J. Ind. Geophys. Union (May 2016)
v.20, no.3, pp: 351-361

Grain Size Distribution of Coastal Sands between Gosthani and Champavathi Rivers Confluence, East Coast of India, Andhra Pradesh

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ABSTRACT

The studies on grain size characteristics are valuable to understand the source for the evolution of coastal sand environments. Seventy one sediment samples from twenty traverses of costal sediments in between Gosthani River mouth in south and Champavathi River in the north (Lat.17°52'-18°.02' N; Long.83°26'-83°36' E) have been collected and studied. The coastal sediments are medium to fine grained (1.68 Ø – 2.80Ø), very well sorted to moderately well sorted (0.26Ø – 0.67Ø), strongly coarse to fine skewed (-0.63 Ø to 0.31Ø) and pltykurtic to leptokurtic (0.74Ø – 1.27Ø) in nature and deposited in moderate to high energy environment conditions with dominant rolling, bottom and graded suspension mechanisms. The observations are supported by the frequency distribution curves, CM plots and scatter plots between parameters, conforming to the bimodal nature to dominant fine sand in different microenvironments (dune, backshore, berm, and foreshore). These textural parameters have been further examined to understand the hydrodynamic conditions of the depositional environments.

Key words: Textural parameters, coastal sands, coastal sediments, Dune, Backshore, Berm, Foreshore, Gosthani and Champavathi rivers

INTRODUCTION

The 20 km stretch of study area (83°26'- 83°36'E longitudes and 17°52'-18°.02' N latitudes) extends from the Gosthani River in the south to the Champavathi River in the north. The area has different geological and geomorphic features generated by the rivers, small creeks, altered coastal trends, and dynamic seasonal winds. The ephemeral Gosthani and Champavathi rivers originate in Ananthagiri hill (1275m) ranges of Eastern Ghats constitute the drainage system. These rivers carry huge amount of sediments and debouch in to the Bay of Bengal at Bhimunipatnam and Konada in the study area. The present study deals with the grain size distribution of coastal sands between Gosthani and Champavathi rivers confluence in order to understand sediment depositional environments and the depositional patterns of the sediments in the study area.

The grain size characteristics of the sediments in the coastal areas are influenced of by various transporting and depositional agents such as rivers, rivulets, streams, waves and currents, sea level oscillations, shoreline configuration, winds, etc. and the distance from the shoreline, distance from the source material, nature of the source material and topography of the area. Earlier, many attempts have been made by several sedimentologists (Udden, 1914; Mason and Folk, 1958; Friedman, 1961, 1967; Sahu, 1964; Veerayya and Varadachari, 1975; Ramamohan Rao et al., 1982; Jagannadha Rao and Krishna Rao, 1984; Dhanunjaya Rao et al., 1989; Frihy et al., 2005; Hanamgoda and Chavidi, 1997; Mohan and Rajamanickam, 1998; Prabhakara Rao et al., 2000; Nageswara Rao et al., 2005; Rajesh et al., 2007; Ergine et al., 2007; Ramanathan et al., 2009; Rajasekhara Reddy et al., 2011; Ganesh et al., 2013; Karuna Karudu et al., 2013) to differentiate the sediments of various environments, such as fluvial, fluviatile, estuarine and other coastal environments. The present study is based on such interpretations to improvise the understanding of the depositional environments and depositional process of the sediments in the study area.

MATERIALS AND METHODS

Sampling and Grain size Analysis

A total of seventy one surficial sediment samples were collected in microenvironments viz. foreshore, berm, backshore and dune along twenty traverses, with an interval of 1 km (A, B, C….. T. from south to north). These traverses are laid perpendicular to the coast. The sample stations are shown in Figure 1. The grain size parameters data are given in the Tables 1 and 2. About one kg of sample is collected from each site/station, using a PVC pipe of 3 inches diameter and 40cm in length. The pipe is carefully inserted into the sediment layers to a depth of 40cm, taking all possible care against contamination. The sediment samples are repeatedly washed with distilled water for removal of salts and then dried. After drying, a sub sample weighing about 100grams is obtained by coning and quartering, to remove carbonate and organic matter. Samples were then treated with 10% dilute HCl and 6% H_2O_2 respectively and then

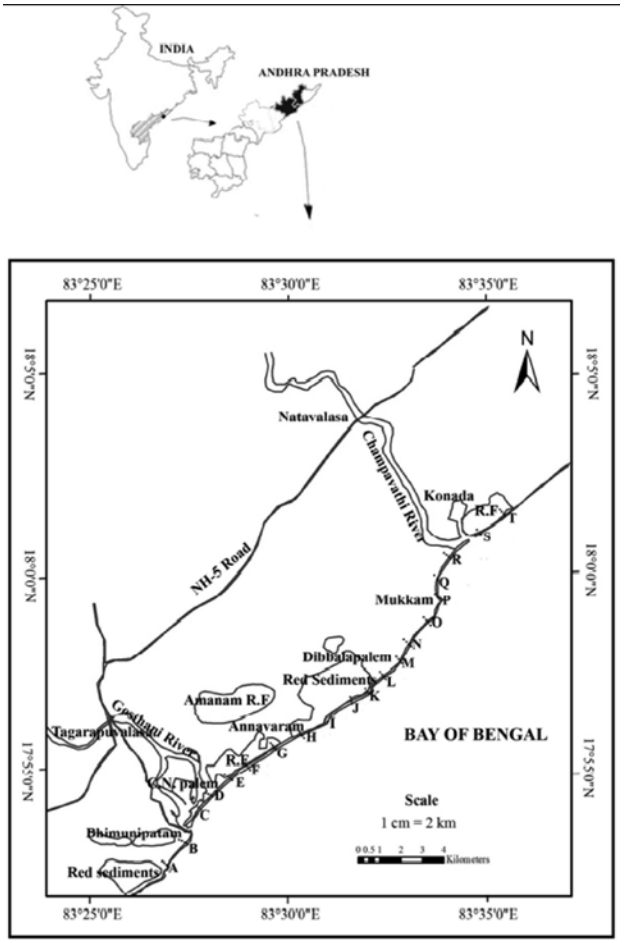


Figure 1. Sample Location Map of the Study Area.

dried. These samples were subjected to sieving with ASTM test sieves of 8″diameter, with successive sieves stoked at ½ Ø intervals for 10-20min. The grain size data obtained was used to determine the Mean size (Mz), Standard deviation (σ_I), Skewness (SK_I) and Kurtosis (K_G) based on method given by Folk and Ward (1957) and G-Stat software (Dinesh, 2009). Frequency curves, scatter plots and CM diagrams were drawn and data was analyzed.

RESULTS AND DISCUSSION

The detailed representation of the grain size parameters in terms of grain size analysis, frequency distribution curves, scatter plots and CM diagrams have been presented and data analyzed.

Grain size analysis

Mean size (Mz)

The graphic mean size is the average size of the sediment represented by Ø mean size and it is an index of energy conditions. The average values show the dominance of fine sediments in all micro environments; the sediments of dune (1.78Ø -2.76Ø), backshore (1.69Ø -2.69Ø), berm (1.69Ø -2.61Ø) and foreshore (1.69Ø -2.69Ø) environments are in medium to fine size. It indicates the high energetic conditions of transportation in the coastal sediments (Folk and Ward (1957). The variations in Ø mean size is a reflection of the differential energy conditions of the depositing media and indicates average kinetic energy of depositing agent (Sahu, 1964).

Standard Deviation (σ_I):

The graphic standard deviation (σ_I) measures sorting of sediments and indicates the fluctuations in the energy conditions of depositional environment. It, however, does not necessarily measure the degree to which the sediments have been mixed (Spencer, 1963). Standard deviation of the present samples range in between 0.26Ø-0.62Ø, with an average of 0.53Ø.It is within the range of well sorted. The sediments of dune, back shore, berm environments are moderately well sorted. Fore shore sediments are well

Table1. Grain size parameters of the coastal sediments between Gosthani River and Champavathi River confluence

Travers No's	Samples No.	Mean(Ø)	Standard Deviation(Ø)	Skewness (Ø)	Kurtosis (Ø)
A	A1	2.78	0.26	-0.04	1.17
	A2	2.44	0.50	-0.28	0.83
	A3	2.34	0.58	-0.26	0.81
	A4	2.54	0.44	-0.12	1.01
B	B1	2.29	0.48	-0.34	0.88
	B2	2.18	0.59	-0.28	0.79
	B3	1.91	0.58	0.16	0.75
	B4	1.98	0.58	0.20	0.74
C	C1	2.41	0.59	-0.12	0.91
	C2	2.33	0.52	-0.13	1.02
	C3	1.94	0.54	0.22	0.89
D	D1	1.73	0.58	0.31	0.88
	D2	1.89	0.64	0.18	0.74
	D3	2.29	0.53	-0.26	1.01
	D4	2.39	0.48	-0.37	0.89
E	E1	2.05	0.62	0.01	0.75
	E2	2.50	0.61	-0.33	0.92
	E3	2.28	0.62	-0.27	0.86
	E4	2.19	0.58	-0.15	0.88
F	F1	2.5	0.49	-0.21	1.1
	F2	2.19	0.58	-0.15	0.88
	F3	2.56	0.45	-0.12	1.07
	F4	2.11	0.56	0.28	0.78
G	G1	2.5	0.49	-0.21	1.1
	G2	2.19	0.58	-0.15	0.88
	G3	2.56	0.45	-0.12	1.07
	G4	2.11	0.56	0.28	0.78
H	H1	2.8	0.49	-0.63	0.92
	H2	2.40	0.59	-0.18	0.89
	H3	2.17	0.62	0.05	0.78
	H4	2.18	0.67	-0.15	0.76
I	I1	2.38	0.48	-0.29	0.86
	I4	2.76	0.48	-0.47	0.83
J	J1	2.14	0.56	-0.05	0.86
	J2	2.33	0.52	-0.13	1.02
	J4	2.62	0.45	-0.09	0.94
K	K1	2.38	0.59	-0.25	0.84
	K3	2.18	0.68	-0.02	0.80
	K4	2.46	0.45	-0.13	0.96
L	L1	2.6	0.46	-0.13	0.98
	L2	2.61	0.41	-0.09	0.99
	L3	1.91	0.58	0.16	0.75
	L4	2.38	0.57	-0.16	0.84
M	M1	2.15	0.55	0.24	0.85
	M2	2.61	0.39	0.01	0.96
	M3	2.15	0.46	-0.06	1.05
	M4	2.61	0.41	-0.09	0.99
N	N1	2.14	0.58	-0.09	0.9
	N2	2.04	0.66	0.20	0.79
	N3	2.29	0.53	-0.26	1.01
	N4	2.09	0.52	0.25	0.89
O	O1	2.11	0.46	-0.03	1.01
	O2	1.72	0.59	0.24	1.22
	O3	1.69	0.65	0.13	0.99
	O4	1.78	0.59	0.30	1.15
P	P1	1.88	0.47	0.11	0.8
	P2	1.72	0.48	0.22	1.15
	P3	2.12	0.42	-0.03	1.04
	P4	2.33	0.52	-0.13	1.02
Q	Q1	2.48	0.46	-0.15	1.1
	Q4	2.42	0.49	-0.11	0.89
R	R1	1.84	0.49	0.18	0.85
	R2	1.69	0.53	0.21	1.25
	R3	1.82	0.52	0.22	0.86
	R4	2.50	0.63	-0.20	0.88
S	S1	1.68	0.51	0.24	1.23
	S4	2.69	0.49	-0.11	1.23
T	T1	2.58	0.38	-0.24	1.27
	T2	2.39	0.48	-0.37	0.89
	T3	2.38	0.59	-0.25	0.84
	T4	2.19	0.58	-0.15	0.88
	1=Foreshore 2=Berm 3=Back Shore 4=Dune				

Table2. Range and average values of grain size parameters of the coastal sediments between Gosthani River and Champavathi river confluence.

Micro Environments	Range	Mean Size (Mz)	Standard Deviation (σ1)	Skewness (Sk)	Kurtosis (kG)
Fore Shore	Min.	1.69	0.26	-0.27	0.75
	Max.	2.69	0.62	0.22	1.23
	Avg.	2.28	0.49	-0.09	0.97
Berm	Min.	1.69	0.39	-0.37	0.74
	Max.	2.61	0.66	0.24	1.25
	Avg.	2.21	0.54	-0.06	0.96
Back Shore	Min.	1.69	0.42	-0.27	0.75
	Max.	2.69	0.68	0.22	1.23
	Avg.	2.12	0.55	-0.04	0.92
Dune.	Min.	1.78	0.41	-0.47	0.74
	Max.	2.76	0.67	0.30	1.23
	Avg.	2.33	0.53	-0.08	0.92
Total	**Min.**	**1.68**	**0.26**	**-0.63**	**0.74**
	Max.	**2.80**	**0.67**	**0.31**	**1.27**
	Avg.	**2.25**	**0.53**	**-0.07**	**0.94**

sorted in nature. The Moderately well sorted nature can be attributed to partial winnowing action and addition of sediments in beach environment by aeolian process (Ramamohan Rao et al., 1982; Narayana Rao et al., 1991; Angusamy et al., 2006; Rajesh et al., 2007).

Skewness (SK_I)

The graphic skewness measures the symmetry of the distribution, i.e. predominance of coarser or fine-sediments. The negative value denotes coarser material in coarser-tail i.e., coarse skewed, whereas, the positive value represents more fine material in the fine-tail i.e., fine skewed. Skewness value ranges in between -0.63 Ø and 0.31 Ø, with an average of -0.07 Ø. Positive skewness of sediments indicates the deposition of the sediments in sheltered low energy, whereas negative skewness of sediments indicates deposition at high energy environments (Rajasekhara Reddy et al., 2011). The negative skewness shown by majority of the samples of the study area indicates high energy nature of the beach deposits in general (Friedman, 1961) and multidirectional sediment transport (Martins 1965).

Kurtosis (K_G)

The graphic kurtosis represents the peak distribution and measures the ratio between the sorting in the tails and central portion of the curve. The values of graphic kurtosis range from 0.74 Ø to 1.27 Ø, with an average of 0.94 Ø. Most of the samples fall under meso-kurtic category. Friedman (1962) suggests that extreme high or low values of kurtosis imply that part of the sediments achieved its sorting elsewhere in a high energy environment. The variation of kurtosis values is reflection of the flow characteristics of the depositional medium (Ramamohan Rao et al., 1982; Seralathan and Padmalal, 1994; Hanamgond et al., 1998).

Frequency Distribution Curves

Frequency distribution curves (FDC) are the pictorial representation of weight percentage of different fractions of sediment. FDC are used to describe the nature of sediments. The assemblages of FDC from five sectors in four microenvironments of Bhimunipatnam to Konada are shown in Figures 2 (a - d). Bhimunipatnam, Nagamayyapalem and Annavaram sectors show bimodal nature and the other two sectors exhibit unimodal nature and fine sand. The majority of samples prominent peaks show the size range between 1.50Ø and 3.00Ø. The sediments seem to have been supplied from two sources, probably from river and beach environments.

Scatter Plots

Scatter plots are used to understand the geological significance of the size parameters by studying the interrelationship between two variables. The grain size parameters of the sediments that are often environmentally sensitive are used to interpret various aspects of depositional environment (Folk and Ward, 1957; Inman, 1949; Friedman 1961, 1967; Moiola and Weiser 1968; Visher 1969). Combinations of various grain size parameters, in the form

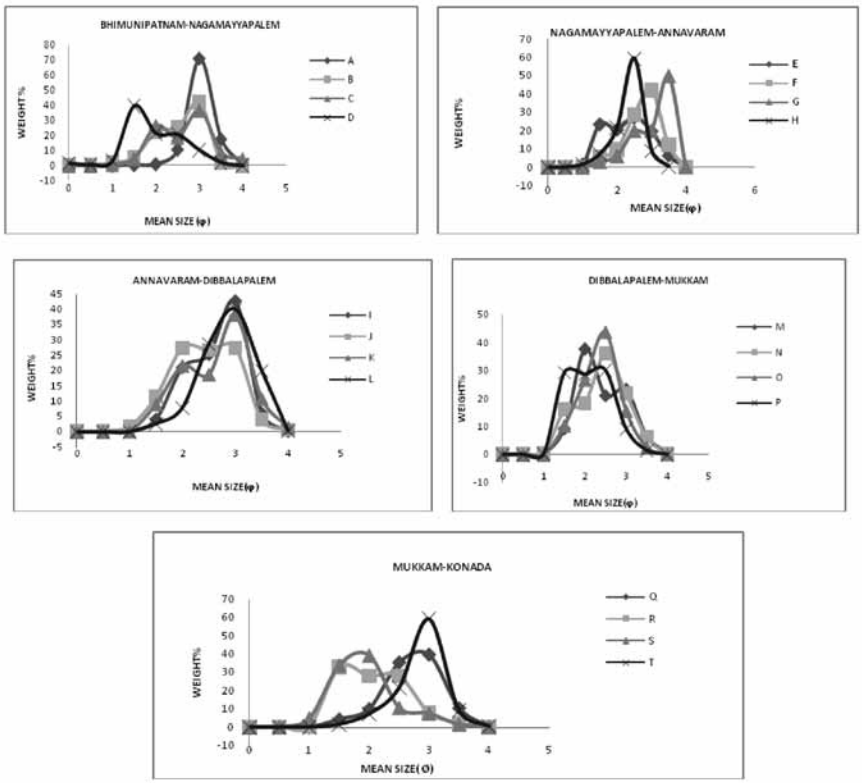


Figure 2a. Frequency Distribution Curves of Fore Shore Sediments, Bhimunipatnam-Konada Coast.

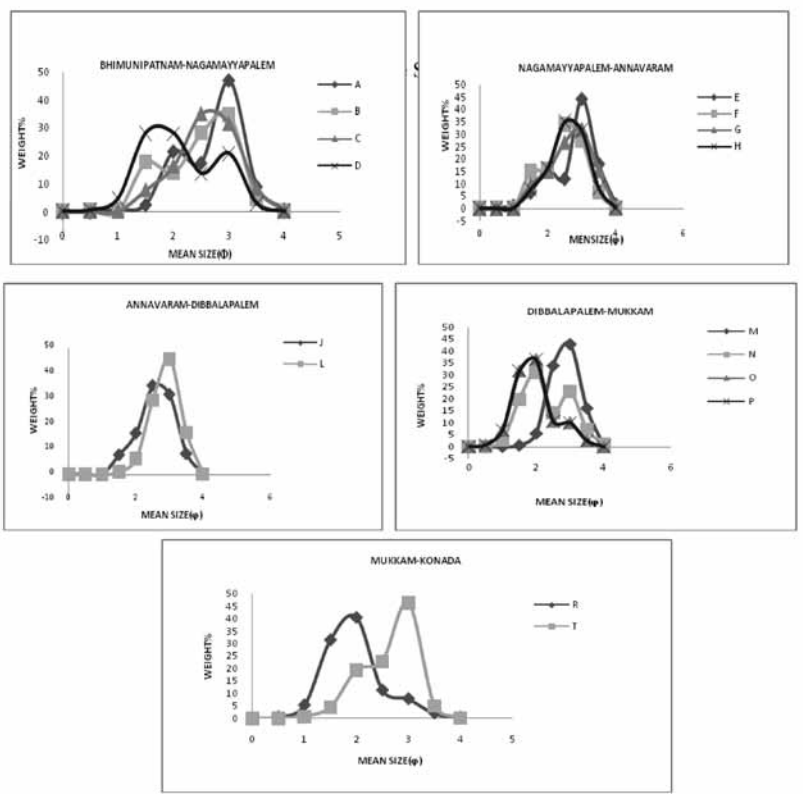


Figure 2b. Frequency Distribution Curves of Berm Sediments, Bhimunipatnam- Konada Coast.

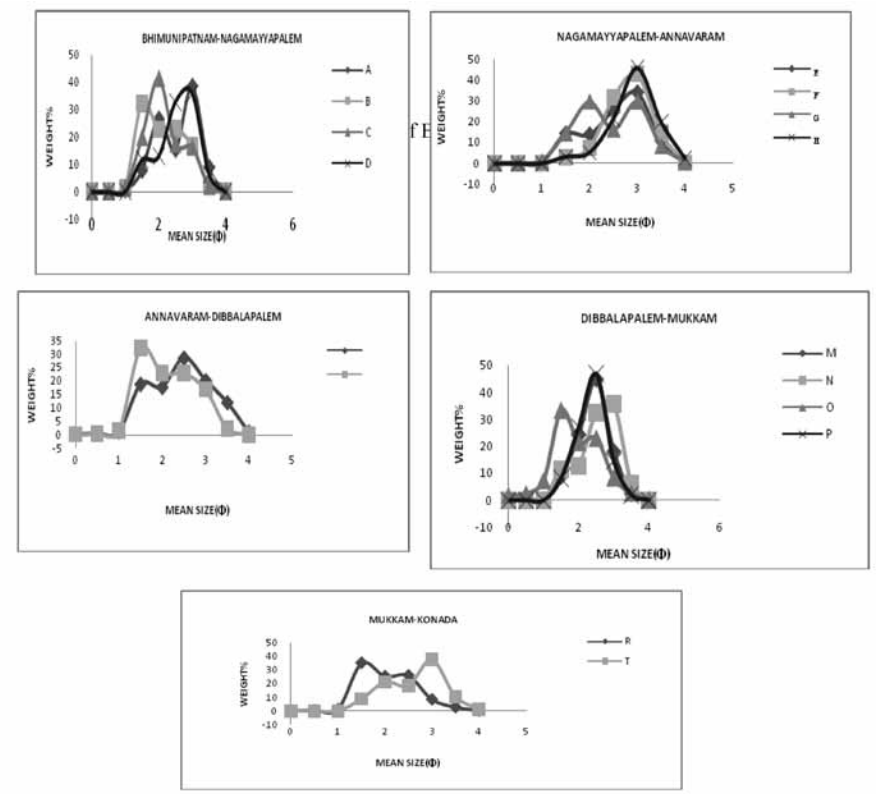


Figure 2c. Frequency Distribution Curves of Back Shore Sediments, Bhimunipatnam – Konada Coast.

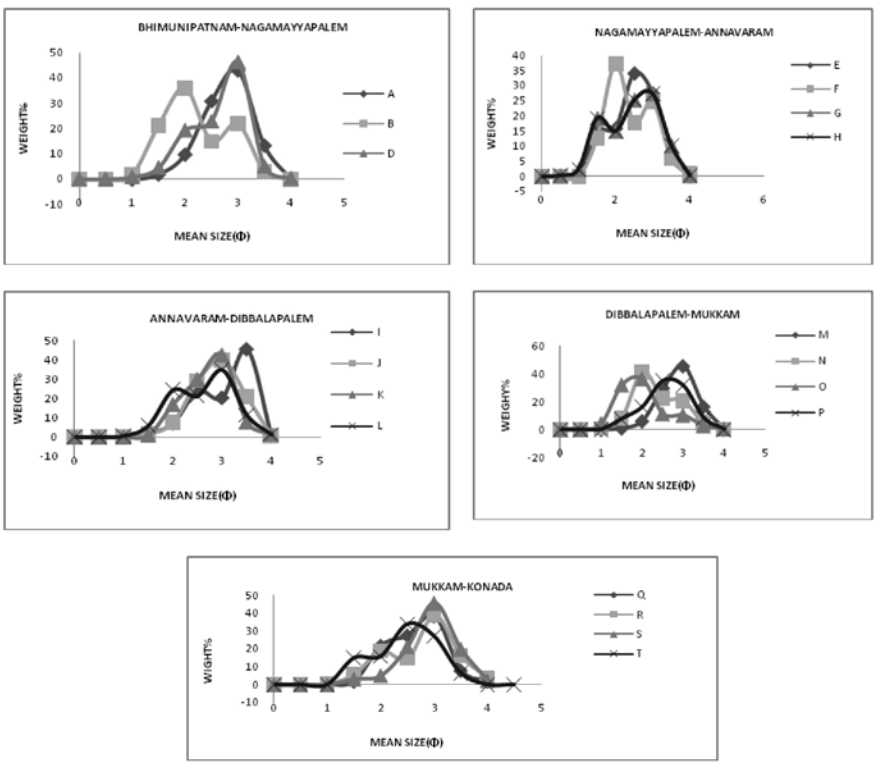
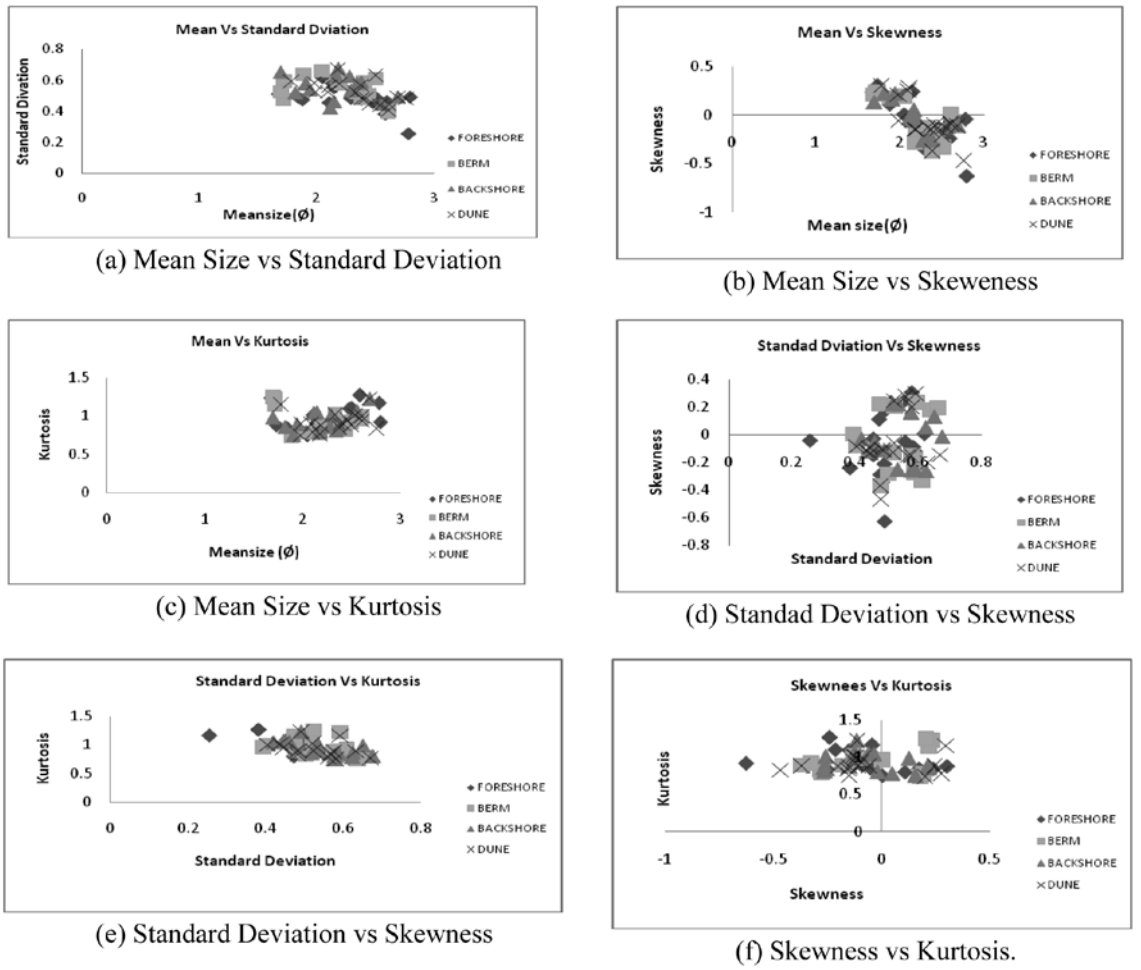


Figure 2d. Frequency Distribution Curves of Dune Sediments, Bhimunipatnam-Konada Coast



(a) Mean Size vs Standard Deviation

(b) Mean Size vs Skeweness

(c) Mean Size vs Kurtosis

(d) Standad Deviation vs Skewness

(e) Standard Deviation vs Skewness

(f) Skewness vs Kurtosis.

Figure 3. Scatter plots of grain size parametars (a) Mean Size vs Standard Deviation ,(b) Mean Size vs Skeweness(c) Mean Size vs Kurtosis ,(d) Standad Deviation vs Skewness, (e) Standard Deviation vs Skewness and (f) Skewness vs Kurtosis.

of scatter plots, have been used to identify the depositional environment (Friedman, 1967). Scatter plots reasonably describe the role of addition and removal of fine and/or coarse fraction during the transit of sediment along beaches as well as in river beds, in controlling the variation in grain size/statistical parameters among the sediments. The relationship between different size parameters were studied by drawing various scatter plots viz. mean size vs. standard deviation, mean size vs. skewness, mean size vs. kurtosis, standard deviation vs. skewness, standard deviation vs. kurtosis and skewness vs. kurtosis Figure 3.

Mean size vs. Standard Deviation

The scatter plot between mean size and standard deviation Figure 3a clearly indicates that sorting decreases with increase of mean size of the dune, backshore, berm and foreshore sediments from bimodal and the dominant constituent is fine sand. Similar types of observations have been reported in the sands of East Coast of India (Nagamalleswara Rao, 1998; Prabhakara Rao et al., 2000; Nageswara Rao et al., 2005).

Mean Size vs. Skewness

The scatter plots between mean size and skewness Figure 3b indicate that in general, the sediments having mean size range from 1.68Ø – 2.80Ø in dune, berm, backshore and foreshore fine sediments exhibit negative skewness. The sediments of negative skewness occur in high energy environments, while sediments with positive skewness occur in low energy environments.

Mean Size vs. Kurtosis

The scatter plot between mean size and kurtosis in dune, berm, backshore and foreshore sediments are shown in Figure 3c. The scatter plot values indicate a dominance of mesokurtic nature (0.74Ø -1.27Ø) in the mean size ranges of 1.68Ø – 2.80Ø i.e. medium to fine sediments.

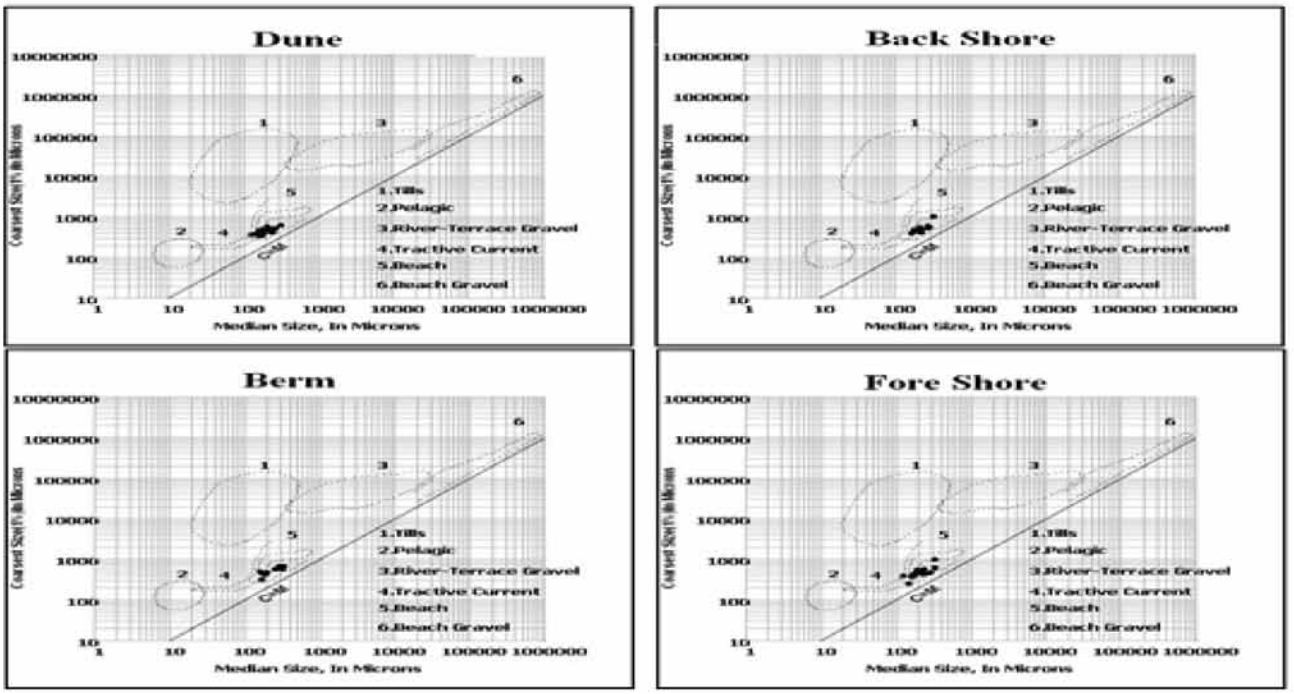


Figure 4a. The basic CM pattern of coastal sediments between Gosthani and Champavathi river mouth.

Standard Deviation vs. Skewness

The scatter plot between standard deviation and skewness Figure 3d shows that sediments are moderately well sorted and negative skewed in backshore, berm, foreshore and dune sediments. If skewness decreases standard deviation improves. This may be due to two conditions i.e. either unimodal samples with good sorting or equal mixture of two models (Ashok et al., 2009; Harsha Sundar et al., 2010).

Standard Deviation vs. Kurtosis

The scatter plots between standard deviation and kurtosis Figure 3e indicate that majority of the sediment samples are of platykurtic to mesokurtic in nature and moderately well sorted.

Skewness vs. Kurtosis

The scatter plot between skewness and kurtosis Figure 3f shows that dune, backshore, berm and foreshore sediment values indicate dominance of platykurtic category followed by mesokurtic (0.74Ø-1.27Ø). The majority of samples are negative skewed (Chakraborthy, 1977)

C M diagrams

The CM patterns of the sediments are useful for analyzing transportation mechanism, depositional environment with respect to size, range and energy level of transportation. They also are useful in determining process and characteristic agents that are responsible for the formation of clastic sediments. The present study is an attempt to identify the modes of transportation and deposition of sediments between Bhimunipatnam to Konada coast, in different microenvironments viz. dune, backshore, berm, foreshore sediments by CM patterns.

The present interpretation is based on procedure adopted by Passega (1957, 1964). He interpreted the distinct pattern of CM plots in terms of different modes of transportation by plotting coarsest first percentile value of the sediments (C). Percentile value is plotted against the median diameter (M) on a double logarithmic paper. Visher (1969) explained a log normal sub populations within the total grain size distribution curves, as representing suspension, saltation and surface creep or rolling modes of transportation mechanisms. The relation between C and M is the effect of sorting by graded turbulence. The C-M plots Figure 4A and 4B show that most of the samples have been formed by two different depositional conditions. The sediment samples of C-M plots Figure 4A from dune, backshore, berm and foreshore fall in region of 4 and 5, which indicates high tractive and beach currents of deposition. Most of the samples fall in the OP, PQ regions Figure 4B. This indicates that part of the load has rolled sediments followed by bottom and graded suspension, representing their deposition through tractive currents. In general, this indicates presence of comparatively more

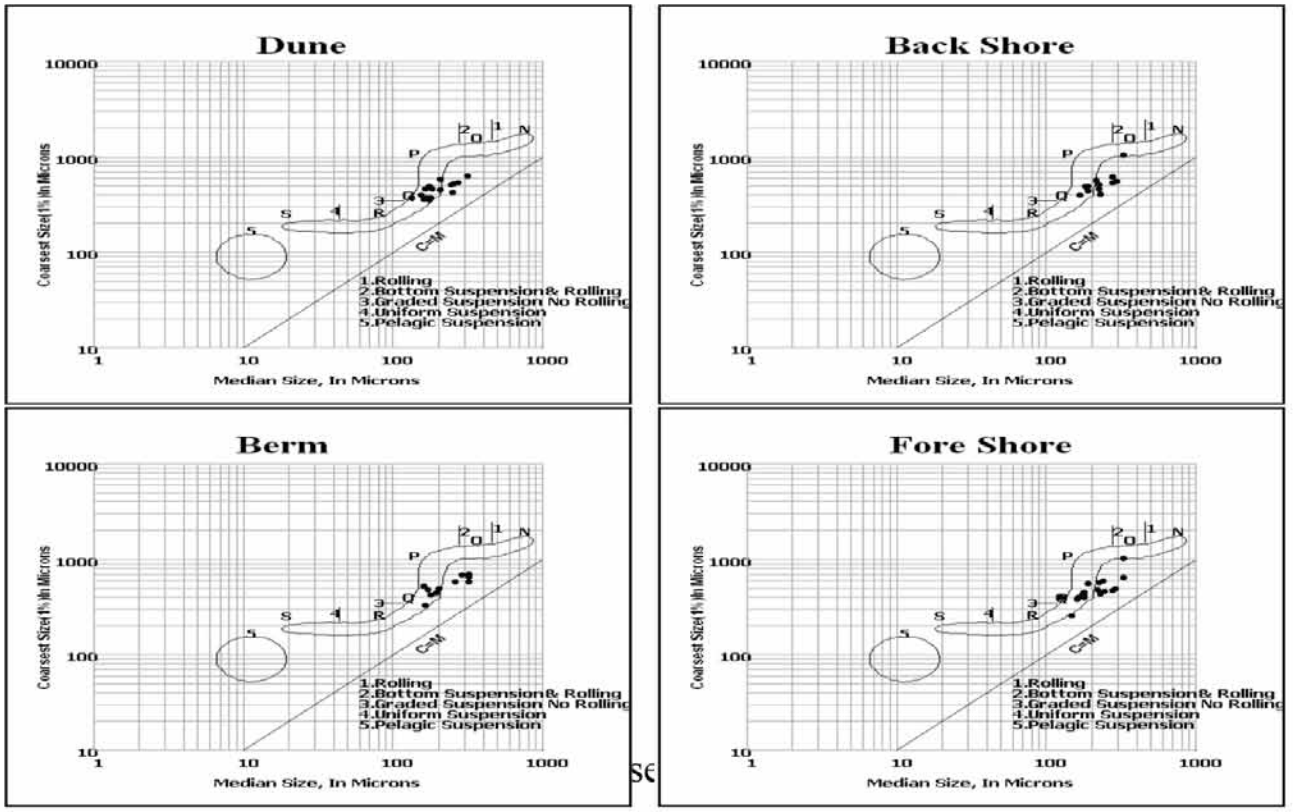


Figure 4b. The tracative currents of CM pattern of Coastal sediments between Gosthani and Champavathi river mouth.

percentage of medium to fine sand grained material (Rajasekhara Reddy et al., 2011; Bull, 1962; Passega and Byramjee, 1969)

SUMMARY AND CONCLUSIONS

The grain size parameters of coastal sediments, between Gosthani and Champavathi rivers confluence, indicate medium to fine sand (1.68Ø – 2.80Ø), well sorted to moderately sorted (0.26Ø -0.67Ø), coarse skewed to fine skewed (-0.63Ø to 0.31 Ø), pltykurtic to leptokurtic (0.74 Ø -1.27 Ø) in nature.

The wide variation of mean size indicates differential energy conditions at different locations. However, the variation in sorting values indicates continuous addition of finer to coarser material in varying proportion at different locations.

Frequency distribution curves and scatter plots drawn between different grain size parameters clearly establish that the sediments are bimodal and composed of mainly fine sand.

The C-M plots indicate that the transportation is mainly in two different depositional conditions, viz. bottom and graded suspension for coastal sediments. This study establishes the usefulness of selecting several stations for better understanding beach environment of deposition.

ACKNOWLEDGEMENTS

We are thankful to the authorities of Department of Geology and Delta Studies Institute, Andhra University for extending the lab facilities to carry out this work. Financial assistance from CSIR-UGC (NET) to K.Bangaku Naidu, in the form of SRF is acknowledged. Valuable comments/suggestions made by anonymous reviewer and apt editing by Chief Editor enhanced quality of the manuscript.

Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copyright norms.

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