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*acta*SATECH **4**(1): 64 - 73 (2011)

Research

Textural Characteristics of Bottom Sediments in Parts of the Lagos Atlantic/Seabed Coastal Waters

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Abstract

Variation in grain size distribution and the intensity of current is significant in determining the pattern of sediment transport, provenace and depositional enviroment. Samples for this study were collected from the Nigeria coastal waters between May to June 2009. The sediments were collected with a grab at water depth of 10-100 m. A total of twenty nine sediment samples were analysed to determine the spatial trend in their textural characteristics. The sediments were mainly silty sand, mud and sand of various sizes. The sediment grain size distribution ranged from fine to medium grained sand, poor to moderately sorted, coarse skewed and with a leptokurtic distribution. The mean grain size varied from 1.85 Φ -2.67 Φ which implies fine to medium grained sand. The sorting values were 0.6 Φ -1.65 Φ representing poor to moderately sorted sand. Skewness value lay between –0.10 and 0.3 Φ while kurtosis was 0.1 - 0.95 Φ. This study showed that sediment along the Lagos coastal water was transported by weak longshore current coupled with slow rate of sedimentation deposited in low energy environment.

Keywords: Textural; Grain size; Longshore current; Sediment; Spatial trend

Introduction

The Nigerian coastal area lies within the Atlantic Ocean with its continental shelf, the Exclusive Economic Zone, the coastal fresh waters and the brackish wetlands typified by network of rivers and creeks. The area includes the uppermost limit of tidal influence and the edge of the continental shelf, and is characterized by periodic tidal variations.

Grain size is a fundamental physical property of sediments and as such it is useful in identifying depositional environment and pattern of sediment transport. Spatial changes or variations in grain size distribution were significant in understanding sedimentary processes. The grain size distribution of seabed sediment tends to vary according to sampling locations (GAO, 2001) which this study examined in addition to determining the textural characteristics of sediments along the Lagos coastal waters. This was undertaken with a view to understanding the source of the sediments and the environment of deposition.

The geologic history of the Nigerian coastal area is associated with the geologic evolution of the continental margin. The continental margin evolved with the separation of the African plate from the South American plate during the Mesozoic. This separation of plates resulted in the opening up of the South Atlantic. These events might have spanned millions of years from the Upper Jurassic to Upper Cretaceous. The final separation of the Brazilian landmass from the Gulf of Guinea resulted in the development of the West African coastline (Emery *et al*., 1974).

In the Tertiary, the Nigerian coastline witnessed a succession of transgressions and regressions, which resulted in an oscillating shoreline that advanced about 250 km southwards. During the Early Pleistocene, the shoreline probably coincided with the present 200 km isobath as evidenced by relic Pleistocene beach sand outcrops on the continental shelf (Allen, 1965). The successive transgressions of the sea were responsible for the morphology of the Nigerian coastal line and continental shelf.

The Nigerian coastal area is bordered by the Gulf of Guinea which is highly stratified. The sea surface temperature of the Nigerian coastal waters varied from 24 to 29^{o}C. Salinity is less than 35 PSU and the wave height between 1.06 and 1.5 m. Currents include longshore and tidal current, (Longhurst, 1964). The tide offshore the Nigerian coast generally approach from the South-west is semi-diurnal in nature with two inequalities. Tidal amplitude along the coast increases from west to east. The waves affecting the Nigerian continental shelf are wind generated with intensities generally determined by wind velocity. Plunging waves are the predominant wave type.

Materials and Methods

Sediment samples for this study were collected during a research cruise on Living resource survey along the Nigeria coastal waters between May and June 2009 (Fig. 1). A total of seventy bottom sediment samples were collected with a grab at water depth of 10 to 100 m. Fig. 2 shows the transect line and various sampling points. Twenty-nine of these samples were selected for grain size analysis by mechanical sieving method. 70 g of each sample was oven dried at room temperature in order to remove the moisture content.

The samples were then subjected to a rotap shaker and sieved for 15 min. Fractions of sample retained on the sieve were carefully weighed on a digital balance. Weight values obtained were then converted to cumulative weight percentage. A graph of cumulative weight percent against phi was plotted on a probability log sheet. The statistical parameters (Mean standard deviation (SD), skewness, and kurtosis) were calculated from the graphic curve obtained according to Folk (1974). Each transect was represented by a sample point in form of Histogram in which frequency percentage by weight was plotted against grain diameter.

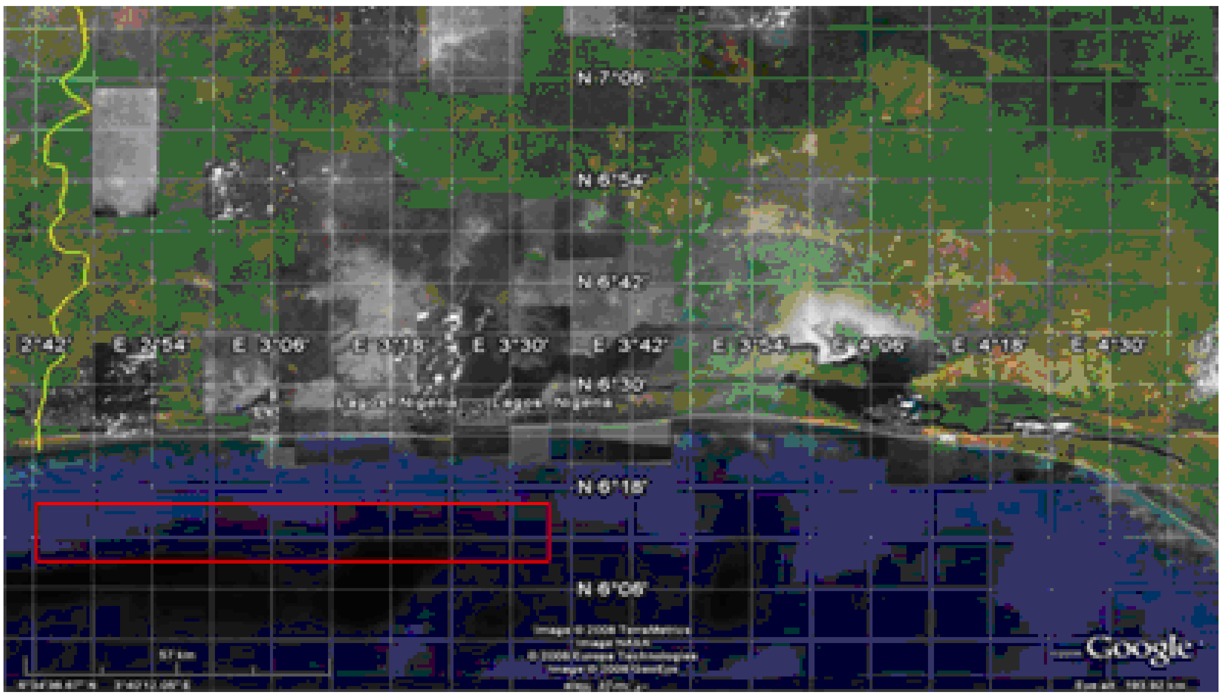

Fig. 1: Map of the study location, Lagos coastal area. Source: Google Earth Satellite imagery, 2007. Accessed 2/9/2010.

Results and Discussion

Grain size

The statistical parameters of grain size distribution have been a major parameter in delineating the influence of depositional processes (Friedman, 1961; Folk, 1966). Generally, standard deviation and skewness are considered environmentally sensitive indicators while the mean is a reflection of the competence of the transport mechanism. The result of the granulometric analysis is presented in Table 1. The sediments distribution ranged from fine to medium grain, poorly sorted, coarse skewed with a leptokurtic distribution.

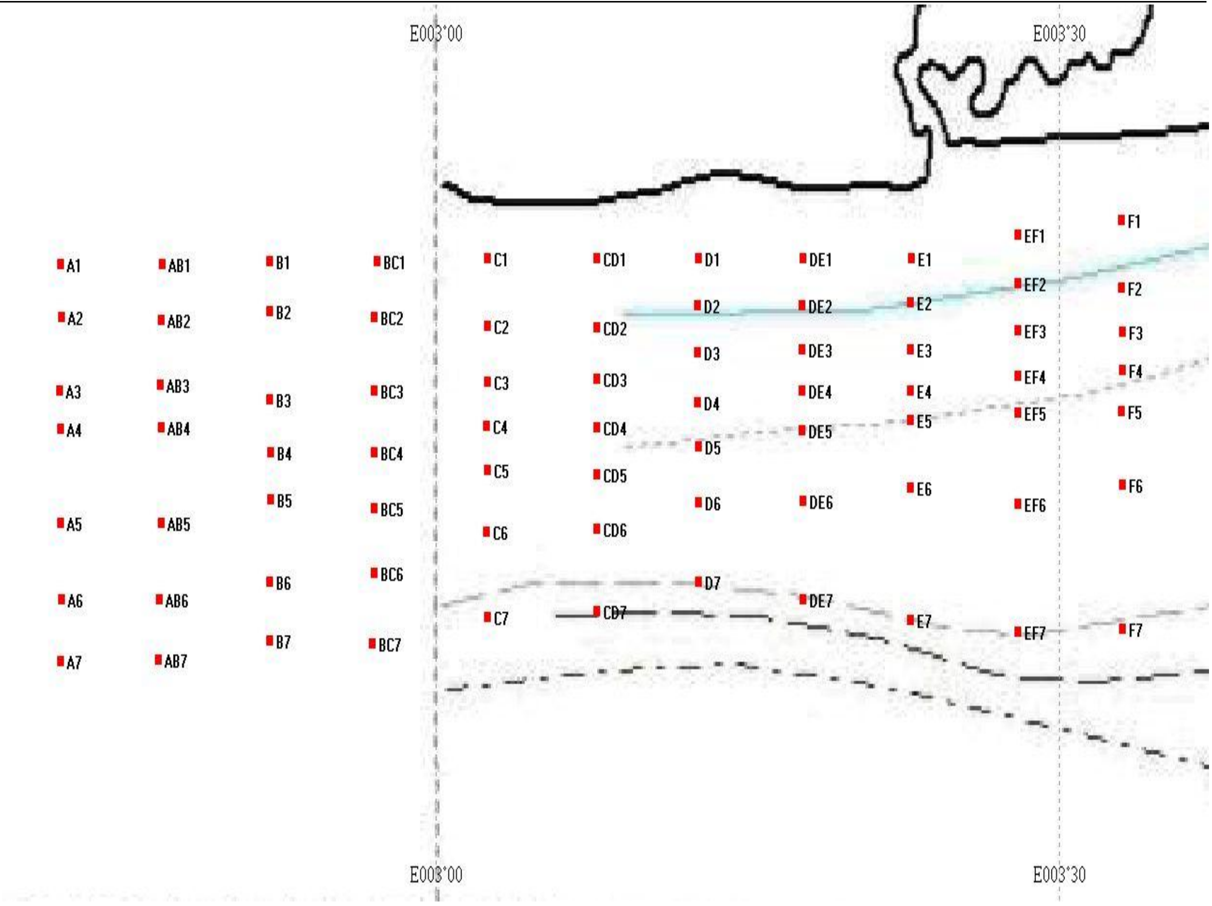

Fig. 2: Transects lines and sampling points

The mean, which is a reflection of the overall size of the sediment ranged from 2.67 Φ - 1.85 Φ (fine to medium sand) while the SD which is a measure of the sorting varied from 1.65 Φ - 0.6 Φ (poor – moderately sorted). Skewness values ranged from – 0.10 to 0.3 Φ while kurtosis was between 0.1 and 0.95 Φ.

The mean grain size is an indication of the overall competence of the transporting medium while the standard deviation and skewness reflect the environment of deposition. Positively skewed sediment with leptokurtic distribution represents sediment with a high degree of textural maturity and reworking whereas positively skewed coarse and well-sorted sediment point to occasional extension of suspended sediment. This study therefore suggests that the sediment along the Lagos coastal waters was transported by weak longshore current, coupled with slow rate of sedimentation deposited in low energy environment. Variations in the grain size distribution are significant in determining the provenance and identifying depositional environment.

Table 1: Grain size analysis

Sample Site	Mean	Std. Dev.	Skewness	Kurtosis	Description
A1	2.15	1.41	-0.11	0.95	Fine sand, poorly sorted, coarse skewed, mesokurtic
A2	0.75	1.38	0.06	0.92	Coarse sand, poorly sorted, near symmetrical, mesokurtic
A7	1.75	1.19	-0.06	1.21	Medium sand, poorly sorted, near symmetrical, leptokurtic
AB2	0.96	0.67	-0.01	0.97	Coarse sand, moderately well sorted, near symmetrical, mesokurtic
AB3	1.61	0.78	-0.02	0.99	Medium sand, moderately well sorted, near symmetrical, mesokurtic
AB4	0.03	0.77	-0.55	0.66	Coarse sand, moderately sorted, strongly coarse skewed, very platykurtic
B1	1.27	0.92	-4.94	0.16	Medium sand, moderately sorted, very platykurtic
B4	3.11	1.20	-0.73	1.32	Very fine sand, poorly sorted, strongly coarse skewed, leptokurtic
BC2	1.02	0.66	1.00	1.16	Medium sand, moderately well sorted, strongly fine skewed, leptokurtic
BC3	1.48	1.41	-0.11	0.97	Medium sand, poorly sorted, coarse skewed, mesokurtic
C1	1.55	0.70	-0.17	1.40	Medium sand, moderately well sorted, coarse skewed, leptokurtic
C2	1.86	0.72	-0.12	1.04	Medium sand, moderately sorted, coarse skewed, mesokurtic
C3	1.37	0.93	-0.28	1.43	Medium sand, moderately sorted, coarse skewed, leptokurtic
CD1	2.67	1.60	-0.52	0.83	Fine sand, poorly sorted, strongly coarse skewed, platykurtic
CD2	2.08	1.42	-0.28	0.86	Fine sand, poorly sorted, coarse skewed, platykurtic
CD3	2.28	0.86	-0.50	0.11	Fine sand, moderately sorted, strongly coarse skewed, very platykurtic
CD4	2.26	1.61	-0.48	1.41	Fine sand, poorly sorted, coarse skewed, leptokurtic
D1	1.28	1.16	-0.22	1.04	Medium sand, poorly sorted, coarse skewed, mesokurtic

Table 1 continued...

Sample Site	Mean	Std. Dev.	Skewness	Kurtosis	Description
D2	1.83	1.61	-0.34	1.15	Medium sand, poorly sorted, strongly coarse skewed, leptokurtic
D3	1.85	1.71	0.09	1.31	Medium sand, poorly sorted, near symmetrical, leptokurtic
DE1	2.73	1.23	-0.55	0.99	Fine sand, poorly sorted, strongly coarse skewed, mesokurtic
DE2	1.72	1.02	0.03	1.26	Medium sand, poorly sorted, near symmetrical, leptokurtic
DE3	1.73	0.86	-0.01	0.05	Medium sand, moderately sorted, near symmetrical very platykurtic
E1	2.05	1.72	-0.16	0.81	Fine sand, poorly sorted, coarse skewed, platykurtic
E7	1.73	1.38	-0.07	0.99	Medium sand, poorly sorted, near symmetrical mesokurtic
F1	3.78	2.29	-0.15	2.21	Very fine sand, very poorly sorted, coarse skewed, very leptokurtic
F2	0.68	0.79	0.03	1.73	Coarse sand, moderately sorted, near symmetrical, very leptokurtic
F3	0.62	0.62	-0.04	1.02	Coarse sand, moderately well sorted, near symmetrical, mesokurtic
F4	2.03	1.65	-0.25	0.94	Fine sand, poorly sorted, coarse skewed mesokurtic

Bivariate Grain size

A scattered (Y) plot of mean against SD of the sediments samples shows that majority of the samples falls within the river sector (Fig. 3). This suggests that the sediment might have been carried by wind into the drainage basin and then transported by current of the coastal waters into the Atlantic. The plot of weight percent against the sieve sizes of the grains depicts a bimodal grain size distribution (Fig. 4). This indicates that the sediment were not laid down in one phase but were reworked and transported for a long period before being redeposited, or may likely be due to mixing in two ways either as bed or suspended sediment. The mean size versus skewness plot also show that most of sediments were coarse skewed (Fig. 5) which implies that the environment of deposition was dominated by weak current action, while, the mean size versus kurtosis plot indicates that the sediments were dominantly leptokurtic (Fig. 6) revealing their textural maturity.

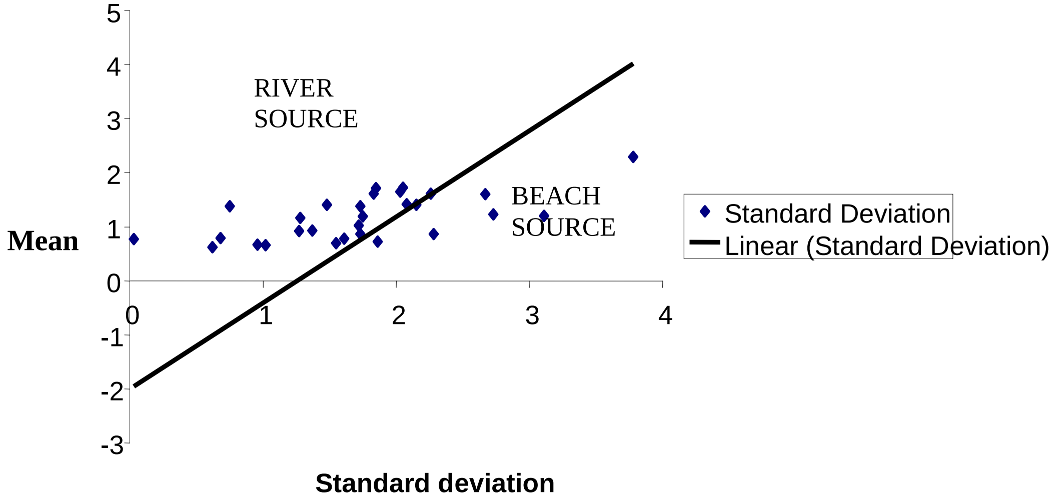

Fig. 3: Y Plot of mean grain size against standard deviation, (Miola & Weiser, 1968).

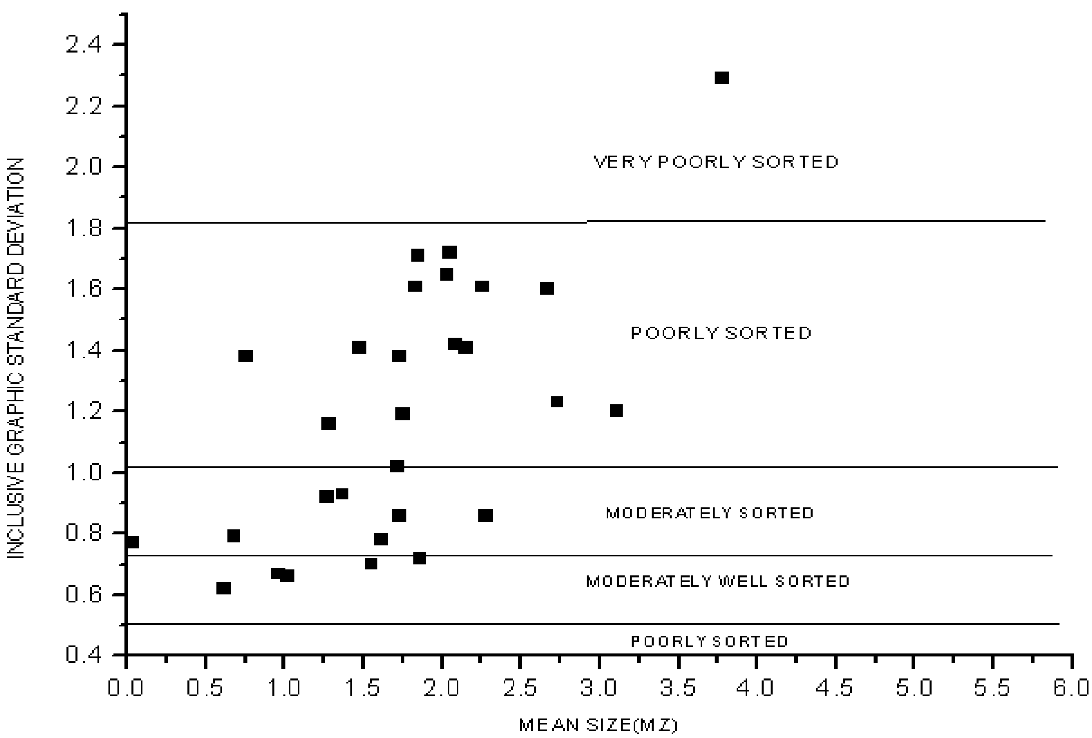

Fig.4: Bivariate plots between mean size and standard deviation

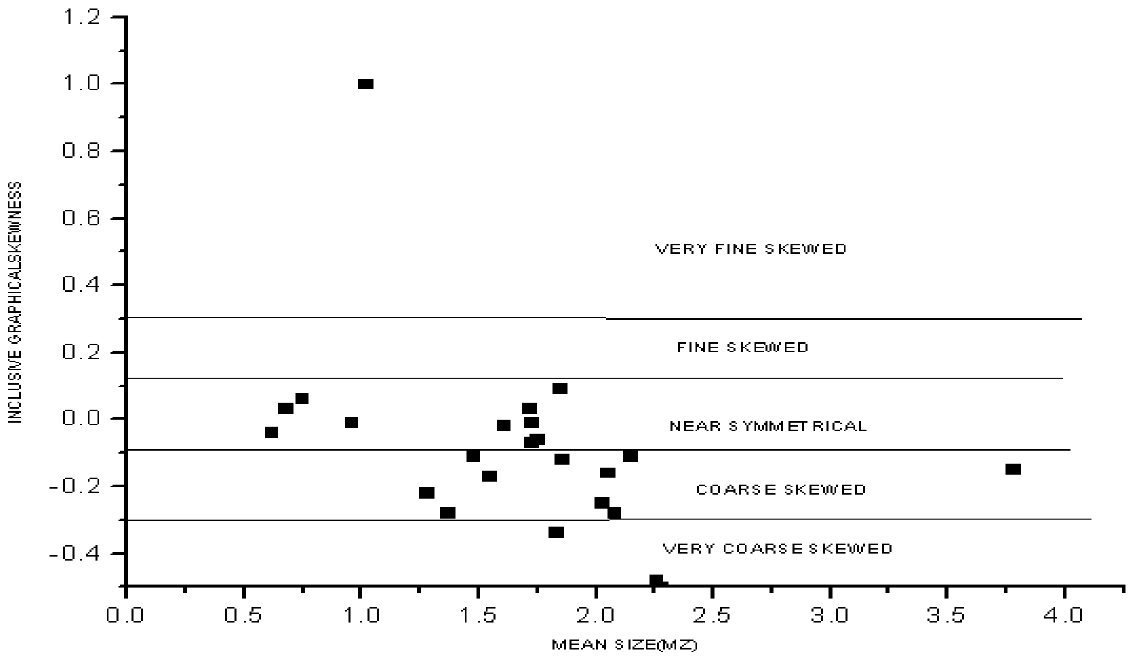

Fig.5: Bivariate plot of mean size versus skewness

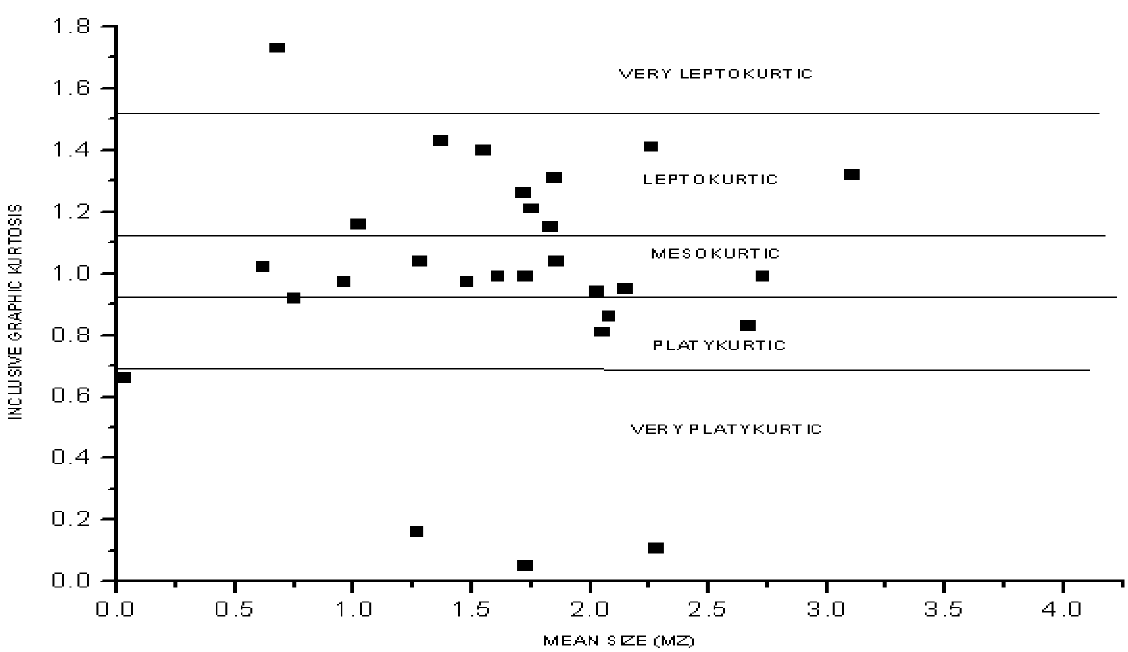

Fig.6: Bivariate plot of mean size versus kurtosis

Conclusion

The analysis of the grain size showed quantitatively the variations in sediments characteristics along the Lagos coastal water. Majority of the samples falls within the river sands environment which suggests they might have been carried by wind into the drainage basin and then transported by current of the coastal waters into the Atlantic Ocean.

The mean, a reflection of the overall grain size, suggests that majority of the sediments ranged from fine to medium grained sand without any lateral or horizontal relationship in their trends. The grains were poorly sorted in most of the sampled points and moderately well sorted in few areas, with majority coarsely skewed and few asymmetrically skewed this shows that most of the sediments have excess of coarse sand. The sediments were mostly positively skewed with leptokurtic distribution which implies the sediments were texturally matured.

Acknowledgement

We thank the Executive Director of the NIOMR and the Head of Department of Marine Geology/Geophysics, Prof. Larry Awosika, for their active support towards the success of this project. Our appreciation also goes to the project supervisors such as Dr. Adegbie and Dr. Folorunsho.

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