

Grain Size Characteristics and Sediments Distribution in the Eastern Part of Lekki Lagoon

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Abstract—A total of 20 bottom sediment samples were collected from the Lekki Lagoon during the wet and dry season. The study was carried out to determine the textural characteristics, sediment distribution pattern and energy of transportation within the lagoon system. The sediment grain sizes and depth profiling was analyzed using dry sieving method and MATLAB algorithm for processing. The granulometric reveals fine grained sand both for the wet and dry season with an average mean value of 2.03ϕ and -2.88ϕ , respectively. Sediments were moderately sorted with an average inclusive standard deviation of 0.77ϕ and -0.82ϕ . Skewness varied from strongly coarse and near symmetrical $0.34 - \phi$ and 0.09ϕ . The kurtosis average value was 0.87ϕ and -1.4ϕ (platykurtic and leptokurtic). Entirely, the bathymetry shows an average depth of 4.0 m. The deepest and shallowest area has a depth of 11.2 m and 0.5 m, respectively. High concentration of fine sand was observed at deep areas compared to the shallow areas during wet and dry season. Statistical parameter results show that the overall sediments are sorted, and deposited under low energy condition over a long distance. However, sediment distribution and sediment transport pattern of Lekki Lagoon is controlled by a low energy current and the down slope configuration of the bathymetry enhances the sorting and the deposition rate in the Lekki Lagoon.

Keywords—Lekki Lagoon, marine sediment, bathymetry, grain size distribution.

I. INTRODUCTION

MARINE sediments are products of the breaking down of preexisting rocks of igneous, metamorphic origin which were transported by the agent of erosion such as rivers, wind and tides into a marine system [1]. These sediments are generally influenced by coastal processes such as wave action and lagoon morphology. They accumulate in various grain sizes depending on the energy of transportation and the environment of deposition [2].

In line with the mandate of the Marine Geology/Geophysics Department of the Nigerian Institute for Oceanography and Marine Research to carry out a geological study of sediments in the Nigerian Coastal zone, this research was carried out with sediments from Lekki Lagoon in order to determine the characteristics and grain size distribution of bottom sediments in the study area. This research work is aimed at using grain size analysis to determine the textural characteristics of bottom sediments and to identify the predominant sediment class within Lekki Lagoon.

The objectives of this study are to establish bathymetry of the area of interest, Lekki Lagoon, to collect and determine the textural characteristics of wet and dry season sediments, to

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infer the energy of sediment transport/deposition within the lagoon, and to integrate the various results obtained from the grain size analysis to interpret the sediment distribution trend in Lekki Lagoon.

II. STUDY AREA

The study area is a heptagon-shaped layout located within the Lekki Lagoon (Fig. 1). It lies within longitudes $3^{\circ}0'$ and $3^{\circ}45'$ E and between latitudes $6^{\circ}25'$ and $6^{\circ}30'$ N [3]. The Lekki Lagoon is located at the eastern part of the Barrier lagoon complex, having an approximate extent of 60 km long and 3 km wide and drains into the Atlantic Ocean through its connection to the Lagos Lagoon.

III. METHODOLOGY

A. Fieldwork and Sample Collection

The survey was carried out in January and July 2014 representing the wet and dry seasons, respectively. A total of 20 bottom sediment samples were collected from the lagoon at georeferenced stations. Ten of these samples were collected during the wet season, while the other 10 were collected during dry season. These sediments were collected along designated transect lines using Van Veen Grab and Global Positioning System, respectively.

For each sampling point, the sediments were stored in well labeled transparent sample bags. Proper megascopic description was done in the field for each sediment sample collected. Each sample location was georeferenced using Garmin 76S GPS, while the bathymetric data for the whole area were obtained using an echo sounder (HydroboxTR).

B. Data Analysis

1. Bathymetry Analysis

The 20 georeferenced stations were analyzed based on the acquired data (depth, latitude and longitude). The MATLAB software was used to make a cross-sectional 3D depth model plot of the study area [4] (Fig. 2).

2. Granulometric Analysis

Twenty sediment samples were analyzed at the Marine Geology/Geophysics Departmental wet Laboratory of the Nigerian Institute for Oceanography to determine the trend in their grain size distribution. The sediment samples were properly dried using a Genlab laboratory oven for 24 hrs to remove the moisture content. The dried samples were weighed 70 grams each for textural and grain size distribution analysis. The 70 g samples were sieved using an Endecott sieve shaker.

The dried and weighed sediment were transferred carefully to stack of set of sieves which mesh sizes ranged for 4 phi to 63 microns (coarse to fine). The samples were sieved for 10-15 mins. When the sieve shaker was stopped, the material on each was emptied on to a sheet of glazed paper and grains lodged in the sieve were removed with a sieve brush. The fraction was then transferred on a digital balance and weighed to the nearest 0.01 g to determine their individual weight and then recorded against their corresponding phi units. The sieving analysis progresses until finally the material passing

the bottom 63 μ m sieve and sediment retained in the pan was recorded [5].

IV. RESULTS AND DISCUSSION

A. Bathymetry Result

Depth profiles showing each sampling positions is presented in (Fig. 2). The Lekki Lagoon has a depth range of 1.1 m to 11.2 m. The deepest point is at SS05 with a value of 11.2 m is located at the southern part of the study area. The northern part has a shallow depth of 0.5 m. The average depth recorded was 4.0m.

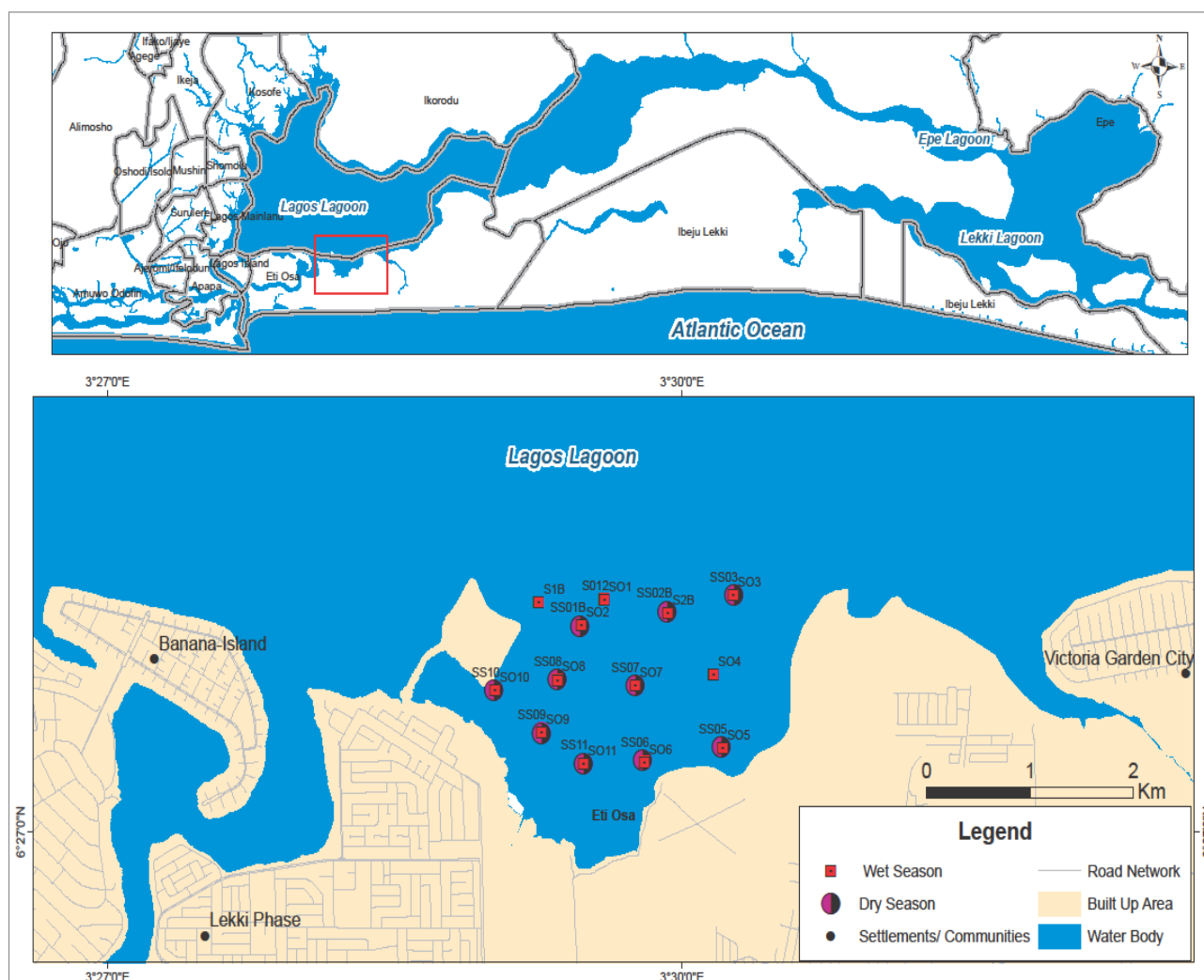


Fig. 1 Map of the study area and sampling points [3]

B. Granulometric Result

Results of the grain size analysis for the 19 sediment samples are presented in Tables I and II. Based on [6] the, statistical parameters and description of the sediment samples for dry season shows that the graphic mean values range from 2.79 ϕ to 2.89 ϕ (fine sand). The standard deviation values ranges from 0.65 ϕ to 0.84 ϕ (moderately well sorted to moderately sorted). The skewness values varied from 0.224 ϕ to -0.35 ϕ (coarse skewed to strongly coarse skewed). Graphic

kurtosis ranged from 1.41 ϕ to -0.81 ϕ (leptokurtic to platykurtic).

The wet season samples show the graphic mean values ranging from 0.35 ϕ to 2.82 ϕ (coarse-fine sand). The standard values ranges from 0.64 ϕ to 1.02 ϕ (moderately well sorted to poorly sorted). The skewness values varied between 0.54 ϕ and -0.10 ϕ (strongly fine to coarse skewed). Graphic kurtosis ranged from 0.79 ϕ and -2.24 ϕ (platykurtic to very leptokurtic).

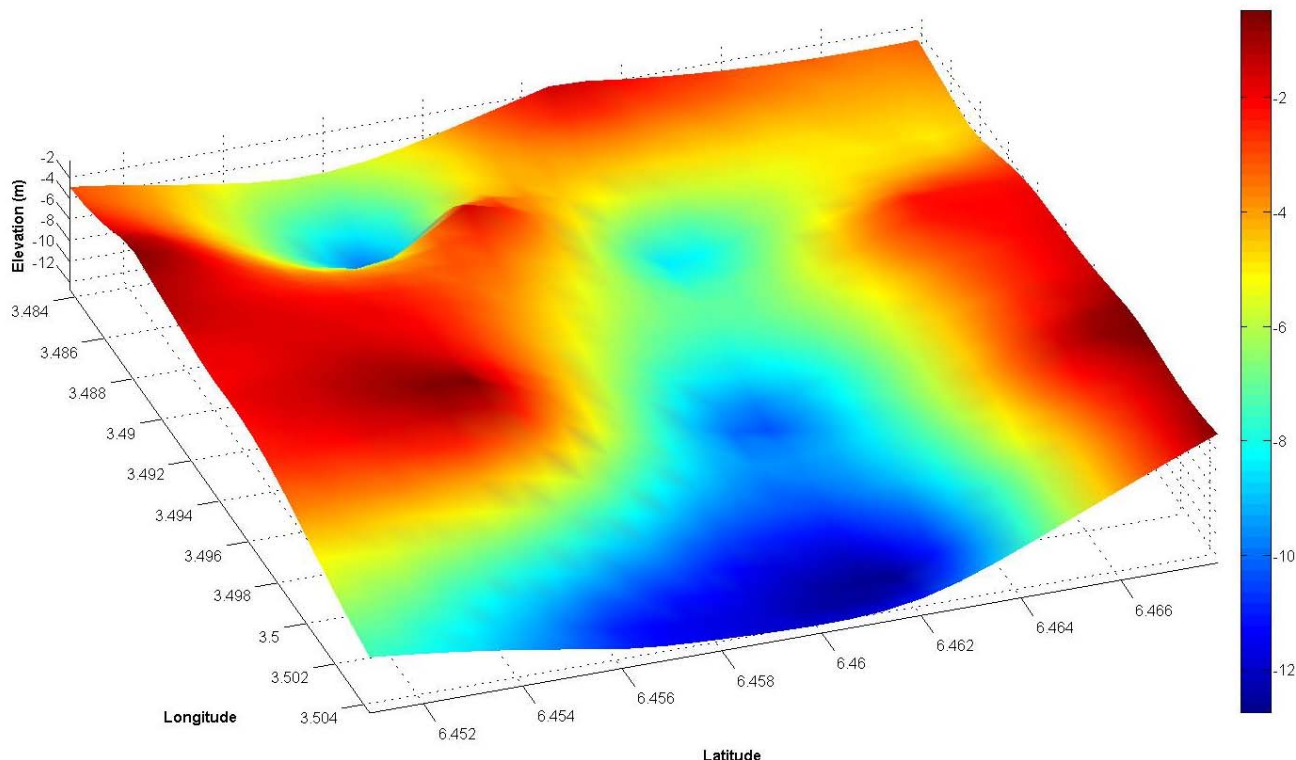


Fig. 2 3D Bathymetric plot of the study area

TABLE I
 STATISTICAL PARAMETER RESULTS OF THE SEDIMENT SAMPLES FOR DRY SEASON

Sample no	Mean	Standard deviation	Skewness	Kurtosis	Description
S1B	2.79	0.65	-0.22	1.41	Fine sand, moderately well sorted, coarse skewed, leptokurtic
S2B	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
S02	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
SO3	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
SO5	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
SO6	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
SO7	2.89	0.84	-0.35	0.81	Fine sand, moderately well sorted, strongly coarse skewed, platykurtic
SO8	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
SO9	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
S11	2.89	0.84	-0.35	0.81	Fine sand, moderately sorted, strongly coarse skewed, platykurtic
AVERAGE	2.88	0.82	-0.34	0.87	Fine sand, moderately sorted, strongly coarse, platykurtic

Interpretation of bathymetric map and 3D model (Fig. 2) reveals the bathymetric configuration of the study area, which showed the bottom configuration of a lagoon system. The nature of bathymetry and hydrodynamic forces of the lagoon explained the sedimentary processes, path of sediment transport and textural characteristics.

The southern part of the lagoon from the bathymetric map has the deepest depth ranging from 6m to 11.5m, while the northern part has depth ranging from 0.5m to 4.0m. An overall average depth of 4.0m was recorded. The bottom configuration of the lagoon from the 3D model shows that the sediment transport pattern was down slope due to the difference in gradient that is from the region of high gradient to low gradient.

The textural characteristics of the sediment within the study area mainly consist of fine to medium grain moderately well

sorted, moderately sorted, and very well sorted sand for wet and dry season. From the overall results of grain size statistical analysis for wet and dry season, the average mean value is 2.03ϕ and -2.88ϕ , which corresponds to the fine grained suggesting that the sediment were deposited under low energy condition over a long distance of transportation causing their grains not to retain its original configuration and texture [7]. The measure of the sorting of the sediments within the lagoon for wet and dry season ranges from 0.77ϕ to -0.82ϕ , showing an average standard deviation which corresponds to moderately sorted indicating a low to very low energy current [8]. The skewness values -0.34ϕ and 0.09ϕ corresponding to a strongly coarse and near symmetrical sediment distribution, indicating that the energy of deposition or transport is reducing which reveals that sediment grain dynamics tends towards fine. The kurtosis falls into the 0.87ϕ - 1.4ϕ

(platykurtic and leptokurtic) classification which implies that the grains are sorted, and strongly suggests an environment of low energy condition [9].

TABLE II
 STATISTICAL PARAMETER RESULTS OF THE SEDIMENT SAMPLES FOR WET SEASON

Sample no	Mean	Standard deviation	Skewness	Kurtosis	Description
S1B	2.25	0.64	0.00	1.92	Fine sand, moderately well sorted, near symmetrical, very leptokurtic
S2B	1.99	0.64	0.22	1.06	Medium sand, moderately well sorted, fine skewed, mesokurtic
S02	2.01	0.65	0.47	1.12	Fine sand, moderately well sorted, strongly fine skewed, leptokurtic
S03	1.53	0.67	0.54	1.39	Medium sand, moderately well sorted, strongly fine skewed, leptokurtic
S05	2.21	0.80	0.18	2.24	Fine sand, moderately sorted, fine skewed, very leptokurtic
S06	2.80	0.98	-0.10	0.79	Fine sand, moderately sorted, coarse skewed, platykurtic
S07	2.35	0.75	0.03	1.42	Fine sand, moderately sorted, near symmetrical, leptokurtic
S08	2.82	0.82	-0.31	1.91	Fine sand, moderately sorted, strongly coarse skewed, very leptokurtic
S09	2.82	0.82	-0.31	1.91	Fine sand, moderately sorted, strongly coarse skewed, very leptokurtic
S11	0.35	1.02	-0.14	0.86	Coarse sand, poorly sorted, coarse skewed, platykurtic
AVERAGE	2.03	0.77	0.09	1.41	Fine sand, moderately sorted, strongly skewed, leptokurtic

V. CONCLUSION

The study shows that Lekki Lagoon is basically shallow with an average depth of 4m and characterized by fine to medium grain, moderately well sorted, moderately sorted, and very well sorted sediments both in wet and dry season. The low energy current dynamics and nature of sea floor topography reveals the sediment distribution and sediment transport pattern exhibited at the lagoon. However, seasonal variability played an insignificant role in sediment supply and distribution in the study.

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