samples with 1:1 hydrochloric acid. The stirred samples were decanted repeatedly using distilled water until the stirring water became clear. The samples were dried in an electric oven for 12 hours and were dry weighed. The amount of calcium carbonate present in the sample was calculated manually. These pretreated samples were sieved using meshes of phi size 20, 30, 45, 80, 120, 170, 200 and

230 by using mechanical sieve shaker (Haver EML digital plus). The sieve sets, stacked in descending order of their sizes, were shaken continuously for about 30 minutes. During sieving, proper attention was given to minimize the sand loss from the sieve sets. The sieve materials were collected separately for weighing. The weight of individual fractions was tabulated for further granulometric studies. The textural analysis of sediment samples were followed by the procedures outlined by Carver [7]. The weights of sediments of each fraction were measured and the cumulative frequency curves were plotted from the representative weight percentages. Various textural parameters such as mean, standard deviation, skewness and kurtosis were calculated from the respective weight percentages using the software, Gradistat. The depositional environments of sediments were reconstructed using the Sahu's [8] linear discriminate factors calculated from the textural attributes.

2.1 Linear discriminate functions (LDF)

Sahu [8] introduced the linear discriminate functions for environmental interpretation and the method is a combination of all the grain size parameters into a single linear equation, in which Y_1 (Aeolian: beach), Y_2 (fluvial: turbidity), Y_3 (shallow marine: fluvial) and Y_4 (beach: shallow marine) values were analyzed. We are using the following discriminate functions in this work. Y_1, Y_2, Y_3 and Y_4 were used for the discrimination between Aeolian processes and inter tidal zone environments, fluvial and turbidity environments, beach and shallow agitated marine environments and shallow marine and fluvial environments respectively.

$$Y_1 = -3.5688Mz + 3.7016\sigma I^2 - 2.0766Sk + 3.1135Kg$$
$$Y_2 = 0.7215Mz - 0.4030\sigma I^2 + 6.7322Sk + 5.2927Kg$$
$$Y_3 = 0.2852Mz - 8.7604\sigma I^2 - 4.8932Sk + 0.0482Kg$$
$$Y_4 = 15.6534Mz + 65.7091\sigma I^2 + 18.1071Sk + 18.5043Kg$$

Where Y is the discriminate function, Mz is mean grain size, σI is graphic standard deviation (sorting), Sk is skewness and Kg is graphic kurtosis.

3. Results and Discussion

Grain size distribution is a very important basic property of clastic sediments. It has a fundamental relationship with the physical forces involving the mechanism of transport and deposition of sediments. The results of granulometric analysis of sample from Kollam beach to Thirumullavaram and those from Thirumullavaram to Marattadi were compared to understand the dominant beach process. On the basis of probability curves, about 50 % of samples indicate moderately high energy condition where as 50 % exhibit low energy condition. The grain size parameter such as mean standard deviation, skewness and kurtosis are given in the following sections.

3.1 Mean

The mean size of first six samples from Kollam to Thirumullavaram ranges from 1.083 to 2.066 with an average mean size is 1.768. The samples fall within the course sand category and this is due to the washing of thin sheets back and forth by the breaking waves which invariably lacks fine grained sediments [9]. The mean size of samples from Thirumullavaram to Marattadi ranges from 0.583 to 1.283 with an average of grains 0.9358. The course grained nature of samples from Kollam beach to Thirumullavaram indicate that they are deposited due to the back and forth action of sea water where as the fine grained nature of samples from Thiruvallavaram to Marattadi suggests the dominance of revering process.

3.2 Standard deviation

The standard deviation values of the samples range from 0.384 to 1.077 with an average of 0.6744. About 8% of samples are well sorted, 8% moderately sorted, 67% moderately well sorted, and 17% purely sorted in nature. In the first six samples, the standard deviation ranges from 0.522 to 1.077 with an average of 0.799. This moderately sorted nature is an indication of prevalence of low energy condition. In samples from Thirumullavaram to Marattadi, standard deviation ranges from 0.384 to 0.6329 with an average of 0.549 indicating the stronger energy conditions of the depositional agents and the sudden winnowing or back and forth motion of depositional agents.

3.3 Skewness

The samples show skewness values ranging from -0.349 to 0.470 with an average of 0.1078. The negative and positive values of skewness suggest the fluctuation of the energy conditions in the depositional environment and unidirectional transport or channel flow or deposition of sediments in sheltered low energy environment respectively [10]. In samples from Kollam beach to Thirumullavaram, skewness range from -0.349 to 0.470 with an average of -0.0219 indicating the fluctuations of energy conditions of depositional environment. In samples from Thirumullavaram to Marattadi, the skewness values range from 0.066 to 0.451, with an average of 0.237.

3.4 Kurtosis

The kurtosis values of samples range from 0.7265 to 1.229, with an average of 1.0297. The nature of distribution of about 33% of samples is platy kurtic, 25% mesokurtic and 42% leptokurtic. Samples from Kollam to Thirumullavarm are mesokurtic with kurtosis values ranging from 0.7265 to 1.229, with an average of 1.003 suggesting good sorting. This indicates moderate winnowing action of the depositing agent. The sediments are keeping their original characters existed during deposition without any mixing of populations. In samples from Thirumullavaram to Marattadi, kurtosis values range from 0.8879 to 1.331with an average of 1.056. The dominance of mesokurtic nature of sediments reveal unidirectional flow of current and settling of sediments in high energy environment [11].

Table 1: Statistics of granulometric analysis of sediments samples

S. No.	Mz	Sd	Sk	Kg	Remarks
1	1.9	0.9	0.2	1.1	Medium sand, Moderately sorted, Course fine skewed, Lepto kurtic
2	1.2	0.7	0.5	0.7	Medium sand, Moderately sorted, Very fine skewed, Platy kurtic
3	1.7	1	0.2	0.8	Medium sand, Poorly sorted, fine skewed, Platy kurtic
4	2	0.6	0.3	0.9	Fine sand, Moderately well sorted, Course skewed, Meso kurtic
5	1.1	0.7	0	1.2	Medium Sand, Moderately well sorted, Symmetrical, Lepto kurtic
6	2.1	1	0.3	1.2	Fine Sand, Poorly sorted, Very Course skewed, Lepto kurtic
7	0.6	0.6	0.5	1.3	Course sand, Moderately well sorted, Very fine skewed, Lepto kurtic
8	0.7	0.4	0.3	1.0	Course sand, Well sorted, fine skewed, Meso kurtic
9	0.9	0.5	0.1	0.9	Course sand, Moderately well sorted, Near symmetrical, Platy kurtic
10	1	0.6	0.4	0.9	Medium Sand, Moderately well sorted, Very fine skewed, Platy kurtic
11	1.3	0.6	0.1	1.1	Medium Sand, Moderately well sorted, fine skewed, Lepto kurtic
12	1.2	0.6	0.1	1	Medium Sand, Moderately well sorted, fine skewed, Meso kurtic

3.5 Environment of Deposition

According to Sahu [9], variation in the energy and fluidity factors seams to have excellent correlation with different processes and the environment of deposition. In littoral zone, there is constant pounding of waves making the beach sediments better sorted and more uniformly distributed than the shallow marine deposits, where the wave action is less prominent and more variable [9]. With reference to Y_1 values, all the samples fall under beach process except sample number 2 and 4. Y_2 values of the samples indicate that 50% of samples fall in shallow agitated water and the rest in beach process category. With reference to Y_3 values, all the samples exhibit shallow marine conditions of deposition. Y_4 values of samples fall under turbidity deposition except 7th sample.

Table 2: Statistics of linear discriminate functions of sediments samples sediments samples

S. No.	Y_1	Y_2	Y_3	Y_4	Remarks
1	-.2	91.2	-4.4	5.6	Aeolian, Shallow agitated water, Shallow marine, turbidity
2	-4.1	78.1	-5.2	8.2	Beach, Shallow agitated water, Shallow marine, turbidity
3	0.2	114.5	-9.8	6.6	Aeolian, Shallow agitated water, Shallow marine, turbidity
4	-2.7	61.9	-0.5	4.5	beach, beach, Shallow marine, turbidity
5	1.8	72.2	-4.1	7.3	beach, Shallow agitated water, Shallow marine, turbidity
6	1.3	123.1	-7.9	4.8	beach, Shallow agitated water, Shallow marine, turbidity
7	2.3	63.1	-4.8	10.4	beach, beach Shallow marine, turbidity
8	0.9	44.8	-2.5	8	beach, beach Shallow marine, turbidity
9	0.9	49.5	-2.5	5.7	beach, beach Shallow marine, turbidity
10	-0.2	65.4	-5	7.8	beach, beach Shallow marine, turbidity
11	0.1	66.9	-3.3	7.4	beach, Shallow agitated, Shallow marine, turbidity
12	-0.1	62.2	-3.2	7.2	beach, beach Shallow marine, turbidity

4. Conclusion

The shore processes are generally affected by significantly sediments brought by the rivers into the sea. Thus the land-ocean interaction in the coastal zone is important in determining the sedimentation and erosion pattern of the coastline. Ashtamudikayal brings considerable sediment load to Arabian Sea. The results of granulometric analysis of sediments indicate well sorted nature of sediments and moderate energy condition in the depositional environment. The graphic mean values suggest that the size of sediments is mainly of fine to coarse sand. Fine grained nature of sand indicates moderately low energy condition in the area of deposition. The standard deviation values of sediments in the study area indicate moderately well sorted to well sorted nature of sediments. The winnowing type of movements in which particles take to and fro motion by depositing agent is also inferred from the results of the study. The predominant positive skewness of sediments indicates a unidirectional transport or deposition in sheltered, low energy condition. Platy kurtic to leptokurtic refers to continuous addition of coarser or finer material. Fine clastics are more common towards the river mouth and coarse grains increases towards the beach. From the discriminate functions, it can be concluded that the sediments were deposited predominantly by beach process under shallow agitating environment carried by turbidity action.

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