Jahangirnagar University Environmental Bulletin, Vol.1,25-34 , 2012 *ISSN:2304-3326*

Textural Analyses of the Bar Sands of Gorai River: Implication for Depositional Phase and Environment

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Abstract

The present research work deals with the qualitative and quantitative estimation of angularity and roundness of sand grains and understanding their distribution pattern in the bars of Gorai river along with the textural analysis of bar sands of Gorai river of Kumarkhali region to infer the depositional environments and processes. The grain size analysis reveals that the bar sands of Gorai river are uni-modal, fine grained sand, well to very well sorted, strongly coarse skewed to near symmetrical and platykurtic to very leptokurtic in nature. From the CM analysis, bar sands of the studied area were deposited likely by the graded suspension of bottom currents. The angularity and roundness analysis of the bar sands of Gorai river are characterized by predominance of sub-angular to sub-rounded grains. Based on integrated information from the methods, especially from the sorting and roundness analyses reveal that the bar sands of Gorai river are in mature stage.

Keywords: Grain Size Analysis, Angularity and Roundness, CM Diagram, Textural Maturity.

Introduction

Gorai - Madhumati are the principal distributaries of the river Padma which is also one of the longest rivers in Bangladesh and its basin is also very wide and extensive. Gorai river is the upper course and the lower course is Madhumati of this distributaries. It flows through Kushtia, Jessore, Faridpur, Khulna, Pirojpur and Barguna districts. The Gorai is a very old river and is formed of three large offshoots of the Padma. The course of the Gorai-Madhumati is wide, long and meandering. The Gorai-Madhumati has a flood discharge of nearly 7,000 cusec (maximum recorded flow is nearly 7,932 cusec at Kamarkhali point) but in winter its flow goes down to 5 cusec (Banglapedia, 2004). The lower course of this river is now almost dry bed.

Size frequency distribution and textural parameters obtained from grain size analyses are the fundamental approach to deduce the detailed geologic information focusing the depositional phase and environment, as they reflect the mode of transportation and deposition history of an area. Many workers have attempted to deduce depositional environment from grain size data (Folk and Ward, 1957; Friedman, 1979, 1967, 1961; Inman, 1952; Klovan, 1966; Mason and Folk, 1958; Passega and Byramjee, 1969; Passega, 1964, 1957; Sahu, 1964; Shepard and Moore, 1955; Shepard, 1960; Solohub and Klovan, 1970; Trask, 1932; Visher, 1969). Folk and Ward (1957), Friedman (1979, 1967, 1961) and Mason and Folk (1958) have used statistical parameters of mean, standard deviation, skewness and kurtosis to deduce the depositional environment of clastic sediments. Friedman (1967) introduced different graphic measurements, which are known as simple sorting measure and simple skewness

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measure to distinguish between beach, dune and river sands. Passega (1964, 1957) and Passega and Byramjee (1969) have tried to establish relationships between texture and depositional processes, rather than between texture and environment and used the relationship between certain grains and the most probable depositional mechanism to classify clastic sediments by subdividing them into types indicative of their genesis. Visher (1969) recognized several sub-populations within the individual log-normal grain size distribution curve with a different mean and standard deviation.

In the present research, an attempt has been made to provide grain size data obtained form textural analyses of the bar sands of Gorai river to get information on the depositional environments and processes; to decipher qualitative and quantitative estimation of angularity and roundness of the sand grains and understanding their distribution pattern in the Gorai river bars; to infer the environment phase, mechanism of transportation and textural maturity of bar sands of Gorai river of Kumarkhali region based on integrated information from the methods.

Study area

The study area of Gorai river situated in Kumarkhali upazila of Kushtia district (Figure 1) and lies between $23^{0}51'07''$N to $23^{0}51'30''$N latitude and $89^{0}12'40''$E to $89^{0}14'02''$E longitude. Tectonically, the studied area falls in the faridpur trough (Alam et al., 1990) of Bengal Basin. The width of this zone varies from 75 to 125 km and it is characterized by a general gravity low with north-east trend. Apparently it relates to general subsidence of the basement.

Bangladesh can be divided into twenty-four sub-regions, with fifty-four units on the basis of physical features and drainage pattern (Rashid, 1991). The studied area lies in Padma-Madhumati floodplain unit of Mature Delta sub region. Padma-Madhumati Floodplain unit situated at the south of the present Padma, west of the Meghna and north of the non-saline tidal floodplain. This area receives flood water from land levels in this large sub-region varies considerably, from very shallowly flooded land in the north-west to deeply flooded basins in the south-west. There is some overland flooding, but the essential feature of this area is that there is neither extensive alluvion nor diluvion. Much of this plain was built up by the Madhumati when it was the main channel of the Ganges, but with the shifting of the main channel the land building process has ceased.

Methodology

In the present research, thirty seven (37) samples of bar sand were collected from different locations of Gorai river and among these ten (10) samples were chosen for grain size and roundness analyses (Figure 1). During the field Investigation, hand auger was used to collect the samples from a depth of about 1 m from the surface of the river bar. After mixing of 1 m column of loose sand followed by a statistical method, namely splitting sample by coning and quartering (Tyler, 1967) an amount of about 500 gm of samples was collected from each sample locations.

Sieving is the common method for laboratory analysis in the textural point of view. In the present research numerous river bar sand samples collected from different locations across Gorai river of Kumarkhali area, Kushtia for textural analysis. In the laboratory, all selective samples were dried in oven at 60°C. About 100 gm of sand were taken and sieved by "Ro-Tap sieving machine" for 25 minutes using 18, 35, 60, 120 and 230 U.S. standard meshes. Histograms were drawn as size grade (in phi-scale) versus weight retained (in gm). Cumulative curves were drawn as size grade (in phi-scale) versus cumulative weight percentage (in gm). Results of sieving have been statistically analyzed, plotted on scatter plot and CM diagrams to deduce the depositional process and environment.

To measure the percentage of grain angularity and roundness, the translucent grains were examined under the polarizing microscope (Meiji) after mounting the grains in Canada Balsam on microscopic slides. More than 350 translucent grains of each sample were counted with the ribbon count method.

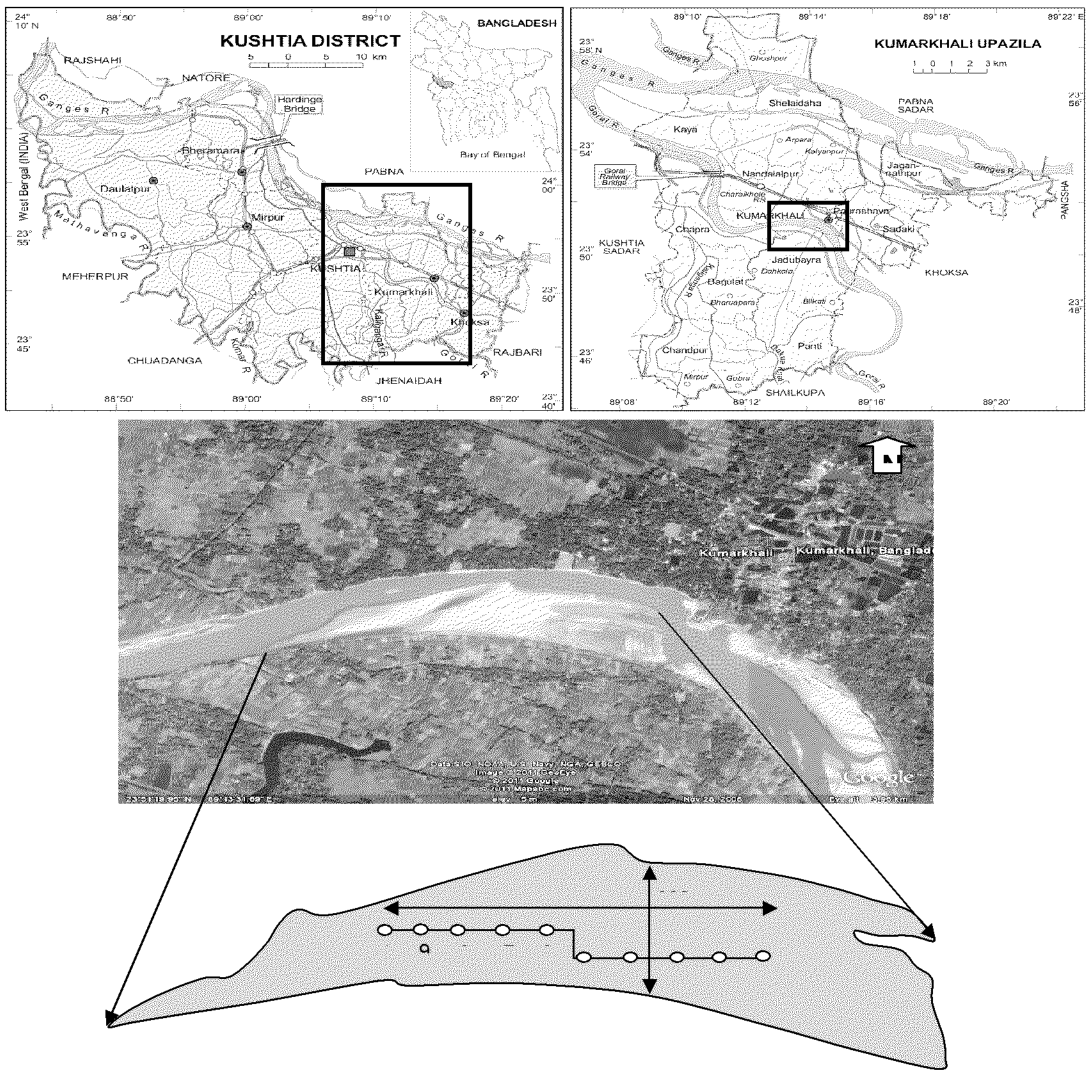

Figure 1: Sample location map of the studied area. (Source: Banglapedia, 2004; Google Earth, 2011).

Results

Grain Size Analysis:

The grain-size parameters of the Gorai river sands and their interpretations are shown in Table 1 and Table 2. From the scatter plots of standard deviation vs. graphic mean (Figure 2) and graphic skewness vs. graphic mean (Figure 3), it appears that most of the samples of the Gorai river bar sands are very well sorted to well sorted (standard deviation, Q_1 value ranges from 0.19Φ to 0.37Φ), fine grained (graphic mean, M_z value ranges from 2.28Φ to 2.62Φ), near symmetrical to strongly coarse skewed (graphic skewness, SK_1 value ranges from -0.87 to 0.013) and platykurtic to very leptokurtic (kurtosis, K_G value ranges from 0.87 to 1.95).

Table 1: Grain size parameters of the Gorai river bar sands

Sample No.	Median (in Φ)	Graphic Mean (in Φ)	Standard Deviation (in Φ)	Skewness	Kurtosis
S01	2.65	2.62	0.24	-0.310	1.95
S02	2.55	2.42	0.36	-0.438	0.93
S03	2.48	2.39	0.33	-0.350	1.72
S04	2.50	2.37	0.37	-0.463	1.08
S05	2.35	2.35	0.35	-0.065	0.96
S06	2.50	2.49	0.19	-0.870	1.48
S07	2.28	2.30	0.26	-0.103	1.11
S08	2.50	2.37	0.37	-0.464	0.87
S09	2.30	2.28	0.32	-0.106	1.05
S10	2.30	2.32	0.25	0.013	1.39

CM Pattern:

The values of C (1 percentile) and M (50 percentile) are listed in Table 3. Following certain grain size (1 percentile and 50 percentile) of the samples plotted on the CM diagram (Figure 4) (Passega and Byramjee, 1969; Passega, 1964, 1957), it appears that the values of C are ranging from 297 μm to 406 μm and the values of M are ranging from 159 μm to 206 μm for the bar sands of the Gorai river. The highest value of C has been observed in the sample S03 and S08 (406 μm) and highest M value has been observed in the sample S07 (206 μm). On the other hand, the lowest value of C has been observed in the sample S06 (297 μm) and lowest M (median) value has been observed in the sample S01 (159 μm) among the selected samples of the Gorai river bar sands.

All of the samples of the study area scattered within class V and fall in the QR segment. The point Q represents suspension sediments with few rolling grains and the point R represents graded suspension sediments (Passega, 1957). Thus the load type of studied samples can be designated as suspension to graded suspension with some rolling grains.

Table 2: Grain size interpretation of the Gorai river bar sands

Sample No.	Graphic Mean	Standard Deviation	Skewness	Kurtosis
S01	Fine Sand	Very Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
S02	Fine Sand	Well Sorted	Strongly Coarse Skewed	Mesokurtic
S03	Fine Sand	Very Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
S04	Fine Sand	Well Sorted	Strongly Coarse Skewed	Mesokurtic
S05	Fine Sand	Well Sorted	Near Symmetrical	Mesokurtic
S06	Fine Sand	Very Well Sorted	Near Symmetrical	Leptokurtic
S07	Fine Sand	Very Well Sorted	Near Symmetrical	Leptokurtic
S08	Fine Sand	Well Sorted	Strongly Coarse Skewed	Platykurtic
S09	Fine Sand	Very Well Sorted	Coarse Skewed	Mesokurtic
S10	Fine Sand	Very Well Sorted	Near Symmetrical	Leptokurtic

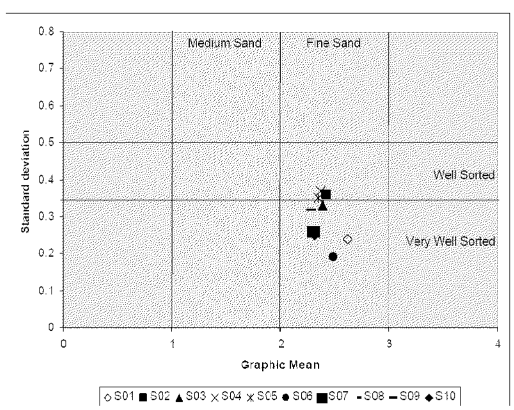

Figure 2: Scatter plot of standard deviation/graphic mean. Classification after Folk and Ward (1957).

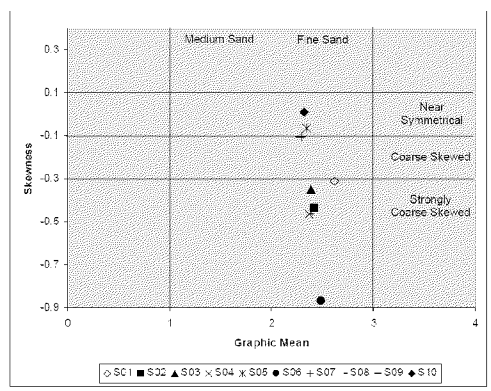

Figure 3: Scatter plot of graphic skewness/graphic mean. Classification after Folk and Ward (1957).

Angularity and Roundness Analysis:

Distribution pattern of different angularity of the grains are given in the Table 4. The angularity and roundness analysis reveals that the Gorai River bar sands contain 4.96% very angular, 23.11% angular, 35.81% sub-angular, 30.98% sub-rounded, 4.58% rounded and 0.56% well rounded grains.

Table 3: C (1 percentile) and M (50 percentile) data of the bar sands of Gorai river

Sample No.	C (Phi 1)	M (Phi 50)	C (mm)	M (mm)	C (μm)	M (μm)
S01	1.70	2.65	0.308	0.159	308	159
S02	1.55	2.55	0.342	0.171	342	171
S03	1.30	2.48	0.406	0.179	406	179
S04	1.60	2.50	0.329	0.177	329	177
S05	1.45	2.35	0.366	0.196	366	196
S06	1.75	2.50	0.297	0.177	297	177
S07	1.40	2.28	0.379	0.206	379	206
S08	1.30	2.50	0.406	0.177	406	177
S09	1.50	2.30	0.354	0.203	354	203
S10	1.42	2.40	0.374	0.203	374	203

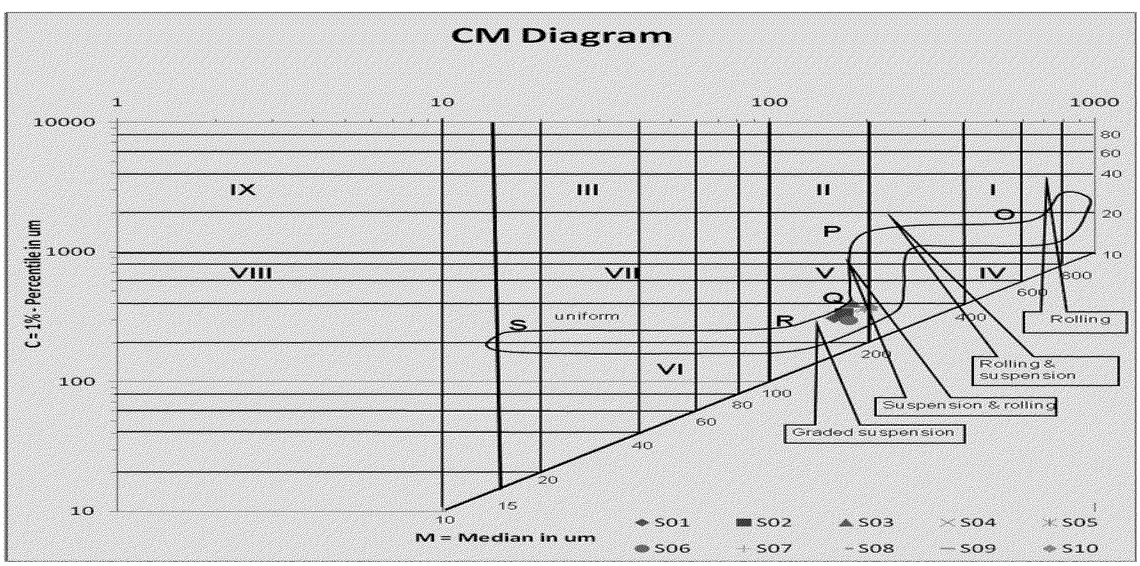

Figure 4: Scatter plot of Gorai river bar sands on CM diagram after Passega and Byramjee (1969).

Textural Maturity:

There are four stages of textural maturity of sediments proposed by Folk (1968) based on sorting and roundness of the grains. When the sediments are poorly sorted and angular in shape contain more than 5% clay called immature stage; grains are poorly sorted and not well rounded contain few clay lies in sub-mature stage; sand grains are well sorted but not well rounded is mature stage; sediment contains no clay with well sorted and well rounded is super-mature stage. Bar sands of Gorai river are in mature stage. Because it is well sorted with standard deviation under 0.5Φ, contain little or no clay with sub-angular to sub-rounded grains.

Table 4: Angularity and roundness analysis of the Gorai river bar sands (in grain %)

Sample no	Very Angular	Angular	Sub Angular	Sub Rounded	Rounded	Well Rounded
S01	6.91	25.3	33.51	27.39	6.38	0.53
S02	6.18	26.6	30.91	29.30	5.65	1.34
S03	7.61	24.9	30.97	29.13	5.51	1.84
S04	6.40	24.5	32.53	29.07	6.67	0.80
S05	5.95	22.9	36.26	29.75	5.10	0.00
S06	4.86	24.1	34.86	32.70	3.24	0.27
S07	2.12	20.7	40.32	33.42	3.45	0.00
S08	3.72	23.1	38.03	32.45	2.66	0.00
S09	2.48	20.9	39.67	32.78	3.31	0.83
S10	3.32	18.0	41.00	33.80	3.88	0.00
Average	**4.96**	**23.1**	**35.81**	**30.98**	**4.58**	**0.56**

Discussions

The grain size parameters of sand samples of the study area of Gorai river are uni modal, fine grained, well to very well sorted, strongly coarse skewed to near symmetrical and platykurtic to very leptokurtic in nature. Roundness of the grains are sub-angular to sub-rounded. Many researchers have attempted to infer the depositional environment and environmental implications from grain size data of the sediments from the Ganges-Brahmaputra-Meghna river system in the Bengal Basin (Alam, 1992; Chowdhury, 1989; Datta et al., 1997; Jasy, 2009; Rahman and Huq, 2000). The grain size parameters of sand samples of the study area are in good agreement with those studies. The Brahmaputra-Jamuna bar sands were found to be uni-modal, very fine to medium grained (mean size range 1.73Φ to 3.88Φ), very well sorted to moderately sorted (sorting range 0.31Φ to 0.76Φ), strongly coarse to fine skewed (range -0.44Φ to0.28Φ) (Jasy, 2009).

According to genetic sorting classification based on standard deviation after Friedman (1962) and CM pattern (Passega and Byramjee, 1969) in Figure 4, it is obvious that the sands were deposited by graded suspension mechanism. The river deposits are generally, coarse grained (>0.5 mm and Φ scale <0.5 phi), poorly sorted (grain size >0.71Φ), positively skewed because of fine tails and angular in grain shape (Boggs, 1987). But in the present study, the graphic mean of all samples fall in the fine sand class. According to Miall (1977), 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 bedload sediment is deposited in down stream in the lee of the bar. Moreover the finer particles are present because river water normally contains a fairly high concentration of suspended clay and silt (Blatt et al., 1980). The studied sample of Gorai river are very well to well sorted. It is assumed that the energy condition of the river can able to allow mainly the fine sand particle (77% to 93%) along with some medium sand fraction (3% to 22%) and negligible amount of very fine sand, silt and clay particles (0.5% to 7.5%). On the other hand the detritus source area of these sediments may consist of such grade of particles from where these reworked sediments came from. Dunification of the central part of the point bar and sinuosity of the Gorai river may responsible for such result. Negative skewness values have been found in most of the samples (90%) of the present study. This negative skewness results are likely from winnowing by waves and tidal currents that removed the finer particles. Friedman (1979) also found a good number of negative skewness values for river sands. Generally positive skewness indicates unidirectional flow of the transporting medium and is believed to provide explanation for the generally positive skewness of dune and river sands, whereas negative skewness indicates to and fro motion of the transporting media particularly in beach environment where finer components are removed by winnowing (Friedman, 1961). Wave action of the Gorai river along with the aeolian effect may be responsible for the negative skewness scenario. Moreover, the point bar deposits of Gorai river are inundated repeatedly in the wet season especially during the flood condition.

Conclusions

The following conclusions can be made by analyzing and reviewing all the textural parameters of the studied sand samples of the Gorai river at Kumarkhali, Kushtia area.

The grain size analysis reveals that the bar sands of the studied area are uni-modal, fine grained, well to very well sorted, strongly coarse skewed to near symmetrical and platykurtic to very leptokurtic in nature. The angularity and roundness analysis suggests that Gorai river bar sands are characterized by predominance of sub-angular to sub-rounded grains. The samples of the Gorai river area plotted on CM diagram represent that the sands were deposited as graded suspension deposits (Passega, 1964). The textural maturity based on the sorting and roundness analyses reveal that the bar sands of Gorai river are in mature stage.

Acknowledgements

This research work was carried out under the financial aid provided by Jahangirnagar University Research Grant 2010-2011 for the Faculty of Mathematics and Physical Sciences. The authors are indebted to the Department of Geological Sciences, Jahangirnagar University, Savar, Dhaka for permitting to conduct the research and using the laboratory facilities. The authors are grateful to Mr. Md. Belayeth Hossain, Lab. Attendant, Dept. of Geological Sciences, JU, for his kind co-operation for the preparation of grain slides and assistance to conduct this research work.

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