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Textural Characterization of Beach Sediments Along Ibeno Beach: A Sector of Atlantic Ocean, South Eastern, Nigeria

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Abstract

Sediments were sourced from 16 stations along the Ibeno Beach sector of the Atlantic Ocean located in Southeastern Nigeria. The areas of interest included; Inua Eyet Ikot, NtaIkang and Itak Iban. The textural characteristics of the sediments include: mean grain size (Mz) which ranges from2.30 to 3.57 with a mean of 2.77 ± 0.34 infering fine grain to very fine sands. The graphic standard deviation (Sorting, σ_I) has a mean value of 0.57 ± 0.10 and ranges from 0.38 to 0.70 inferring moderately well sorted to well sorted sediments. Sediments Skewness (S_{KI}) and kurtosis (K_G), have ranges values of -0.48 - 0.49 and 0.78-1.50 with mean values of 0.08 ± 0.21 and 0.92 ± 0.22 respectively depicting sediments that are dominantly coarse skewed in nature with kurtosis giving the scenario of platykurtic – leptokurtic. Based on the calculated discriminant function, the sediment of the study areawas derived from shallow agitated marine environment (subtidal environment) with some contribution from aeolian processes.

Keywords: *Discriminant function, Ibeno beach, Sediments, Shallow agitated marine environment, Textural characteristics*

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Background to the Study

The study of sediment characteristics has become a fundamental practice in hydrological, geomorphological and sediment logical studies [1]. Geologists use grain size statistical attributes as an excellent application in system''s energy level, modes, medium, mean grain size, uniformity of grain size, distribution of sediment around the central position (peakness) as well as variation in the energy of distribution of the particle size. Grain size analysis as a sediment logical tool is useful in unravelling the hydrodynamic conditions of sediment transport and depositional histories. In hydrology, the movement of subsurface fluid can be evaluated using grain size. On the other hand, engineers have applied the knowledge of grain size in revising sample permeability and stability under load especially for non-cohesive sand and gravels [2]. The main thrust of this paper is to show how sediment grain size are spatially distributed and with their characteristics in a section of Ibeno Beach, which is a part of the coastal portion of the Atlantic Ocean in Southeastern Nigeria. This may be useful in checking coastal erosion, rate of penetration of coastal oil spillage, estimation of sediment budget for purposes of beach nourishment as well as the erection of engineering structures within the study area.

Location of Study Area

The area under investigation is a section of the Ibeno Beach, which is a part of the coastal portion of the Atlantic Ocean exposed in Ibeno Local Government Area of Akwa Ibom State and lies entirely on the coastal plain of Southeastern Nigeria (Figure 1). Ibeno Beach is one of the beaches on the Atlantic Ocean along the Ibeno shoreline. It is a low gradient (<5°), mainly featureless and longest sandy beach type in West Africa; it spansup to 45km in length and103m in width during low water tide. The study area is characterized by semi-diurnal tide with a meso-tidal range of 2.4m [3].It is the most popular beach in Akwa Ibom State, attracting a lot of tourist and also houses Exxon Mobile operational Headquarter; which is a multi-international oil company in West Africa.

The geology of the area shows that itis part of the Coastal Plain sediment in Nigeria belonging to the Tertiary Benin Formation, that spans along coastal sedimentary basins in Nigeria. The geographic coordinates of the sixteen (16) stations (S1-16)sampled is located within Latitudes $04^0$32'32.9'' N and $04^0$32'40.5'' N, and Longitudes $008^0$01'06.3'' Eand $008^0$04'04.3'' E (Figure 1).

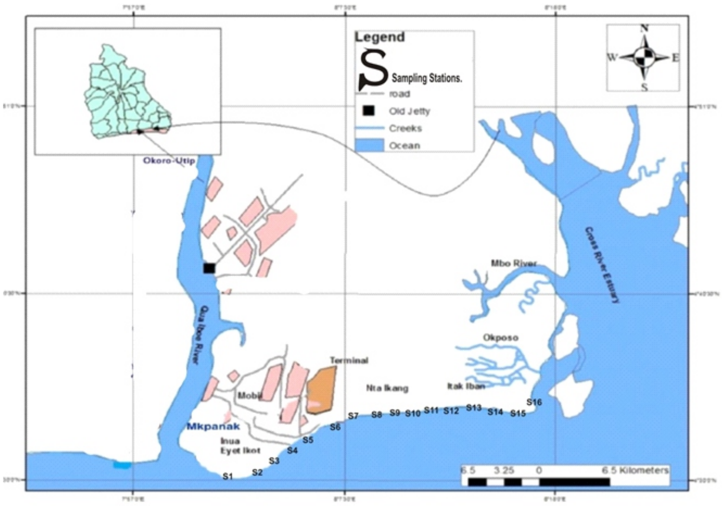


Figure 1. Map of the study area.

Materials and Method

Sediments deposited within 16 (S1-16) stations in Ibeno Beach were sampled using a corer. This was done in order to avoid sampling the surface sediments which may not be in-situ and may either be transported by any agent of erosion or man. A total number of 80 samples were obtained from the various sampled stations. A breakdown of this shows 6 sub- stations of 30 samples each from Inua Eyet Ikot (S1-S6) and NtaIkang (S7-S12) were carried out respectively, while 4 sub-stations totaling 20 samples were from Itak Iban (S13-S16). About 1kg to 2kg (wet weight) of sediments were collected per location. The wet sediment samples were stored in polythene bags, tied, labeled and transported to the laboratory for analysis. They were washed to remove debris and later dried in a hot air oven at 60^0C to remove any moisture content present. This was followed by oven drying and 100mg of the dried sample was taken by conning and quartering method in order to subject them to standard method of sieving using ASTM sieve set, which allows for better discrimination of the sub- populations. This was done for about 15 minutes in an electric Ro-Top sieve shaker. The sieved fractions were weighed and the overall results from all sampled stations computed. Cumulative graphs were plotted and the different phi (ϕ) values derived for each sample. The various statistical textural parameters of [4, 5] were analyzed. The average result from each of the investigated areas were computed and the results are presented in table 1

Table 1: The Calculated values of the Average Statistical Parameters of Grain Size Analysis from the present Investigated Area

Locations	Mean, $M_z(\phi)$	Sorting σ (ϕ)	Skewness (S_{KI})	Kurtosis (K_G)
S1	2.49 Fine grain	0.55 Moderately well sorted	0.31 Strongly fine Skewed	1.34 Leptokurtic
S2	2.30 Fine grain	0.42 Well sorted	0.49 Strongly fine Skewed	1.21 Leptokurtic
S3	2.68 Fine grain	0.66 Moderately well sorted,	0.03 Near symmetrical	0.80 Platykurtic
S4	2.66 Fine grain	0.63 Moderately well sorted	0.11 Fine skewed	0.80 Platykurtic
S5	2.63 Fine grain	0.71 Moderately well sorted	0.2 1 Fine skewed	0.92 Mesokurtic
S6	2.40 Fine grain	0.70 Moderately well sorted,	-0.02 strongly oarse skewed	1.50 Leptokurtic
S7	2.85 Fine grain	0.59 Moderately well sorted	-0.01 strongly coarse skewed	0.78 Platykurtic
S8	2.65 Fine grain	0.63 Moderately well sorted	0.09 Near symmetrical	0.80 Platykurtic
S9	2.63 Fine grain	0.58 Moderately well sorted	0.24 Fine skewed	0.85 Platykurtic
S10	3.57 Very fine grain	0.41 Well sorted	-0.48 Strongly coarse Skewed	0.83 Platykurtic
S11	3.42 Very fine grain	0.38 Well sorted	0.03 Near symmetrical	0.79 Platykurtic
S12	2.70 Fine grain	0.60 Moderately well sorted	0.14 Fine skewed,	0.82 Platykurtic
S13	2.74 Fine grain	0.65 Moderately well sorted	0.02 Near symmetrical	0.80 Platykurtic
S14	3.17 Very fine grain	0.43 Well sorted	-0.19 Strongly coarse Skewed	0.92 Mesokurtic
S15	2.63 Fine grain	0.62 Moderatelyl well sorted,	0.16, Fine skewed	0.80 Platykurtic

S16	2.73 Fine grain	0.59 Moderately well sorted	0.08 Near Symmetrical	0.84 Platykurtic
AVG	2.77 Fine grain	0.57 Moderately well sorted	0.08 Near symmetrical	0.92Mesokurtic
MIN	2.30 Fine grain	0.38 Well sorted	-0.48 Strongly coarse Skewed	0.78 Platykurtic
MAX	3.57 Very Fine grain	0.71 Moderately well sorted	0.49 Strongly fine skewed	1.50 Leptokurtic
SD	0.34	0.10	0.21	0.22

Legend: M_Z = Mean Grained Size, σ_I = Inclusive Standard Deviation (Sorting), S_{K1} =Inclusive Graphic Skewness, K_G =Graphic Kurtosis, AVE=Average, MIN =Minimum, MAX =Maximum and SD = Standard Deviation

Results and Interpretation

A. Univariate Plot

The statistical grain size parameters used to describe the particle size distribution from the study area were grouped into four primary groups: the graphic mean, (Mz), inclusive graphic standard deviation (sorting σ), inclusive graphic skewness (S_K) and kurtosis. ($K_{G)}$.

Graphic Mean

The mean size is a function of the size range of available materials and amount of energy impacted on the sediment which depends on current velocity or turbulence of the transporting medium. The mean grain sizes (M_z) for the 16stationssampled has an average and range value of 2.77ϕ± 0.34ϕand 2.30ϕ - 3.57ϕ (table 1) respectively. This indicates that 81% of the samples are fine-grained sands while 19% indicate very fine-grained sands (Figure, 2) This suggests that the sediments were deposited under a low energy condition, as sediment usually become finer with decrease in energy of the transporting medium [6]. Also, the occurrence of fine grain sediment infers intensive effect of the erosive wave action prevailing in the study area. The overall sediment size greater than 2.00ϕ show that sediments have travelled a greater distance from the provenance area.

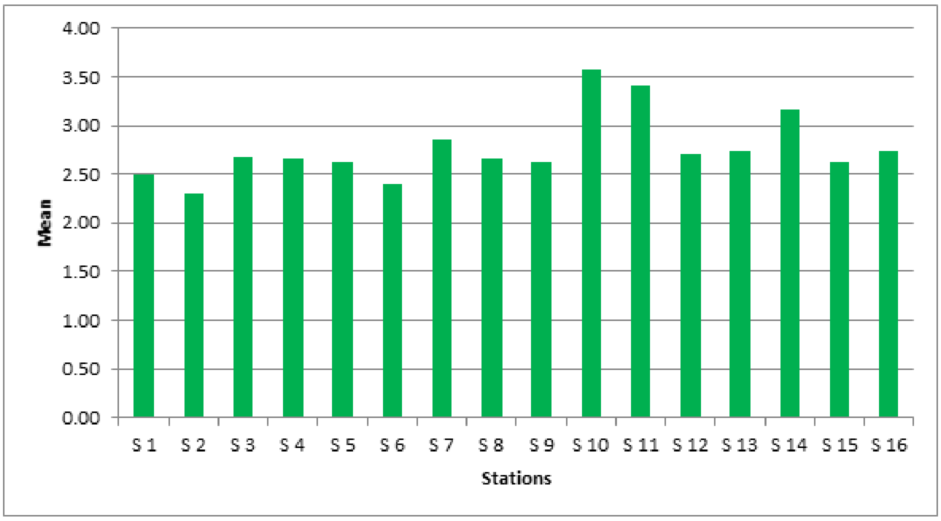


Figure 2.: Distribution of mean grain size from study stations

Standard Deviation (σ_I)

This is a measure of the standard deviation, which is the spread of the grain size distribution with respect to the mean. Sorting is the most useful grain size data since it gives an indication of the effectiveness of the depositional medium in separating grains of different classes. The analyzed sediments show a standard deviation (Sorting) range value of 0.38ϕ – 0.71ϕ and an average value of 0.57ϕ ± 0.10ϕ (Table1 and Figure,3), showing that 75% of the samples were moderately well sorted while 25% were well sorted. According to [7] the various ranges of sorting indicate the various environments of the sand. Well sorted to moderately well sorted grains are typical of moderate to low energy environment which in turn is indicative of low to fairly high energy current without turbulent condition, that prevailed during the transportation and deposition of the sediments [7, 8].

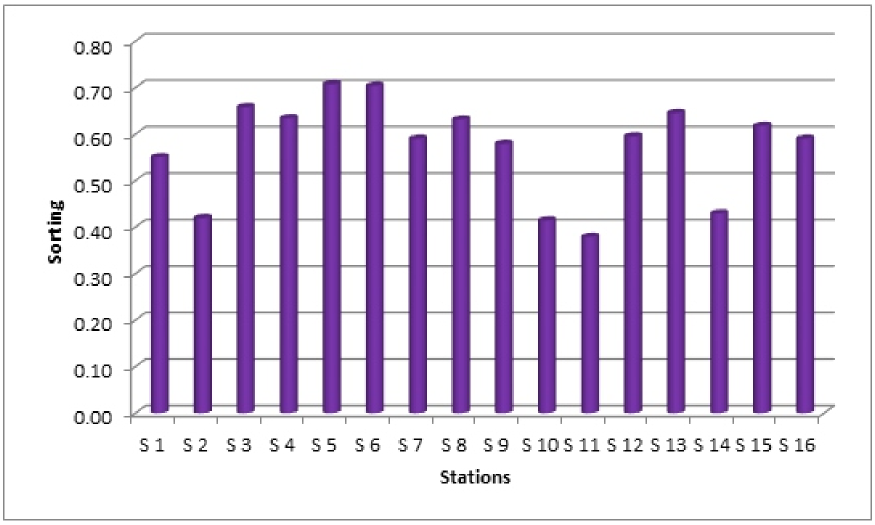


Figure 3. Distribution of grain size uniformity (Sorting) from study stations

Skewness

This reflects the depositional process. It is simply a measure of the symmetry of the distribution. Skewness is useful in environmental diagnostics because it is directly related to the fine and coarse tails of the size distribution, and hence suggestive of energy of deposition. The skewness from the investigated stations ranges from -0.48 to +0.49 with average value of 0.08 ± 0.21(Table 1 and Figure 4). The predominance of positive values indicates skewness towards the finer grain sizes and the negative values indicates skewness towards the coarser grain sizes. The analyzed samples are predominantly fine skewed inferring finer grain size.

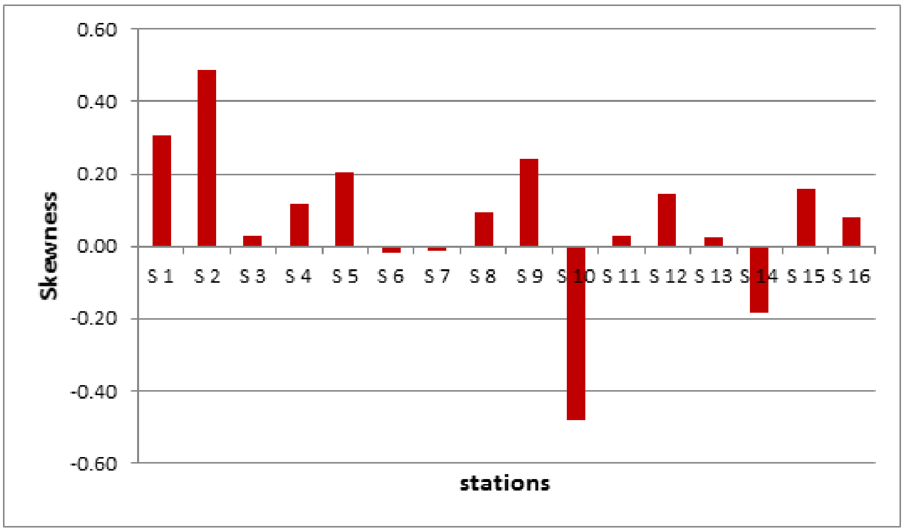


Figure 4.: Skewness distribution from the study area

Kurtosis

This measures departure from the normal distribution. It is the ratio of sorting in the central portion of the curve and the tail. The minimum and maximum values of kurtosis of the investigated area are 0.78and 1.50respectively with an average value of 0.92± 0.22 (Table 1 and Figure 5). The total samples analyzed shows that 68% of the samples are platykurtic (central portion is better sorted than the tails), 19% are leptokurtic (tails were better sorted than the central), and 13% are mesokurtic (sorting is uniform in both the central portion and tails. According to [7] inferred that where the values of kurtosis are extremely high or low they suggest that part of the sediment achieved their sorting outside the depositing setting in a high energy environment. This kurtosis variation values show that sub-population of the samples were derived from slightly different sources.

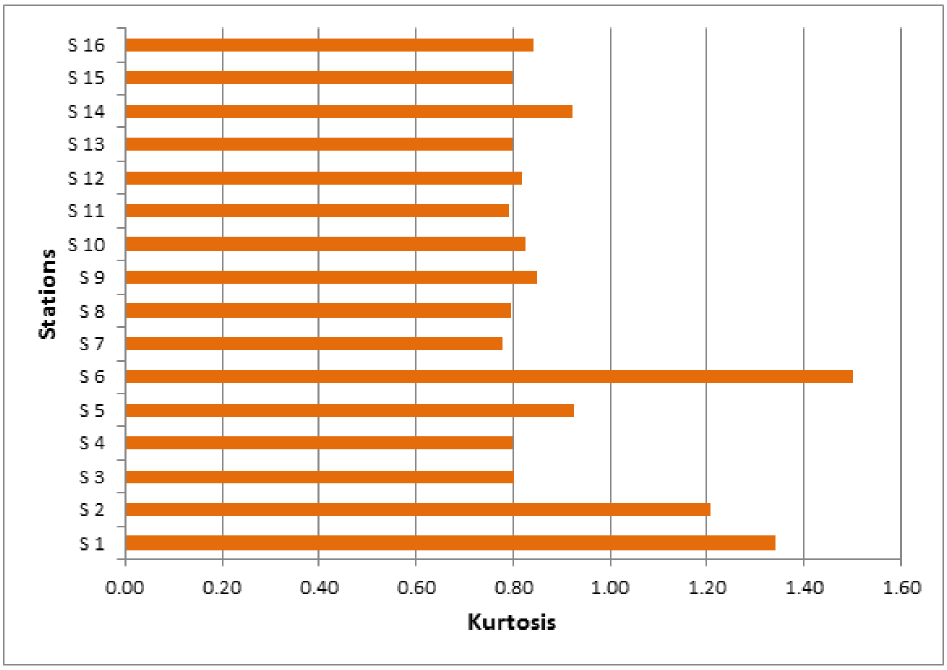
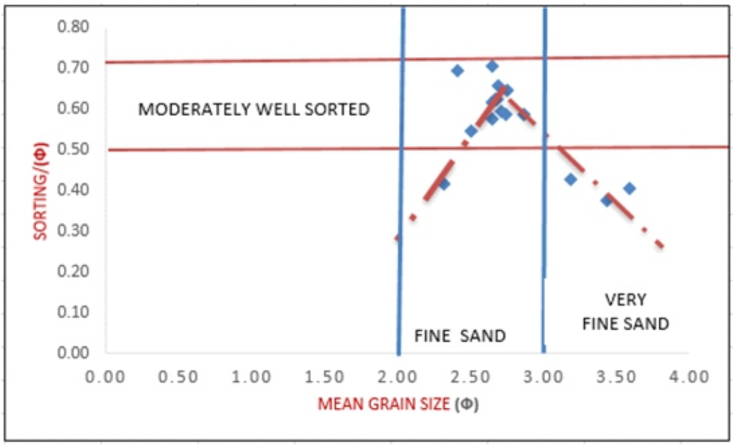


Figure 5: Variation in Kurtosis from each of the study location

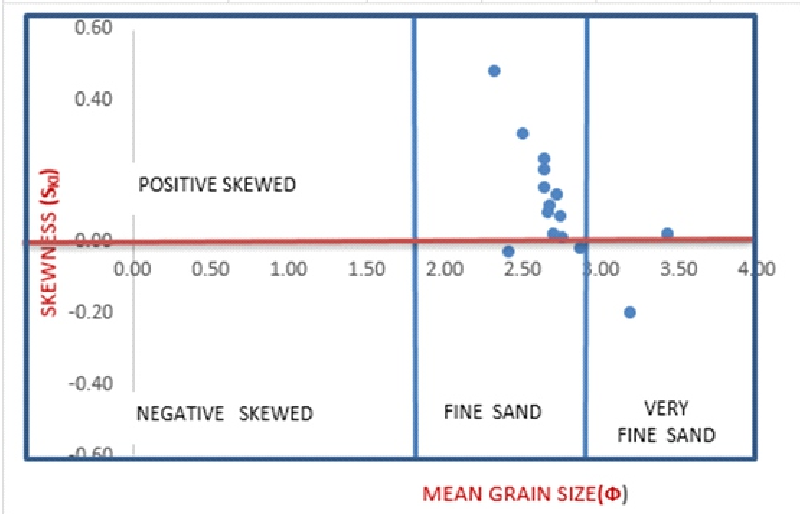
B. Bivariate Plot

The various bivariate plots are presented in figure 6 and discussed here:

The bivariate plot between mean grain size and standard deviation (sorting) from Ibeno Beach (Figure.6a) shows a total dominance of fine grain sizes which are moderately well sorted to well sorted. Standard deviation (sorting) is considered as a sinusoidal function of the mean grain size [4]. If statistically a wide range of grain size (gravel to clay) is present, scatter plot of sorting versus grain size, often form some segments of broadened 'M' - shaped trend, but if ' V ' shaped or inverted 'V '



6a.



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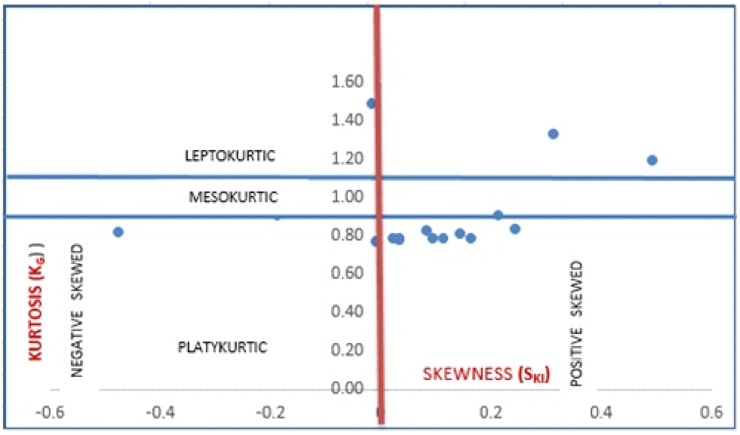

6c.

Figure 6: Bivariate plot of average values of grain size statistical parameters:
(a) Sorting versus Grain size [4].
(b) Skewness against Grain size
(c) Kurtosis versus Skewness

Trend appeared, the size range is small [4]. From the present investigation, the plotted values developed inverted 'V ' trend and concentrated closer to the two limbs of the inverted 'V ' trend (Figure 6a). This infers that there are no size ranges of sediments from the study area. This is an indicative of a steady and quiet energy flow during the deposition of these sediments. The plot shows that sediments become finer as sorting value increases [9]) and that the best sorted sediment have their mean size in a finer sediment fraction.

The scatter plot of mean grain size against skewness (Figure 6b) indicates dominance of fine grain sand with positive skewed over negative skewed. The positive skewness according to[10]indicate sediments which are transported by wind. Also, the bivariate plot between skeweness and kurtosis (Figure.6c), shows that 68% of the samples are platykurtic, 19% are leptokurtic, and 13% are mesokurtic. This suggests predominance of a single source with slightly variation of sediments provenance to Ibeno Beach.

Discriminant Functions

Some environmental discriminant functions (Y_1, Y_2 and Y_3) of [11]were used to characterize the sediment of Ibeno sandy beach. A similar method was adopted on sediments along the Qua Iboe River/Estuary Bank, South East Nigeria to infer provenance setting by [12]. The calculated discriminant functions used in this present investigation are presented in table 2.

For the discrimination between aeolian processes and littoral (intertidal zone) environments, the equation is given as:

$$Y_1 = -3.5688M_Z + 3.7016\,\sigma_I 2 - 2.0766SK_1 + 3.1135K_G$$

Where M_Z is the Mean Grain Size, 6_1 is the Inclusive Standard Deviation (Sorting), S_{KI} is Skewness and K_G is the Graphic Kurtosis. When Y_1 is less than -2.7411 it is an aeolian

Table 2: Summary of the environmental discriminations functions (Y1, Y_2 andY_3) from the study area

Stations	Y_1	Y_2	Y_3
S1	-4.23842	89.2629	-3.9455
S2	-4.8056	78.8566	-3.7649
S3	-5.5237	85.9207	-3.73603
S4	-5.7617	84.5132	-3.7970
S5	-5.09194	95.1189	-5.1969
S6	-2.0399	97.1599	-3.9228
S7	-6.4335	81.7378	-2.7947
S8	-5.6845	83.9945	-3.6992
S9	-5.9928	83.3473	-3.9150
S10	-8.5375	73.5955	1.0331
S11	-9.2735	78.1846	-1.2653
S12	-6.0411	83.6280	-3.6282
S13	-5.7656	85.8180	-3.5752
S14	-7.3698	75.3545	-0.5231
S15	-5.8047	84.1276	-3.9350
S16	-6.0053	82.5993	-3.2322

Deposit whereas if Y_1 is greater than – 2.7411 a beach environment is suggested. All the analyzed samples have Y_1 values less than- 2.7411 inferring source of Aeolian processes (Table2).

For the discrimination between beach (back –shore) and shallow agitated marine environments (sub tidal environment) the following equation is used:

$$Y_2 = 15.6534M_z + 65.7091\sigma_I + 18.1071S_{k1} + 18.5043K_G.$$

If Y_2 is less than 65.3650 the source of the sediment is beach environment and if $Y_2$is greater than 65.3650 it is shallow agitated marine sediment is inferred. From the result on table 2, all Y_2 values are greater than 65.3650 inferring shallow agitated marine sediment source.

For the discrimination between shallow marine and fluvial/ deltaic environment the following equation was used: $Y_3 = 0.2852M_z - 8.7604\,\sigma_I - 4.8932S_{k1} + 0.0482K_G$.

If Y_3value is less than -7.419 the sample is identified as a fluvial deposit whereas if Y_3 is greater than -7.419 the sample is described as a shallow marine deposit. The analyzed results showed 100% of the total samples from the study area have values of Y_3greater than -7.419 (Table 2), suggestive sediment provenance from shallow marine environment.

Conclusion

Sediments from a sector of Ibeno Beach which is a part of the coastal portion of the Atlantic Ocean exposed in Ibeno Local Government Area of Akwa Ibom State, Southeastern Nigeria were investigated in order to interpret their textural characteristics. The areas where this investigation was carried out include; Inua Eyet Ikot, NtaIkang and Itak Iban. The textural parameter investigated include: grain size, sorting, skwenessamd kurtosis. The result showed that study area is characterized by a predominance of fine grained, moderately well sorted, positively skewed and platykurtic sediments. The environmental discriminant functions applied to sediment of the study area indicates sediments provenance were from shallow agitated marine with some Aeolian contribution

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