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Grain size Analysis of the Sediments of the Jayanti Estuary, Shariatpur-Barisal, Bangladesh

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Abstract: *The size of the sediment varies from very fine sand to coarser silt. The frequency curves of the most samples are sharp peaked and narrow, indicating that the samples are well sorted to moderately well sorted, while one is moderately sorted. The average percentage of traction population is 2.90%, of saltation population is 71.24% and suspension population is 26.38%. The leptokurtic nature of the deposits in the study area suggests that the sediments have achieved good sorting in the high-energy condition of the estuary and/or delta. The plot of graphic kurtosis Vs inclusive graphic skewness indicates the deposition of the sediments in the river influenced environment.*

Keywords: *Sand, Silt, Saltation, Leptokurtic and River.*

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I. Introduction

The grain size of detrital sediment is of considerable importance (Saha et al., 2017). The size of the fragments comprising the clastic sediments is, in part, the basis of subdivision into sand, silt and clay. The grain size of the sediments reflects the abundance of sedimentary particles and energy condition of the transporting medium. The present study area lies in the south eastern part of Bangladesh. Sedimentological studies of the study area reveal that the deposits are mainly characterized by the fluvial and marine sediments (Roy et al., 2005).

Environmental studies with the help of statistical parameters of frequency distribution have long been attempted. Many generalizations have been made to figure out the relationship between grain size parameters and the environment of deposition. Current velocity, turbulence, density and velocity of the transporting medium and the stability of flow conditions are no doubt largely responsible for different types of size frequency distribution.

Friedman (1961, 1962 and 1967) attempted to distinguish between beach and river sands by plotting skewness against standard deviation (sorting). Friedman (1979) used different scatter plots using statistical measures such as mean, standard deviation, simple skewness measure and simple sorting measure of size frequency distribution of beach and river sediments.

The grain size of the sediments varies in the downstream direction of the Jayanti River. The mean sediment size can decrease (Pettijohn and Ridge, 1932; Self, 1977; Chen *et al.*, 2013) or increase (McCave, 1978; Nordstorm, 1981). A combination of statistical parameters (that is, mean size, sorting and skewness) helps to delineate the sediment transport direction.

STUDY AREA

The study area lies in Hizla thana of Barisal and Gosairhat , Damudya and Bhedargonj thanas of Shariatpur district. It bounded by latitude of 22°59′30″ N to 23°11′30″ N and longitude of 90°22′30″E to 90°28′30″ E (Fig. 1).Superficially Estuarine and Deltaic Deposits with an area of 231 square kilometers cover the study area.

Simple Location

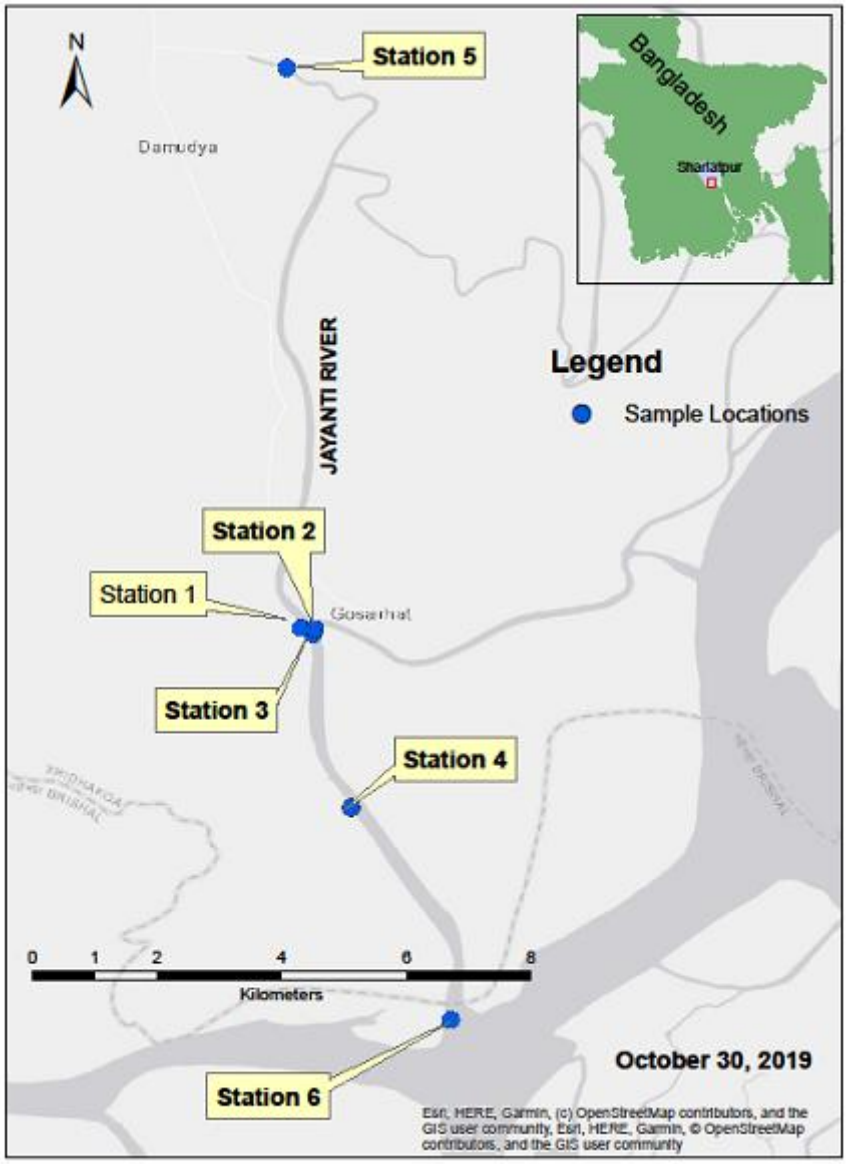


Figure 1: Map of the study area

The Meghna estuary is the most dominant of many riverine estuaries of the Bay of Bengal. It has got the fluvial source from the Ganges, Brahmaputra and Meghna river systems of Indian plate. The study area is located along a small branch of this estuary that extends for about 25 kilometers from the Hizla thana of Barisal district through Gosairhat and Damudya to Burirhat, Shariatpur district. It is a river dominated estuary visited by mixed semidiurnal tide throughout the year. The estuary experiences a humid tropical monsoon climate with mild summer and fairly heavy rainfall, 1770-2030mm/year. The mean sediment discharge for the Meghna river estuary is about 2.4 billion tons (Sikder, 1999), although discharges are highly seasonal.

There are three distinct geomorphic units in the field area. These are estuarine channel, estuarine plain and deltaic plain. The morphology of the estuary is determined by a valley system which is inherited from the erosion as well as deposition of estuarine and delta plain deposits of Holocene age. The stratigraphic units which are at the same time facies units vary in thickness both vertically and laterally. The lithocolumn consists of medium sandy deposits at the base which fines upward to silt and clay.

The geomorphic elements of estuarine plains include estuarine mud flat, sand flat, tidal marsh, swamps, tidal creeks and channels. The landforms have specific tidal process enhanced origin with little or no fluvial influence. The estuarine plain is generally overlain by silt to clayey silt, sandy silt, and clay and underlain by sandstone, siltstone and silty clay. The above morphogenetic units within this plain inundated by daily semidiurnal tide, throughout most of the year except a short period (December to March). During the high monsoon flood the whole area is inundated by water column. Some high energy influx (mostly silt and fine sand

in the form of ripples) deposits on this plain during peak flood period, though a part of which may be washed out during subsequent tidal reworking.

Deltaic plains cover the north and north-western part of the study area and include plains and backswamps. The deltaic plain area is covered with sand and silt rich sediments (dsd) to the north and silty clay and clayey silt (dsl) to the north-west.

II. Methodology

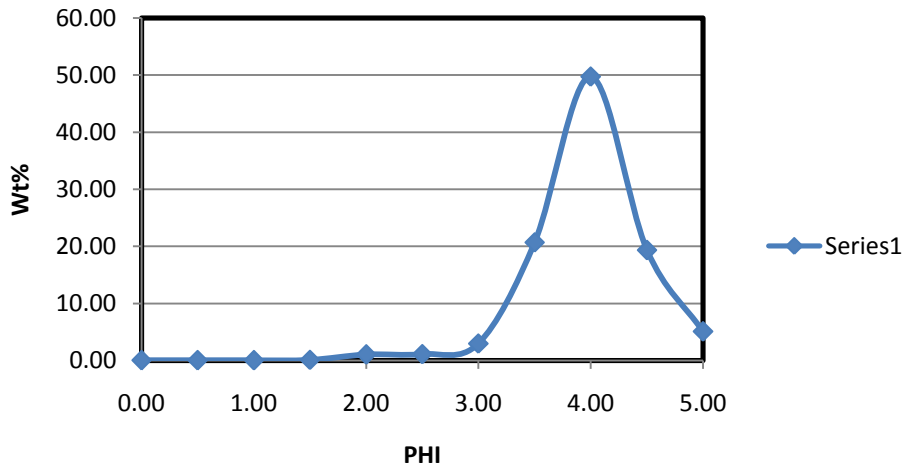
The grain size analysis of sediments was completed in the laboratory following a standard procedure for sieve analysis of twenty six sand samples. The materials and instruments used for the laboratory analysis are: a) balance, b) sieve mesh openings, c) thermostatically controlled oven, d) trays, e) sieve brushes, f) mortars with rubber cover pestle and g) Tyler Ro—Tap resting sieve shaker. Sediment samples were kept in an oven dryer for twenty four hours at 105°C temperature and then cooled to the room temperature. 100 grams of each of the samples weighed using a balance. The samples were then sieved. Each of the samples was sieved for 15 minutes and grains retained on each sieve were weighed.

III. Results And Discussion

FREQUENCY CURVE

For all of the analyzed samples the frequency curves are plotted taking the frequency of different size classes along the vertical axis (ordinate) and the phi sizes along the horizontal axis (abscissa). As the frequency curves are assymetrical and are not bell shaped (Fig. 2), the distribution of different size classes are not normal.

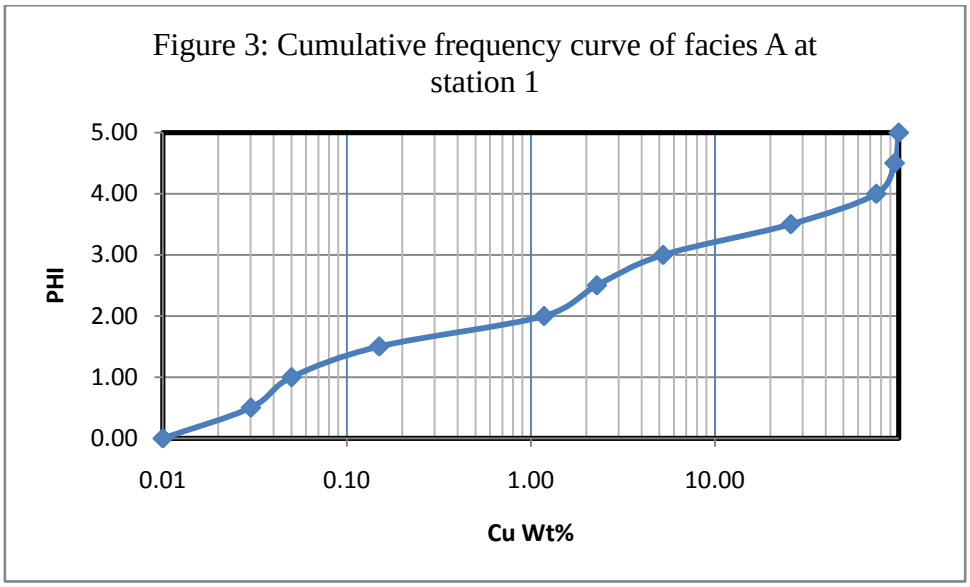
Figure. 2 Size frequency curve of facies A at station 1



The frequency curves of the most samples are sharp peaked and narrow, indicating that the samples are well sorted to moderately well sorted, while one is moderately sorted.

THE CUMULATIVE-FREQUENCY CURVE

The cumulative-frequency curves as drawn are not continuous straight lines showing that the distribution of different size classes are not log normal (Fig. 3). In fact, four straight line segments are present in each sample; each having the different slopes and is separated by a more or less sharp break. These segmented curves indicate that each of the samples is constituted by three populations: traction, saltation and suspension. The slope of each straight line segment of each curve reflects the mechanism of transportation and deposition.



The average percentage of traction population is 2.90%, of saltation population is 71.24% and suspension population is 26.38% (Table 1). The saltation population can be further divided into two sub-populations as lower saltation and upper saltation.

Table 1: Showing the traction, saltation and suspension population on the analyzed samples of the study area (in weight percent).

Sample No.	Traction	Saltation		Suspension
		Lower	Upper	
A_1	0.14	6.05	88.02	5.79
A_4	1.95	8.21	73.86	15.98
A_4	3.85	92.97		3.19
A_6	1.20	7.42	80.43	10.95
B_3	4.10	13.37	51.85	30.68
B_2	7.49	14.30	38.41	39.79
B_5	0.89	5.10	64.02	29.99
F_4	1.36	9.15		89.49
G_3	0.50	7.65	80.33	11.52
Average	2.39	71.24		26.38

The cumulative-frequency curves represented curves represented from the analyzed samples show that the majority of the sediments within the facies A, B, F and G in the stratigraphic column might had followed the saltation path, while the suspension possessed second highest path.

The dominant saltation population depends upon various hydrodynamic factors such as current velocity, water depth and nature of depositional slope.

Traction population closely related to the turbulence of the transporting medium. Suspension population is an indication of the distribution of fine-grained sediments (especially clay) and low energy condition of the transporting agents. The sediments, which are carried by suspension, might have deposited during flood tides and slag water periods when velocity of the medium ceases.

It is also notable that the steeper slope of the cumulative-frequency curve implies better sorting (Friedman & Sanders, 1978; Reineck & Singh, 1980; Pettijohn, 1984).

MEDIAN

The median values of the analyzed five samples range from 3.53 to 3.98φ which indicate very fine sand and of the rest three samples range from 4.00 to 4.30φ indicating coarse silt grade. The difference between the numerical value of median diameter and graphic mean (Mz) ranges from 0.01 to 0.41φ.

MODE

The samples analyzed from various facies at various locations in the field area have both unimodal and bimodal distribution. Only one sample is bimodal while the major amounts are unimodal. It can be concluded that most of the sediment A, B and G and sandy part of the facies F would be bimodal in principle because of

the sediments are product of tidal current activities within the estuary. The mode values ranges in between 3.70 to 4.20φ with an average value of 4.15φ.

GRAPHIC MEAN (Mz)

Size of the sediments retains the characteristics of the environment of sedimentation mainly because it is an index of the energy conditions. The estuarine sediments are characterized by very fine sand size (3φ to 4φ) and as such can be distinguished from the sediments accumulating in the aeolian and lacustrine environments which too have finer size of the sediments as compared to that of the glacial, fluvial and beach environment (Chaudhri *et al.*, 1981). The competency of the river at this stage reduces to the extent that it cannot carry coarser fraction due to sluggish movement of water and wider span of the channel.

The graphic mean values of different samples range from 3.30φ to 3.97φ (five samples) and 4.05φ to 4.08φ (for three samples). It differs from that of average mode and median by 0.38φ and 0.07φ respectively.

From the result it is clear that not simple distributions in these sediment columns have identical values of mode, median and mean. This is because of the fact that the flood tide carries only fine detritus in suspension (mostly clay and silt) and ebb tide transport the coarse sediments (sand and coarse silt) that were transported by the mighty Ganges-Brahmaputra-Meghna river system at its mouth.

Table 2: Graphic measure values of the analyzed samples of the Jayanti Branch of the Meghna estuary

Graphic measures	Sample No. A_1	Sample No. A_4	Sample No. A_4	Sample No. A_6	Sample No. B_3	Sample No. B_2	Sample No. B_5	Sample No. F_4	Sample No. G_3
C	2.00	1.80	1.20	1.64	--	0.82	1.60	0.75	1.78
M_d	3.72	4.04	3.54	3.98	4.30	4.30	3.35	3.40	4.00
M_o	4.00	4.20	3.90	4.05	4.75	5.00	3.70	3.70	4.10
M_z	3.77	4.08	3.51	3.97	4.06	3.89	3.30	3.37	4.05
σ_1	0.44	0.46	0.48	0.44	0.96	1.08	0.55	0.63	0.42
SK_I	0.17	0.02	-0.08	-0.06	-0.62	-0.65	-0.09	-0.20	0.03
K_G	1.29	1.09	1.34	1.32	2.05	1.93	1.10	1.25	1.21
SO_S	0.79	0.81	0.85	0.79	1.94	1.88	0.90	1.19	0.74
α_S	0.04	-0.17	-0.10	-0.18	-2.99	-2.64	-0.10	-0.74	-0.16

INCLUSIVE GRAPHIC STANDARD DEVIATION (σ_1)

Standard deviation is an environment sensitive textural parameter. Sorting of sediments reflects the velocity of the transporting medium, energy of waves, turbulence of water, depth of the basin and the rate of sedimentation. The slope of the cumulative curves and log-probability plots reflect the sorting of the sediments deposited in the estuarine environment (Fig. 3).

The inclusive graphic standard deviation of the analyzed samples range from 0.44φ to 1.08φ (Table 2) indicating well sorted to moderately sorted nature of sediments. Friedman & Sanders (1978) concluded that the well sorted sediments are nature of most beaches (foreshores), shallow marine shelf and at the end point of the rivers where it falls in the sea. From the above discussion it may be summarized that well sorted sediments are tide generated and in the field area these indicate an estuarine environment.

INCLUSIVE GRAPHIC SKEWNESS (SK_I)

Although skewness is environmentally sensitive textural parameters, yet in polymodal distributions the parameters loses much of its significance. The importance of skewness in deciphering the environments of sedimentation has been emphasized among others by Mason & Folk (1958) and Friedman (1979). In general beach, coastal dune, deltaic and estuarine sediments have negative skewness (Mitra & Ahmed, 1990).

The values of inclusive graphic skewness (SK_I) range from -0.65ϕ to 0.17ϕ with an average value of 0.14ϕ. The sediments of facies A at location 1 is finely skewed which might have happened by the excessive supply of fine grained materials. The strongly coarse skewed nature of the deposits of facies B at locations 3 and 5 are either indicative of supply of finer sediments from tributaries/upstream direction or subjected to the washing effect of the coarser light fraction and facies F at location 17 probably suggests the sedimentation from the suspended load. Rest of the samples is negatively skewed. This may be attributed to the higher degree of winnowing applied over the sediments brought by the rivers to the downstream by means of tide.

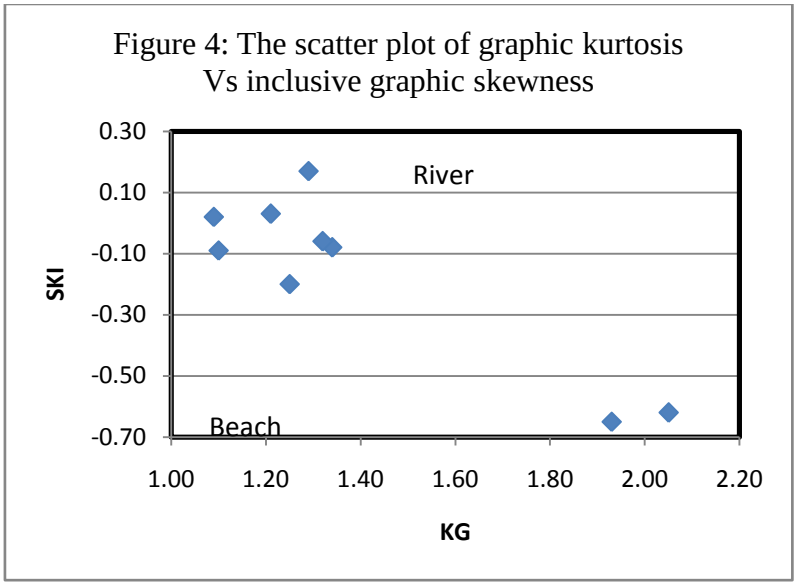
GRAPHIC KURTOSIS (K_G)

Kurtosis values do show any definite pattern in different modern environments of sedimentation and the parameter is a mediocre mean for distinguishing the aeolian, glacial, fluvial, lacustrine and deltaic environments.

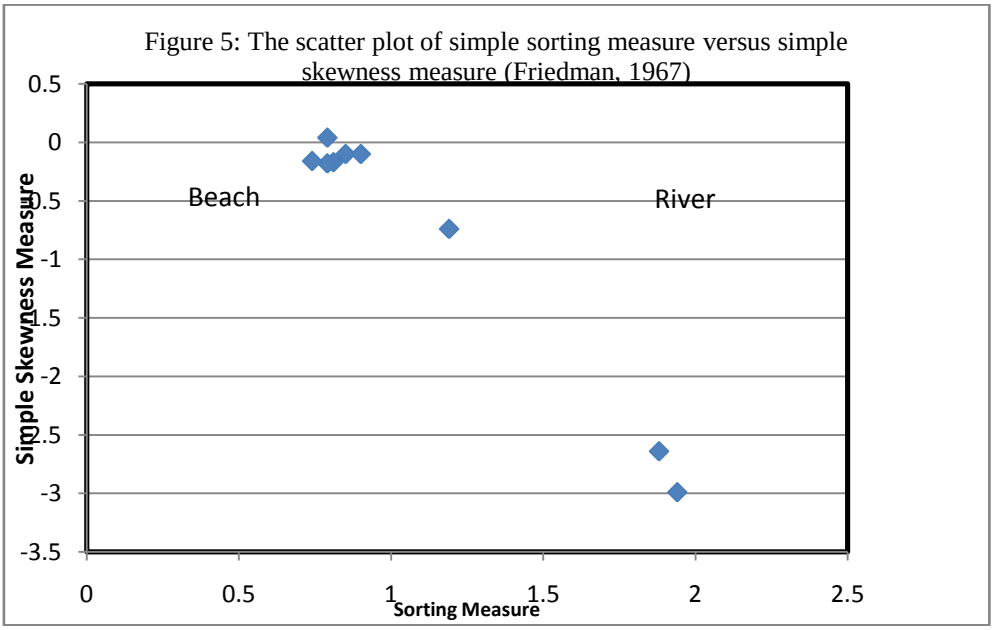
All the analyzed samples of the field area are leptokurtic. The leptokurtic nature of the deposits in the study area suggests that the sediments have achieved good sorting in the high-energy condition of the estuary and/or delta.

DEPOSITIONAL ENVIRONMENT THROUGH SCATTER PLOTS

Previous observations by many workers have proven that representative fields of a particular modern environment can be separated by scatter plots of one sediment size descriptor against another. The scatter plots of various workers have been used for recognizing the environments of different sediments in the field area.
The plot of graphic kurtosis Vs inclusive graphic skewness (Fig. 4) indicates the deposition of the sediments in the river influenced environment.



The scatter plot of the simple sorting measure versus simple skewness measure (Friedman, 1967) has shown that the field sediments are deposited in two environments: facies A, B and G in beach zone while facies F falls within the river zone (Fig. 5).



The study on the basis of scatter plots of textural parameters of the sediments of the field area inferred to be influenced by river and beach conditions. The sedimentation takes place at the mouth of the Ganges-Brahmaputra-Meghna river system where it falls into the Bay of Bengal and sediments are characterized by the winnowing nature of tidal action.

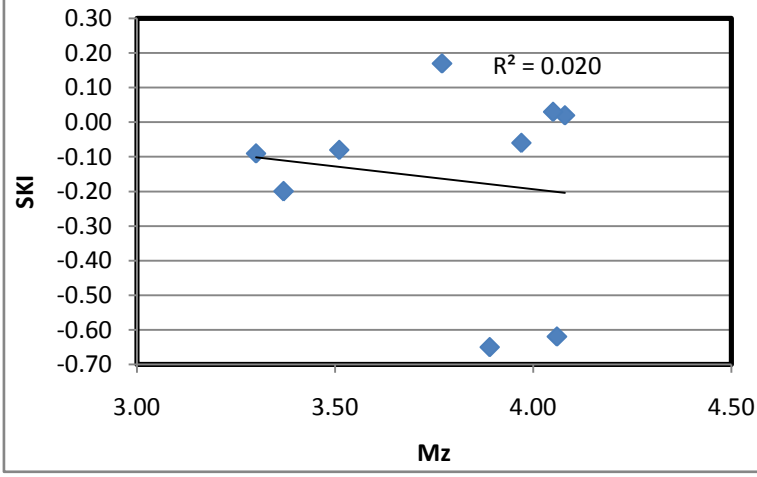
IV. Conclusion

The analyzed samples from facies A, B, G and sandy part of F of the Hizla-Gosairhat-Damudya-Burirhat branch of the Meghna estuary belongs to very fine sand and coarse silt class. The sediments experienced tidal action. Based on the standard deviation values, the sandy analyzed samples of the study area moderately sorted to well sorted. The skewness value ranges from 0.65ϕ to 0.17ϕ with an average value of -0.14ϕ. The analyzed coarser sediments give a leptokurtic distribution whereas the dominance of one mode gives a distribution that is leptokurtic (Folk and Ward, 1957). The sediments of facies A, B and G are not unimodal and necessarily they are bimodal. But contradiction arises due to more leptokurtic distribution of the sediments which is because of finer sediment fraction (clay) could not be studied for grain size analysis for constraints of laboratory facilities.

The scatter plots of the more significant environmentally sensitive size parameters reveal that most of the analyzed sediments fall within the river and beach environments, which can be explained in the form of deposition took place tide dominated estuary and tide influence delta.

A negative correlation is resulted by the plot of Mz vs SK_I (Fig. 6) indicating that as grain size increases the skewness changes from negative to slightly positive in value. Similar relationship has also been noted from the beach sands of Kerala (Purandara *et al.*, 1987).

Figure 6: The relationship of mean size versus inclusive graphic skewness



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Reference

[1]. Chaudhri, R.S., Khan, H.M.M., & Kaur, S. (1981) Sedimentology of beach sediments of West Coast of India, *Sed. Geol., 30,* pp. 79-94.

[2]. Chen, G., Yi, L., Chen, S., Huang, H., Liu, Y., Xu, Y., & Cao, J. (2013) Partitioning of grain-size components of estuarine sediments and implications for sediment transport in southwestern Laizhou Bay, China, *Chinese Journal of Oceanology and Limnology, 31,* pp. 895-906.

[3]. Friedman, G.M. (1961) Distinction between dune, beach and river sands from their textural characteristics. *Jour. Sed. Petrology, 31,* pp. 514-529.

[4]. Friedman, G.M. (1962) On sorting, sorting coefficients, and the log-normality of the grain-size distribution of clastic sandstones. *Jour. Sed. Petrology, 35,* pp. 643-655.

[5]. Friedman, G.M. (1967) Dynamic process and statistical parameters compared for size frequency distribution of beach and river sand. *Jour. Sed. Petrology, 37,* pp. 327-354.

[6]. Friedman, G.M. (1979) Differences in distribution of populations of particles among the sands of various origins. *Sedimentology, 36,* pp. 3-32.

[7]. Friedman, G.M., & Sanders, J.E. (1978) Principles of Sedimentology, *John Wiley and Sons,* New York.

[8]. Mason, C.C., & Folk, R.L. (1958) Differentiation of beach, dune and aeolian flat environment by size analyses, Mustang Island, Texas, *Jour. Sed. Petrol., 28,* pp. 211-226.

[9]. McCave, I.N. (1978) Grain-size trends and transport along beaches: an example from eastern England, *Marine Geology, 28,* pp. 43-51.
[10]. Mitra, S.N., & Ahmed, S.S. (1990) Distribution and textural characteristics of the heavy minerals in the beach and dune sands of Cox's Bazar, Bangladesh, *Jour. Geol. Soc. India, 36(1),* pp. 54-66.
[11]. Nordstrom, K.F. (1981) Differences in grain-size distribution with shoreline position in a spot environment, *Northeastern Geology, 3,* pp. 252-258.
[12]. Pettijohn, F.J. (1984) Sedimentary Rocks, *CBS Publishers and Distributors*, Delhi, *3rd ed*., pp.24-99.
[13]. Pettijohn, F.J., & Ridge, J.D. (1932) A textural variation series of beach sands fron Cedar Point, Ohio, *Journal of Sedimentary Petrology, 2,* pp. 76-88.
[14]. Purandara, B.K., Unnikrishnan, V.P., Gupta, C.S., & Dora, Y.L. (1987) Textural and mineralogical studies of the beach sands from Fort Cochin to Chellanam, Kerala, *Jour. Geol. Soc. India, 30,* pp. 524-531.
[15]. Renick, H.E., & Singh, I.B. (1980) Depositional Sedimentary Environments, *Springer-Verlag*, New York, pp. 122-123.
[16]. Roy M.K., Saha S., Ahmed S.S. and Mazumder, Q.H., 2005 Tide, morphology, litho-facies, zonation and evolution of a Middle Holocene to present estuary-Meghna, in south central Bangladesh: Journal of Geological Society of India v.66(3), pp. 354-364.
[17]. Saha S., Roy M.K. and Reza, A.H.M.S., 2017 Textural Characteristics of the Sediments of the Tista River, Rangpur, Bangladesh:Journal of Life & Earth Sciences v.12, pp. 73-79, 2017, JLES, RU.
[18]. Self, R.P. (1977) Long shore variation in beach sands, Nautla area, Veracruz, Mexico, *Journal of Sedimentary Research, 47,* pp. 1437-1443.
[19]. Sikder, D. H. (1999) Hydrodynamic characteristics of the coastal areas of Bangladesh: International Seminar on Quaternary development and Coastal hydrodynamics of the Ganges Delta in Bangladesh, 20-24 September, 1999, *Geol. Surv. of Bangladesh,* Dhaka p. 5.

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