Granulometric Characteristics of Estuary bar Sediments of the Gosthani River, Bhimunipatnam,East Coast ofIndia

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Abstract: *The granulometric characteristics of the sediments of estuary bars of the Gostani River (lat. 17. 56' – 17.54' N: long. 83 26'- 83 28' E) have been carried out. A total of forty three samples were collected along the river profile from upper estuary and lower estuary. The upper estuary bar indicates that the sediments possess a coarse sand (0.77 Ø); moderately sorted (0.79 Ø); negatively skewed (-0.17 Ø) and leptokurtic (1.21 Ø) and lower estuary bar sediments are medium sand (1.73 Ø), moderately sorted (0.70 Ø); symmetrical skewed (0.07 Ø) and mesokurtic (1.03Ø). Frequency distribution curves and scatter plots clearly established that the sediments are of unimodal nature and are having medium sand in lower estuary bar and coarse sand with weakly bimodal nature in upper estuary bar. The sediments are deposited under tractive current conditions with dominant rolling mechanism in upper estuary bar sediments and graded and bottom suspension in lower estuary bar. Costal wave dynamics and seasonal shifting of estuary mouth causes the variations in the texture of the sediments.*
Keywords:Granulometricparameters, Estuary bar, Gostani estuary, Frequency distribution curves, Scatter plots.

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I.   Introduction

The Gostani River originates in the Ananthagiri hill range, situated northwestof Arakuand flows for about 120 km before entering the Bay of Bengal. The Gostani River covers an area of 1540 sq.km and drainage through khondalites, charnockites and granite gneisses. The length of the Gostani estuary is 8 km from Tagarapuvalasa to Bhimunipatnam in Visakhapatnam district of Andhra Pradesh. In estuarine part, the river width varies from 141 m to 352m (Fig. 1). The estuary is a coastal indentation, at the mouth of a river, in which seawater can circulate freely. In estuaries, the freshwater and saltwater usually flow in opposite directions at least part of the time. The position of the estuary mouth changes due to sand bar formation and amount of flow of freshwater during monsoon months. The estuary bar is open to sea throughout the year. The tapering of the estuary bar on both ends the result of tidal and fluvial forces operating in opposite directions. According to Miall[1], bars are small when they are first formed but continue to grow in length and height as fine particles are trapped in the interstices of the original deposit and as more bed load sediment is deposited in downstream in the lee of the bar. Moreover the fine particles are present because river water normally contains a fairly high concentration of the suspended clay and silt [2]. Studies on texture and clay mineralogy of estuarine sediments of Gostani River were carried out [3], and foraminifera [4]. The present study deals with estuary bar characterization through the granulometric parameters. The upper estuary bar -1 occupies an area of 25833 sq.mt (308 m length x 103 m width)   whereas upper estuary bar -2 occupies an area of 18579 sq.mt (223 m length x 78 m width). The lower estuary bar -3 occupies an area of 17742 sq.mt (323 m length x 163 m width) whereas lower estuary bar -4 occupies an area of 12524 sq.mt (277 m length x 108 m width).

II.   Method of study

Four stations in the river estuary have been covered whereupon forty three surface and near-surface (1m) sediment samples were collected in estuary bars of the Gostani estuary.   About 150-200 grams of sample is taken in porcelain dish and air dried, taking all possible care against contamination.   Sandy samples are repeatedly washed in distilled water for removal of salts and then air dried. After drying, a sub sample weighing about 40-50 grams is obtained by conning and quartering, H_2O_2 and HCL were added to remove organic matter and shell material in the sample and then dried. The sub sample (very coarse sand) is subjected to sieving by ASTM test sieves of 8″ diameter with successive sieves spaced at ½ Ø interval. Some of the samples (medium sand to silty sand) are determined using particle size analyzer (master sizer 2000E). The sediment samples have been subjected to size analysis [5] and grain size parameters were calculated [6]. The grain size data obtained

was used to determine the grain size parameters [7].Frequency distribution curves,scatter plots and CM diagrams were drawn and the data was analyzed.
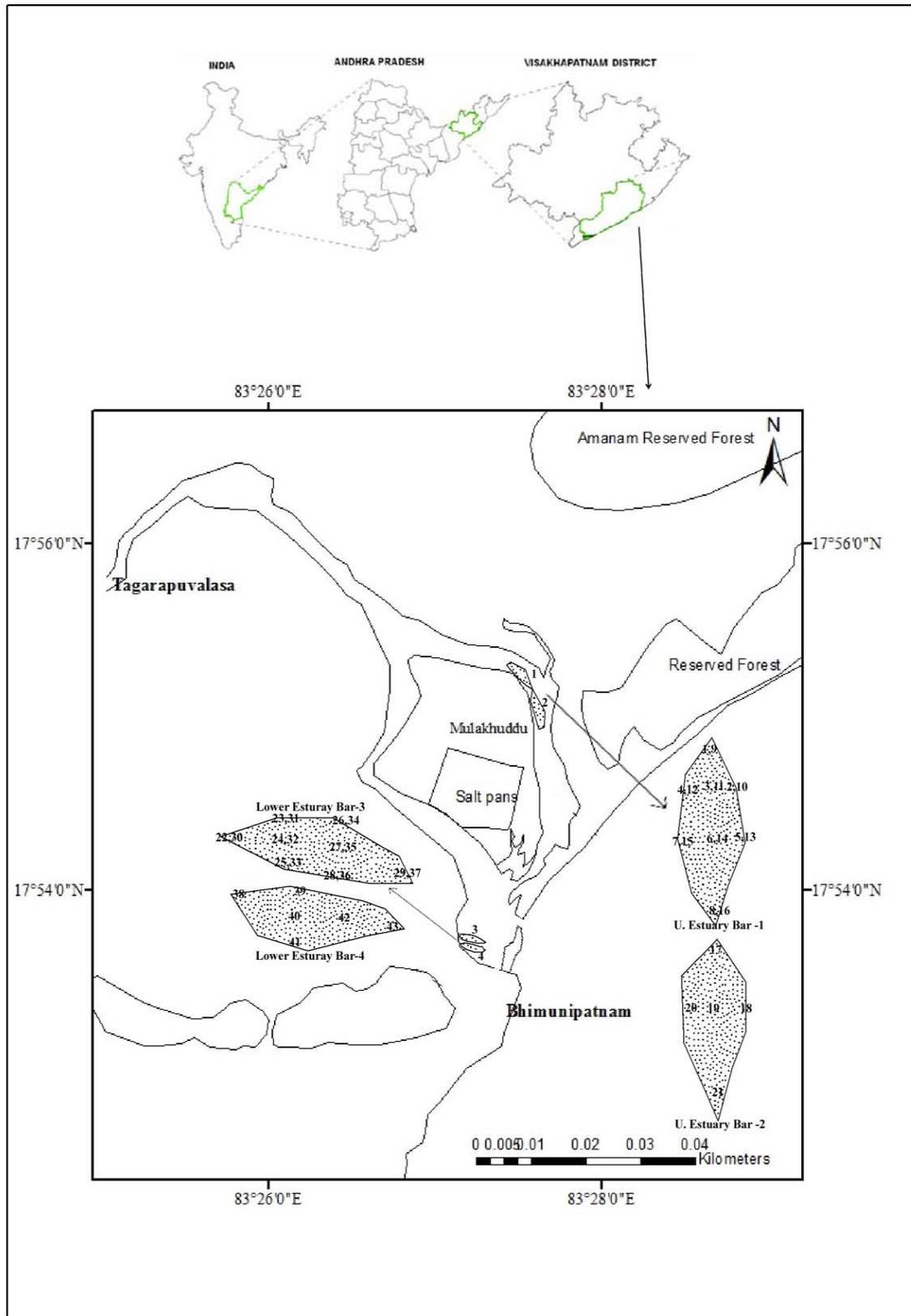

Fig.1. Sample location map of Gostaniestuary.

III. Results and Discussion

The results of the grain size analyses carried out and the grain size parameters and sand, silt, clay ratios are presented in tables 1-6. The range and average values of grain size parameters are presented in table.7.

Surface Sediments of Upper Estuary Bar (1)

Upper estuary bar surface sediments consist of coarse sands (0.20 to 0.99Ø; av. 0.54Ø); moderately sorted (0.58to 1.08Ø; av. 0.85Ø); negatively skewed (–0.41 to -0.18Ø; av. -0.25Ø); and leptokurtic nature (0.1.07 to 1.63Ø; av. 1.28Ø). These sediments are mostly sand is (92.623%) and granule is (7.378%).

Sub-Surface Sediments of Upper Estuary Bar (1)

Upper estuary bar near-surface sediments consists of coarse sands (0.27 to 1.21Ø; av. 0.69Ø); moderately sorted (0.57 to 1.02Ø; av. 0.75Ø); negatively skewed (–0.26 to -0.04Ø; av. -0.18Ø); and leptokurtic (0.97 to 1.45Ø, av. 1.21Ø). These sediments consist of sand (96.08%) and granule (3.91%).

Surface Sediments of Upper Estuary Bar (2)

Upper estuary bar surface sediments range in size from coarse to medium sands (0.92 to 1.48Ø; av. 1.09Ø); moderately sorted (0.64 to 0.98Ø; av. 0.78Ø); negatively skewed to (-0.008 to –0.21Ø; av. -0.08Ø); and leptokurtic (1.02 to 1.37Ø; av. 1.15Ø). These sediments consist of sand (99.28%) and granule (0.71%).

Upper estuary bar consists of coarse sand because of the prevailing high wave energy environment, strong winnowingaction must have removed the fine sediments, leaving the coarser sediments. Moderately sorted sediments indicate the mixing of the coarse and fine mode sediments. The negative skewness results are likely from winnowing by waves and tidal currents that removed the fine particles. Negative skewness indicates to and fro motion of the transporting media where finer components are removed by winnowing action [8]. Wave action of the Gostani River along with the aeolian process effect may be responsible to the negative skewness. Variation in the kurtosis values is a reflection of the flow characteristics depending up on the medium, dominance of coarse size sand of leptokurtic nature reflecting the maturity of the sand. This may be due to the aggregation of sediment particle size by dense and the variations in the sorting values are likely due to continuous addition of medium / coarse materials in varying proportions [9]. Krumbein[10] andplumley[11] proposed that if sediment contains sub equal amounts of gravel and sand or if sand dominates, the resulting size distribution would be nearly symmetrical and negatively skewed.

Surface Sediments of Lower Estuary Bar (3)

Lower estuary bar surface sediments consist of medium sands (1.41 to 1.80Ø; av. 1.61Ø); moderately sorted (0.55 to 0.76Ø; av. 0.66Ø); nearly symmetrical skewed (-0.005 to 0.09Ø; av. 0.05Ø); and mesokurtic (0.1.07 to 1.63Ø; av. 1.28Ø). These sediments consist of mostly sand (98.38%).

Sub-Surface Sediments of Lower Estuary Bar (3)

The surface sediments of lower estuary bar consist of medium with size varying from sand (1.483 to 1.980Ø, av. 1.729Ø), moderately sorted (0.57 to 0.84Ø, av. 0.68Ø), nearly symmetrical skewed (-0.07 to 0.15Ø, av. 0.04Ø) and mesokurtic (0.96 to 1.16Ø, av. 1.01Ø). These sediments consistof sand (99.30%) silt (0.68%) and clay (0.005%).

Surface Sediments of Lower Estuary Bar (4)

The surface sediments of lower estuary bar consist of medium to fine sand (1.43 to 2.44Ø, av. 1.85Ø), moderately sorted (0.68 to 0.82Ø, av. 0.76Ø), positively skewed (0.02 to 0.23Ø, av. 0.11Ø) and mesokurtic (0.98 to 1.16Ø, av. 1.04Ø). These sediments consist of sand (97.79%), silt (2.12%) and clay (0.08%).

Lower estuary bar sediments are medium to fine sands. These sediments are better sorted than very fine sediments [6]. A moderately well sorted value for estuarine bar sands shows that there is a fair amount of variability among the diameters of their particles. This means that the sediments are matured to a reasonable extent and the particles have been transported quite far away from its source. Positive skewness of sediments indicates the unidirectional transport (channel) or the deposition of sediments in sheltered low energy environment ([12], [13], [14]). The lower estuary bar sediments are mesokurtic nature. These sediments were generally mesokurtic close to the mouth, and dominantly very leptokurtic further upstream. The middle portion of the river was dominated by leptokurtic sediments. The trend revealed a decrease in kurtosis from the

upstream to the mouth [15]. The wide variation in the kurtosis values exhibit mesokurtic and the mixing of the two populations in sub equal amounts results in leptokurtic nature [16].

Table1. Grain Size Parameters of**Surface** Sediments of**Upper Estuary Bar(1)** of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
1	0.627	0.639	-0.215	1.256	3.684	96.316	-	-	CS, Mwsd, Nsk, LK
2	0.776	0.752	-0.227	1.209	3.640	96.360	-	-	CS, Msd, Nsk, LK
3	0.394	0.963	-0.413	1.635	11.133	88.867	-	-	CS, Msd, Vnsk,VLK
4	0.753	0.772	-0.180	1.375	4.886	95.114	-	-	CS, Msd, Nsk, LK
5	0.994	0.582	-0.189	1.178	-	100	-	-	CS, Mwsd, Nsk, LK
6	0.260	1.082	-0.251	1.135	13.235	86.765	-	-	CS, Psd, Nsk, LK
7	0.206	1.079	-0.223	1.075	13.448	86.552	-	-	CS, Psd, Nsk, MK
8	0.343	0.963	-0.320	1.392	8.994	91.006	-	-	CS, Msd, Vnsk, LK

Table2. Grain Size Parameters of **Sub-Surface** Sediments of **Upper Estuary Bar (1)**of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
9	0.623	0.769	-0.109	1.215	4.655	95.345	-	-	CS, Msd, Nsk, LK
10	1.217	0.630	-0.044	1.459	-	100	-	-	MS, Mwsd, Sysk, LK
11	0.941	0.574	-0.111	1.202	-	100	-	-	CS, Mwsd, Nsk, LK
12	0.731	0.679	-0.256	1.175	3.578	96.422	-	-	CS, Mwsd, Nsk, LK
13	0.693	0.674	-0.149	0.973	-	100	-	-	CS, Mwsd, Nsk, LK
14	0.275	1.024	-0.267	1.160	10.952	89.048	-	-	CS, Psd, Nsk, LK
15	0.586	0.902	-0.253	1.230	6.250	93.750	-	-	CS, Msd, Nsk, LK
16	0.492	0.802	-0.250	1.299	5.903	94.097	-	-	CS, Msd, Nsk, LK

Table 3. Grain Size Parameters of**Surface** Sediments of**Upper Estuary Bar (2)**of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
17	1.126	0.711	-0.063	1.124	-	100	-	-	MS, Msd, Sy.Sk, LK
18	0.945	0.719	-0.048	1.025	-	100	-	-	CS, Msd, Sy.Sk, MK
19	0.992	0.842	-0.090	1.140	-	100	-	-	CS, Msd, Sy.Sk, MK
20	0.923	0.980	-0.211	1.103	3.589	96.411	-	-	CS, Msd, Nsk, MK
21	1.481	0.649	0.008	1.376	-	100	-	-	MS, Mwsd, Sy,Sk, LK

Table4. Grain Size Parameters of**Surface** Sediments of**Lower Estuary Bar (3)** of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
22	1.802	0.650	0.093	1.031	-	100	-	-	MS, Mwsd, Sy.Sk, MK
23	1.781	0.589	0.032	0.952	-	98.424	1.566	0.010	MS, Mwsd, Sy.Sk, MK
24	1.523	0.718	0.065	1.175	-	100	-	-	MS, Msd, Sy.Sk, LK
25	1.666	0.627	0.042	1.028	-	97.712	2.276	0.012	MS, Mwsd, Sy.Sk, MK
26	1.415	0.555	-0.005	1.005	-	98.287	1.703	0.010	MS, Mwsd, Sy.Sk, MK
27	1.553	0.665	0.050	1.028	-	97.599	2.388	0.013	MS, Mwsd, Sy.Sk, MK
28	1.701	0.720	0.086	1.015	-	97.618	2.370	0.012	MS, Msd, Sy.Sk, MK
29	1.452	0.764	0.094	1.068	-	97.469	2.519	0.012	MS, Msd, Sy.Sk, MK

Table 5. Grain Size Parameters of**Sub-Surface** Sediments of**Lower Estuary Bar (3)**of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
30	1.968	0.681	0.041	0.968	-	98.750	1.240	0.010	MS, Mwsd, Sy.Sk, MK
31	1.980	0.661	0.045	0.961	-	98.451	1.539	0.010	MS, Mwsd, Sy.Sk, MK
32	1.699	0.846	-0.074	0.995	-	100	-	-	MS, Msd, Sy.Sk, MK
33	1.802	0.738	0.157	0.993	-	100	-	-	MS, Msd, Psk, MK
34	1.710	0.711	0.060	1.041	-	100	-	-	MS, Msd, Sy.Sk, MK
35	1.622	0.636	0.030	1.166	-	100	-	-	MS, Mwsd, Sy.Sk, LK
36	1.566	0.579	0.060	0.992	-	98.479	1.511	0.010	MS, Mwsd, Sy.Sk, MK
37	1.483	0.607	0.024	0.993	-	98.773	1.217	0.010	MS, Mwsd, Sy.Sk, MK

Table 6. Grain Size Parameters of **Surface** Sediments of **Lower Estuary Bar (4)**of Gosthani River.

Sample No.	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay	Remarks
38	1.436	0.687	0.023	0.982	-	98.909	1.081	0.010	MS, Mwsd, Sy.Sk, MK
39	1.757	0.783	0.126	1.167	-	96.780	3.207	0.013	MS, Msd, Psk, LK
40	2.144	0.818	0.122	1.034	-	96.420	3.289	0.291	FS, Msd, Psk, MK
41	1.562	0.828	0.124	1.082	-	97.595	2.392	0.012	MS, Msd, Psk, MK
42	1.805	0.773	0.231	1.006	-	100	-	-	MS, Msd, Psk, MK
43	2.440	0.706	0.077	1.014	-	97.052	2.753	0.195	FS, Msd, Sy.Sk, MK

CS: Coarse Sand, MS:Medium Sand, FS: Fine Sand, Msd: Moderately Sorted, Mwsd: Moderately Well Sorted, Psd: Poorly Sorted, Vnsk: Very Negatively Skewed, Nsk: Negatively Skewed, Sy.Sk: Symmetrical, Psk: Positively Skewed, VLK: Very Leptokurtic, LK: Leptokurtic, MK: Mesokurtic.

Table. 7. Range and Average Values of Grain Size Parameter of Estuary Bars of Gosthani River.

Environment	Range	Mean	SD	Skewness	Kurtosis	Granule	Sand	Silt	Clay
Upper Estuary Bar(1) Surface	Min	0.206	0.582	-0.413	1.075	0.00	86.552	-	-
	Max.	0.994	1.082	-0.180	1.635	13.448	100	-	-
	Av.	0.544	0.854	-0.252	1.282	7.378	92.623	-	-
Upper Estuary Bar(1) Sub-Surface	Min	0.275	0.574	-0.267	0.973	0.00	89.048	-	-
	Max.	1.217	1.024	-0.044	1.459	10.952	100	-	-
	Av.	0.695	0.757	-0.180	1.214	3.917	96.083	-	-
Upper Estuary Bar(2) Surface	Min	0.923	0.649	-0.211	1.025	0.00	96.411	-	-
	Max.	1.481	0.980	0.008	1.376	3.589	100	-	-
	Av.	1.093	0.780	-0.081	1.154	0.718	99.282	-	-
Lower Estuary Bar(3) Surface	Min	1.415	0.555	-0.005	0.952	-	97.469	0.00	0.00
	Max.	1.802	0.764	0.094	1.175	-	100	2.519	0.013
	Av.	1.612	0.661	0.057	1.038	-	98.389	1.603	0.009
Lower Estuary Bar(3) Sub-Surface	Min	1.483	0.579	-0.074	0.961	-	98.451	0.00	0.00
	Max.	1.980	0.846	0.157	1.166	-	100	1.539	0.010
	Av.	1.729	0.682	0.043	1.014	-	99.307	0.688	0.005
Lower Estuary Bar(4) Surface	Min	1.436	0.687	0.023	0.982	-	96.420	0.00	0.00
	Max.	2.440	0.828	0.231	1.167	-	100	3.289	0.291
	Av.	1.857	0.766	0.117	1.048	-	97.793	2.120	0.087

Scatter Plots

The scatter plot between mean size and standard deviation (Fig. 2) clearly indicating that the upper estuary bar sediments are predominantly coarse sand and a few samples are medium sand which were poorly to moderately sorted by reducing its grain size, whereas in lower estuary bar sediments are medium to fine grained with moderately sorted. The scatter plot between mean size and skewness (Fig. 3) showing an exponential increase of sediments deposition which was clearly indicating that the coarse sand is deposited at very high energy environments and gradually with the reduction in grain size its deposition is also reduced to low energy environments respectively. In upper estuary bar, sediments are coarse to medium sand with very negatively to near symmetrical skewness, whereas lower estuary bar sediments are medium to fine grain with near symmetrical to positively skewed. The scatter plot between mean size and kurtosis (Fig. 4) indicating in upper estuary bar sediments are mostly coarse sand and leptokurtic whereas in lower estuary bar sediments are medium to fine sand and mesokurtic nature. The scatter plot between standard deviation and skewness (Fig. 5) is showing,in upper estuary bar, moderately to poorly sorted sediments and negatively to very negatively skewed whereas in lower estuary bar sediments are near symmetrical to positively skewed and moderately sorted. The scatter plot standard deviation vs. kurtosis (Fig. 6) showing that in upper estuary bar, mostly moderately and some poorly sorted sediment which are leptokurtic to in nature whereas in lower estuary bar, moderately sorted sediments are mesokurtic in nature. The scatter plot skewness vs. kurtosis (Fig. 7) is indicating in upper estuary bar negatively skewed sediments are leptokurtic in nature whereas in lower estuary bar, near symmetric to positively skewed sediments are mesokurtic.
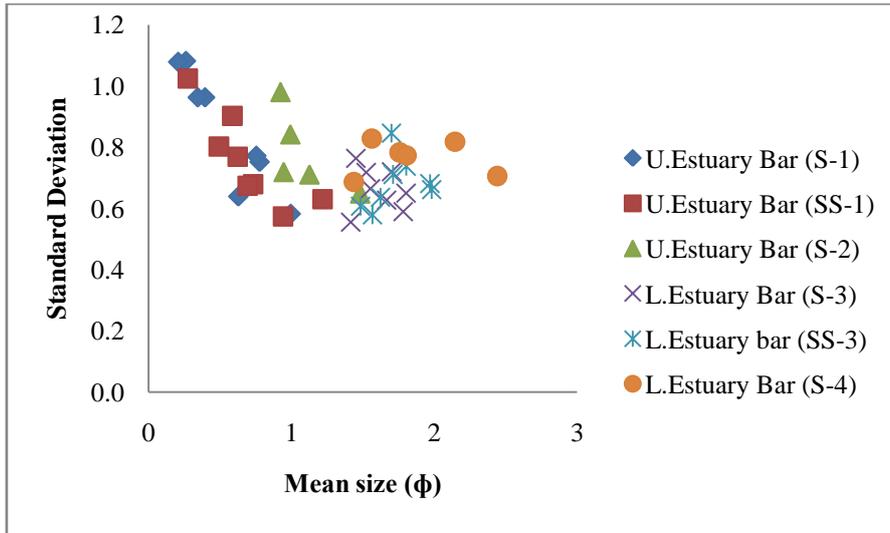
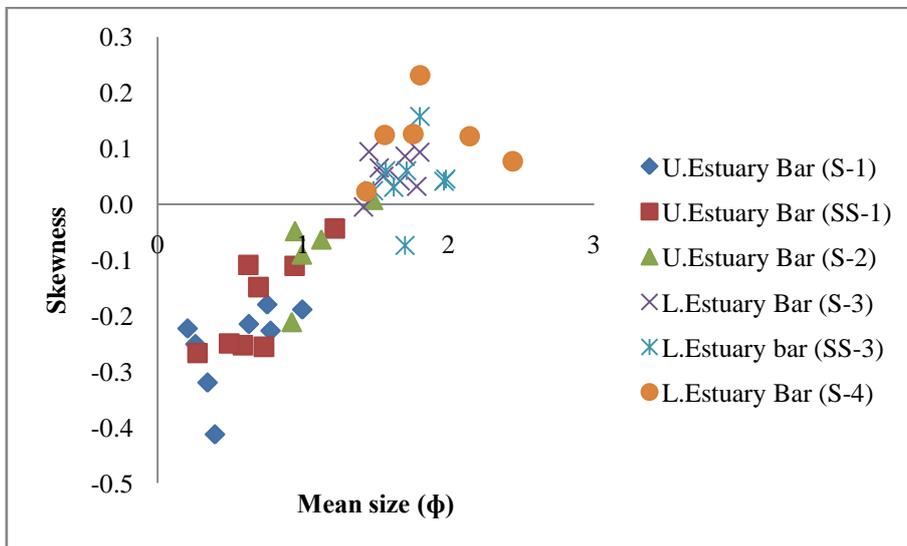**Fig.2.**Scatter Plot between Mean Size Vs. Standard Deviation of Estuary Bar Sediments.

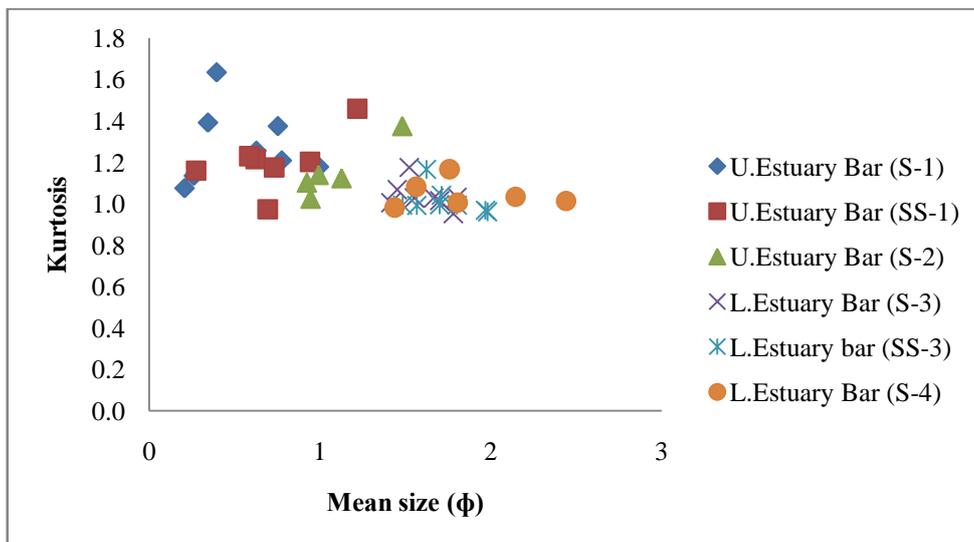**Fig.3.**Scatter Plot between Mean Size Vs. Skewness of Estuary Bar Sediments.

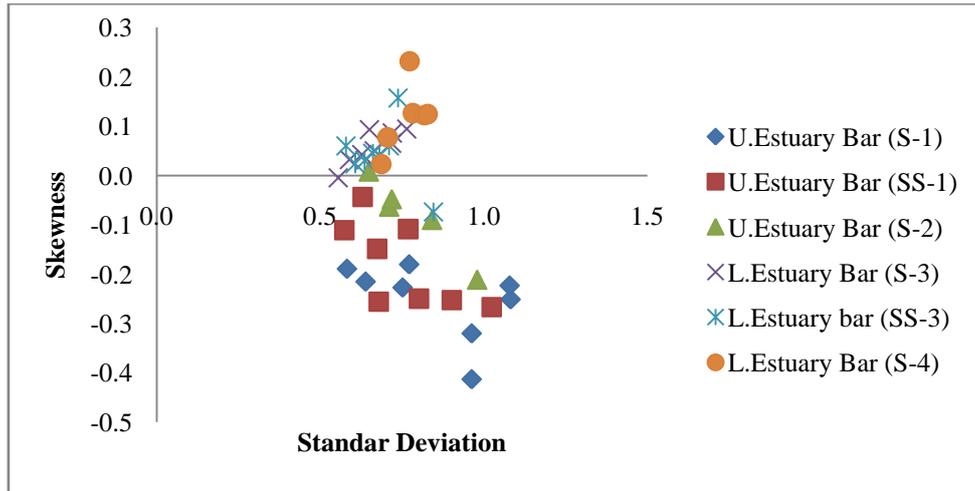**Fig.4.**Scatter Plot between Mean Size Vs. Kurtosis of Estuary Bar Sediments.

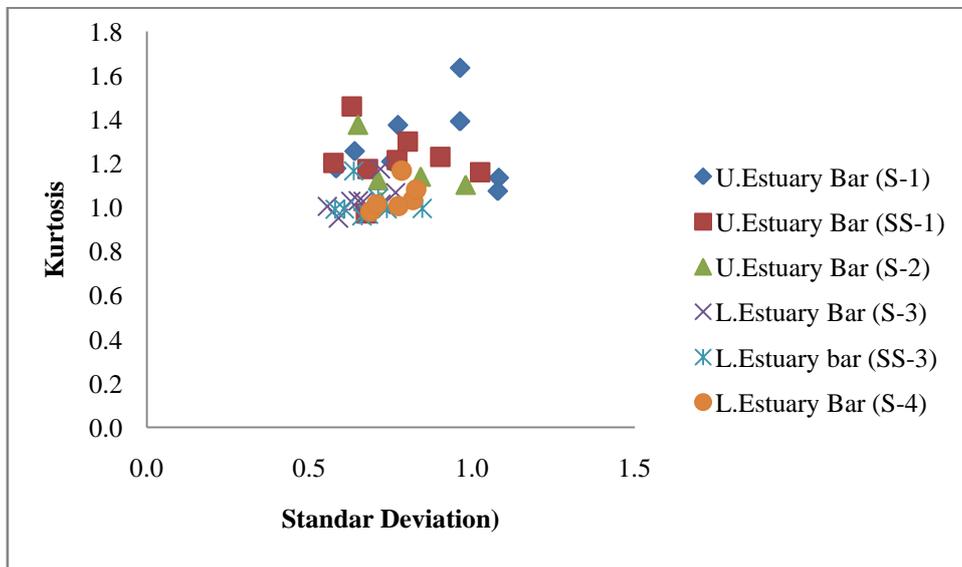**Fig.5.**Scatter Plot between Standard Deviation Vs. Skewness of Estuary Bar Sediments.

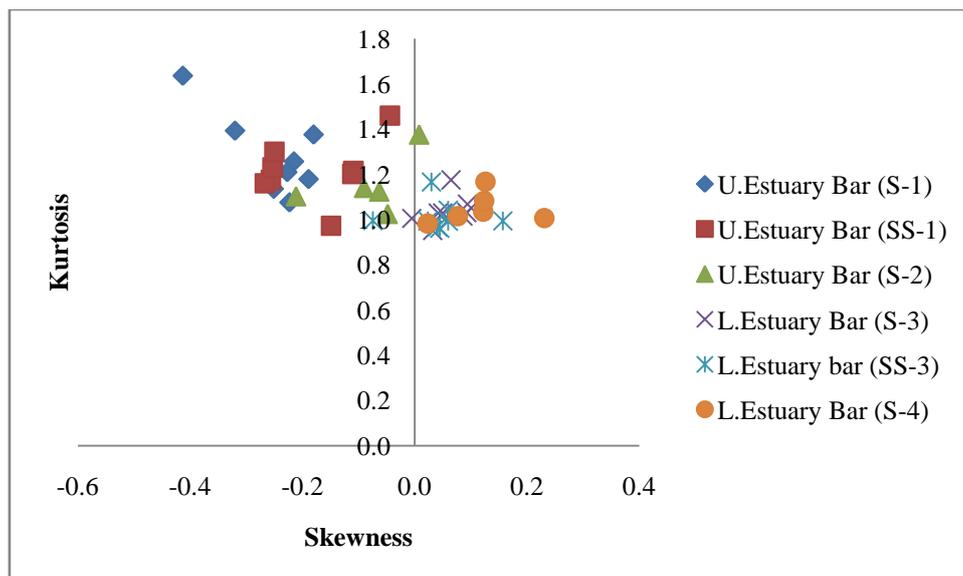**Fig.6.**Scatter Plot between Standard Deviation Vs. Kurtosis of Estuary Bar Sediments.

Fig.7. Scatter Plot between Skewness Vs. Kurtosis of Estuary Bar Sediments.

Frequency Distribution Curves

The Frequency Distribution Curves (FDC) ofsurface sediments of upper estuary bar 1 (Fig. 8) are medium sand (1.5 ɸ) dominated. The sediments from sample No. 2, 8 and 5 show nearly fine sand (2 ɸ). The sediments from sample No. 1, 4, 6, 7 and 8 show medium sand (1.5 ɸ). Maximum sediments in the GosthaniRiver upper estuary surface samples are of unimodalnature with medium sand and few sediments are weekly bimodal.

The Frequency Distribution Curves (Fig. 9) of sub-surface sediments of upper estuary bar (1) are medium sand (1.5 ɸ) dominated. The sediments from sample No. 10, 11 and 12 show nearly fine sand (2 ɸ). The sediments from sample No. 9, 13, 14, 15 and 16 show medium sand (1.5 ɸ). Maximum sediments in the GosthaniRiver upper estuary sub-surface samples are of unimodalnature with fine sand and few sediments are weakly bimodal.

The Frequency Distribution Curves (Fig. 10) of surface sediments of upper estuary bar (2) are fine sand (2 ɸ) dominated. The sediments from sample No. 17, 18, 19, 20 and 21 show fine sand (2 ɸ). Maximum sediments in the GosthaniRiver upper estuary surface samples are of unimodalnature with fine sand and few sediments are weakly bimodal.

The Frequency Distribution Curves (Fig.11) of surface sediments of lower estuary bar (3) are fine sand (2 ɸ) dominated. The sediments fromlower estuary bar show fine sand (2 ɸ). The sediment sample No. 22 show fine sand (2-2.5 ɸ). Sediments intheGosthaniRiver lower Estuary surface samples are of unimodalnature with fine sand.

The Frequency Distribution Curves (Fig.12) of sub-surface sediments of lower estuary bar (3) are fine sand (2 ɸ) dominated. The sediments from samples No. (30, 31, 32, 33,34,35,36 and 37) show fine sand (2 ɸ). Sediments in the GosthaniRiver lower estuary sub-surface samples are of unimodalnature with fine sand.

The Frequency Distribution Curves (Fig.13) of surface sediments of lower Estuary Bar (4) are fine sand (2 ɸ) dominated. The sediments from samples No. E1, 38, 39, 40 and 41show fine sand (2 ɸ).The sediment sample No. 43 show very fine sand (3 ɸ). Sediments in the GosthaniRiver lower estuary surface samples are of unimodalnature with fine sand and sample No. 40 is weakly bimodal in nature.
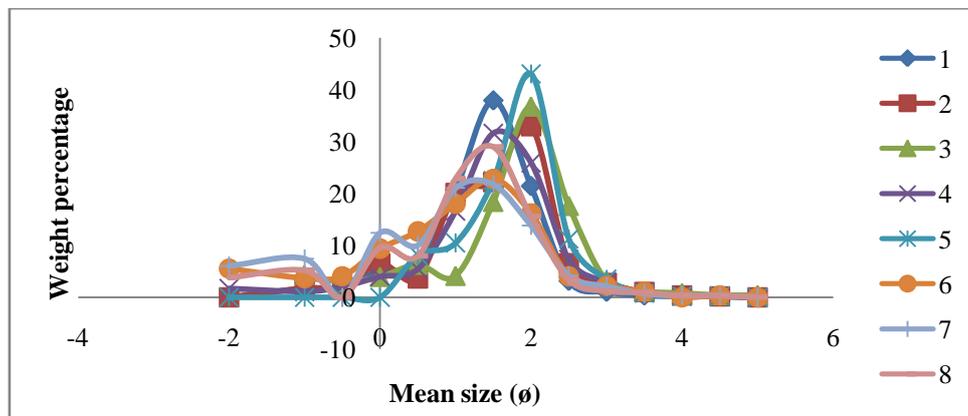

Fig.8. Frequency Distribution Curves of **Surface** Sediments of **Upper Estuary Bar(1)**of Gosthani River.
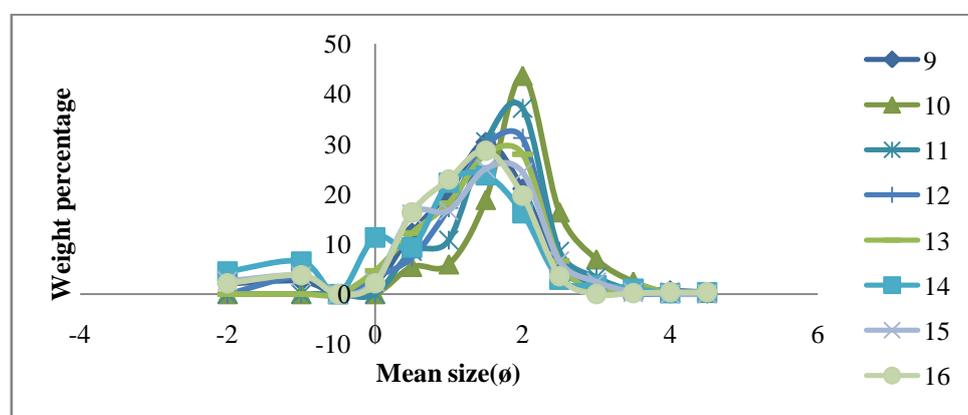

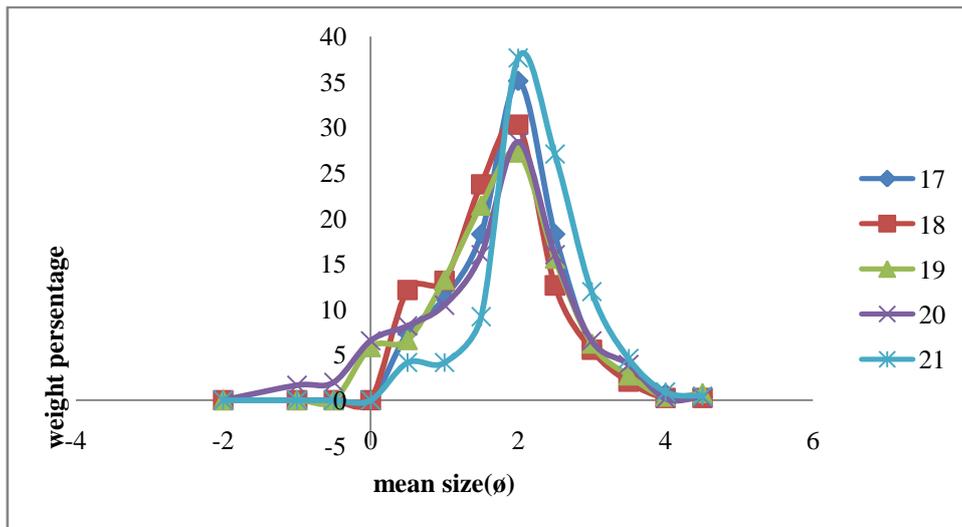**Fig.9.**Frequency Distribution Curves of **Sub-Surface** Sediments of **Upper Estuary Bar(1)**of Gosthani River.

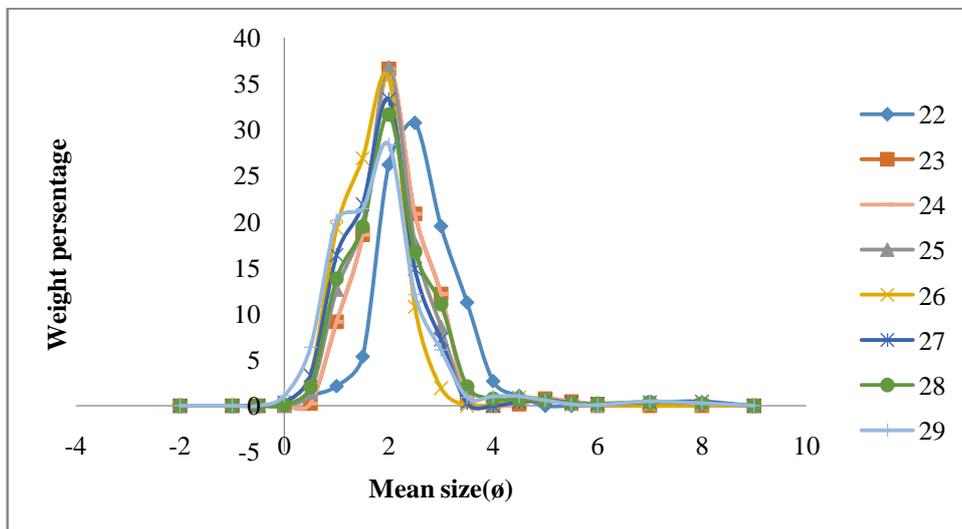**Fig.10.**Frequency Distribution Curves of **Surface** Sediments of **Upper Estuary Bar(2)**ofGosthani River.

Fig.11. Frequency Distribution Curves of **Surface** Sediments of **Lower Estuary Bar(3)**of Gosthani River.
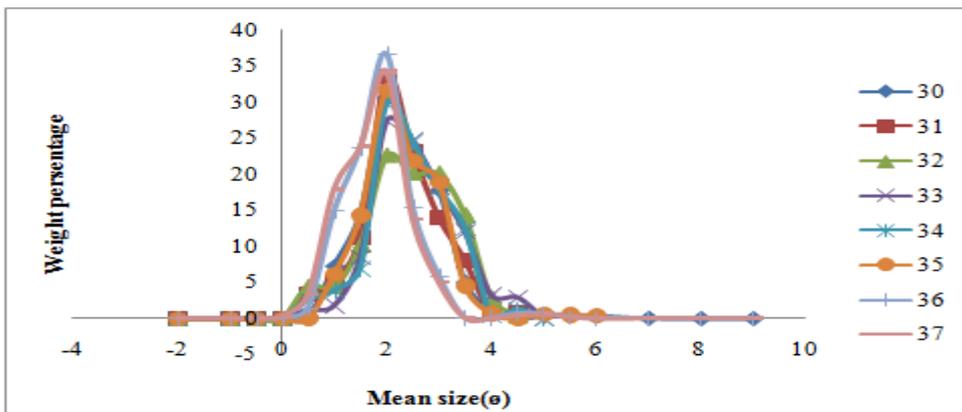

Fig.12. Frequency Distribution Curves of **Sub-Surface** Sediments of **Lower Estuary Bar(3)**of Gosthani River.
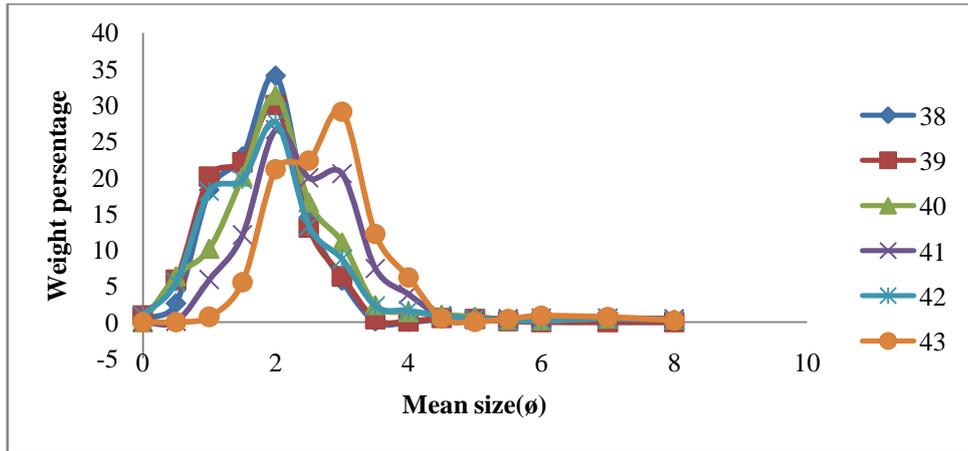
Fig.13. Frequency Distribution Curves of **Surface** Sediments of **Lower Estuary Bar(4)**of Gosthani River.

CM Diagrams

        Passega([17], [18]); Visher[19], Kumar and Singh [20] and several other workers have used the grain size parameters and the plots of CM patterns to distinguish between the sediments of different environments.

        The CM plot (Fig. 14) of sandy sediments shows that the samples formed by two depositional conditions. This field represents the tractive current deposition and these sediments are deposited by both rolling and bottom suspension and rolling sediments (Fig. 15) show graded suspension and no-rolling. The upper estuary bar sediments are deposited mostly rolling whereas lower estuary bar sediments are deposited bottom and graded suspension.
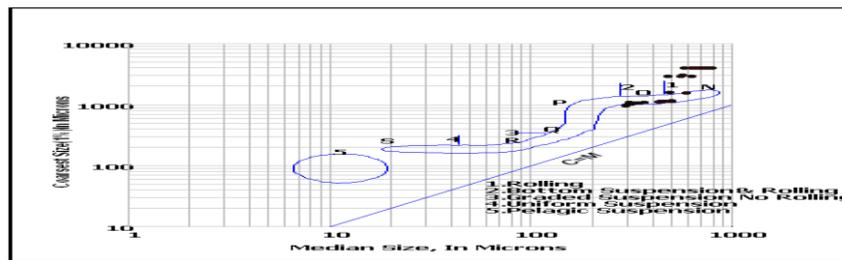

Fig.14. Complete CM Pattern of Tractive Current Deposits of Estuary Bar **Sandy** Sediments
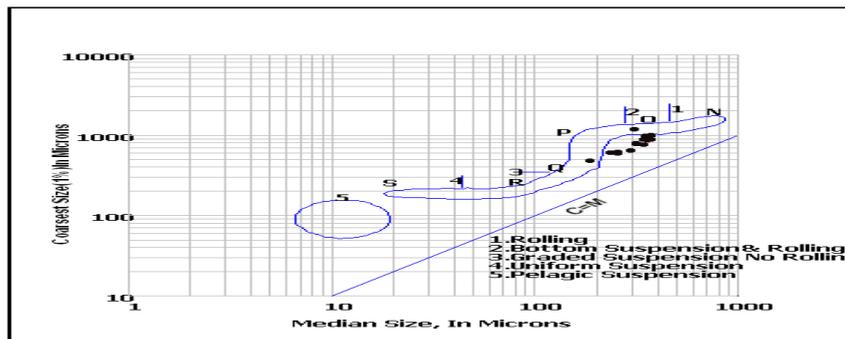

Fig.15. Complete CM Pattern of Tractive Current Deposits of Estuary Bar **Silt and Clayey** Sediments

IV. Conclusions

        The upper estuary bar sediments consists of coarse sand, moderately sorted,negatively skewed and leptokurtic in nature and the lower estuary bar sediments are medium sand with moderately sorted; positively skewed and mesokurtic in nature. Upper estuary bar was formed during high energy environment of indicates the presence of the river mouth nearby the upper estuarine bar. Thus the tidal energy is influencing the nature of the upper estuary bar sediments.Lower estuary bar after few months has the river mouth shifted towards north part of the river channel sediment deposition takes place in the sheltered environment. The diagram shows the unimodal nature with size medium sand of low energy environment.

The scatter plot (Fig.2) clearly brings out, the upper estuary bar mostly (medium sands) sediments are predominately sorted while lower estuary bar (medium to fine sand) sediments are moderated sorted. Upper estuary bar (Fig.3) sediments is negatively skewed whereas lower estuary bar sediments are positively skewed. Upper estuary bar (Fig. 4) sediments are leptokurtic while lower estuary bar sediments are mesokurtic nature. Moderately to poorly sorted (upper estuary bar-Fig. 5) sediments are negatively skewed, poorly sorted sediment are very negatively skewed while moderately sorted (lower estuary bar) sediments are positively skewed. Negative skewness (upper estuary bar- Fig.7) sediments are leptokurtic whereas positive skewness (lower estuary bar) sediments are mesokortic in nature.

The Frequency Distribution Curves (FDC) clearly suggests that the upper estuary bar sediments are bimodal and lower estuary bar sediments are unimodal in nature.

The CM plot of upper estuary bar sediments indicates two different depositional conditions viz. bottom suspension and rolling whereas lower estuary bar sediments are, bottom suspension and graded suspension.

The costal wave dynamics are varying from season to season. The estuary mouth position shifts according to the seasonal coastal tidal currents; it's clearly observed that the texture of the estuary bar sediments are influenced by the oscillation of estuary mouth from time to time. The pendulum effect of the estuary is controlling the granulometry of the coastal sedimentary environments of the Gostani River.

Acknowledgments

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