***Original Research Article***

**GRAIN SIZE DISTRIBUTION OF SEDIMENTS AND ITS ENVIRONMENTAL IMPLICATIONS ON UBULU OKITI, OGWASHI-ASABA FORMATION**

**Abstract**

The research area's depositional surroundings, energy, and method of movement were exposed through an investigation of the dispersion of sediments and their patterns of transportation. In all, 10 ditch cutting samples were taken in the investigation location and presented for granulometric testing to a lab. The findings of the investigation indicated how highly sensitive the relationships between multiple statistical measurements of size of particles (mean size, sorting, skewness, and kurtosis) were to small modifications in the composition formula of the sediment mixture. The particle size circulation findings were then utilised to determine statistical and textural features. The results reveal that the spectrum of particle sizes is 2φ – 3φ (very fine sand) to -3φ – -2φ (granules). With a modal category in the 1φ – 2φ size grade, the sample's average mean is 0.79φ. A population that has been improperly sorted is represented by an average sorting value of 1.34σ. The change from coarse to fine skewed sediments under leptokurtic to platykurtic nature, as well as from moderately well-sorted to well-sorted sediments, was discovered to occur in distinct sites with important environmental repercussions. A wide range of discriminating instruments, which includes the means of transport (C-M diagram), bivariate cross plot of grain size parameters, Linear Discrimination Functions (LDF), skewness and kurtosis connection as a non-dimensional representation of sediment/energy simulations, and Energy Process illustration, indicate the marine signature, which follows the riverine input as a function of the sediments locality. The constant power activities of the marine environment acted as the principal hydraulic mechanism for control over depositional processes. The fluvial nature of the silt indicated the graded suspensions and salt formation modes, which are the key elements impacting movement in a shallow, turbulent aquatic setting impacted by coastal and turbidity environment activities.

**Key words:** Grain-size Distribution, Depositional processes, turbidity, marine environment, depositional environment.

**1.0: Introduction**

When dealing with outcrops and essential data in clastic sedimentation systems, sedimentologists, geomorphologists, geographers, and civil engineers typically apply the grain-size analysis approach. Further strategies are needed to offer a more quantitative overview of grain-size and sorting for comprehensive investigation whenever the information from a hand lens is insufficient. The classic grain-size analysis approaches are based on sifting for coarse-grained fractions (silt and larger) and rates of sedimentation for fine-grained fractions (clay to silt) (Buller and McManus, 1972; Gee and Bauder, 1986). Rivers are bodies of water that flow downstream or downward as a function of gravity. They have the dual tasks of acting as agents of erosion for worn materials from the highlands and enabling the passage and deposition of sediment. They often act as the link across the land, where weathering occurs and the water bodies, oceans, and seas, wherein a thick sequence of sediments are deposited. Additionally, a portion of the sediments they deliver are deposited on territory where thick and widespread fluvial sedimentation occurs, such as flood plains and alluvial plains. From 6000–8000 years B.P., the Niger Delta's massive flow of fluvial deposits to the Atlantic Ocean through its main branches contributed to the gradual formation of the delta (Late Pliocene) (Stanley, 1990; Said, 1993; Stanley and Warne, 1993). On the continental shelf, however, portion of the released sediments were carried alongshore and cross-shore by oceanic and other environmental processes (Stanley, 1990).   
  
The depositional settings of clastic sediments are commonly identified and reconstructed utilising grain-size analyses (Passega, 1957, 1964; Passega and Byramjee, 1969). The regulated waves and currents that allow the sand from the beach to be separated are represented by the longshore and cross-shore grain-size distributions (Frihy and Komar, 1993; Frihy et al., 1995). The primary goals of this work are the properties of particle size, the distribution of grain sizes in the sediments, and the derivation of depositional energy. By using energy and hydrodynamic factors to determine the depositional environment and the sediments' path of transit inside the research region, it also takes into account the environmental consequences of these findings.

**2.0: Location and Geology of Study Area**

Within latitudes 060 051 N and 060 171 N, and longitudes 060 371 E and 060 451 E, is the study region (Figure 1). It is situated on the Niger Delta Basin's northern flank. The River Niger, an excellent road network, and walking trails all lead to the area. The Rivers Atakpo and Anwai are the two rivers that efficiently drain the region. The typical pattern of drainage is dentritic. Because of the porous nature of the soil, runoff replenishes and penetrates the surface water. The underlying Pleistocene to Recent Alluvium, the Oligocene – Miocene Ameki Formation, and the Eocene Ogwashi – Asaba Formation are some other subterranean water sources.

The Asaba environment is dominated by the River Niger and the Asaba Plateau, which has gently sloping hills. Asaba city is situated on the valley and west bank of the River Niger as a result of these hills' gentle eastward descent. On the edge of the Asaba plateau are the towns of Okpanam and Ibusa. South of Asaba, the plateau itself totally vanishes. The plateau slopes are crisscrossed by several streams that rise to greater elevations as springs, but only one, the comparatively wide Amilimocha River, meets the River Niger in Asaba town. The average annual temperature is between 2200C and 3400C degrees Celsius, with 1,501 to 1850 millimeters of rainfall and 1117 millimeters of evapotranspiration.

**3.0: Materials and Methods**

Both fieldwork and laboratory study methods were used in the project. The field samples were taken, and they underwent examination and interpretation in the lab.

**3.1: Sample Collection**

In Delta State, which is a portion of the research region located in the Western section of the Niger Delta, samples were collected at 10 distinct places along the Western Ashaba Ikiti. One sample is obtained from the river bottom, while the other samples are taken from the beach line to 40–50 meters south of the shoreline. They are dispersed over 19 sites that are perpendicular to the shoreline and separated by 1-3 km.

The samples are dispersed using three primary profiles that run parallel to the shoreline: Profile A begins at the seaside, Profile B is formed from the semi-wet area less than 20 meters from the beach, and Profile C is generated from the dry area less than 40 to 50 meters from the shoreline. Using a plastic scoop, each representative beach sample (1-2 kg) was taken from the top 15 cm of the sand beach face, and it was then placed in plastic bags for storage. A GPS was used to determine each station's location throughout the study region, as shown in Fig 1. With the assistance of divers, new samples were taken from the riverbed, and the color and grain sizes of the sediment were recorded.

After being labeled and packed in bags, they were brought to the lab for examination. Ten samples, one for each of the ten locations, were brought in for a laboratory analysis of grain size. Following an oven drying process to eliminate moisture content, the grains were arranged onto a range of BSS standard sieves featuring specific aperture diameters. The grains were mechanically vibrated for a minimum of fifteen minutes in order to allow them to split into their various sizes. The outcome was utilized to determine the statistical characteristics of the grain population in the sediment, per Folk (1991). The grain population's skewness, kurtosis, median, mean, and sorting (standard deviation) are the parameters.

1) The median's diameter (Md) With half of the grains being finer and the other half being coarser than the median, this represents the sample's average size at a 50% percentile.

2). Mean (GM): The distribution's mean size. The spread of a grain size distribution's percentile values yields the most accurate approximation of the average grain size. It is calculated with the help of:

M=ϕ (6+ϕ50+ϕ 84)

3

3) Mode (Mo) On a size-frequency plot, the class with the highest representation is the modal class. This is the most typical grain size.

4) Standard Deviation (GSD) (σ) / Sorting Coefficient (So): This quantifies the extent to which the size distribution deviates from the average diameter.

GSD = ϕ84- ϕ16+ ϕ95- ϕ5

4 6.6

5) The tendency of a grain size distribution to lean to one side and deviate from normalcy is known as skewness (GSK). It is a number without dimensions that can be either positive or negative. It has no metric or phi values and is between -1 and +1.

GSD = ϕ84- ϕ16-2(ϕ50) + ϕ95- ϕ5-2(ϕ50)

2 (ϕ84- ϕ16) 2 (ϕ84- ϕ16)

6) Kurtosis (K) It is a measurement of the grain distribution's peakiness. It has to do with the distribution's normalcy and dispersion.

K= ϕ95- ϕ5

2.44 (ϕ75- ϕ25)

**3.2: Presentation and Discussion of Results**

Tables 1 and 2 as well as Figures 3–8 display the statistical parameters that were computed for the sediments that were examined in the Ashaba Ikiti river bed. The sediments that were collected had particle sizes ranging from granules (-2 φ – -1 φ) to very fine sand (3-5 φ – 4 φ). The coarse sand proportion, or 0.89 φ, is the population's average mean. While the majority of the samples, based on the analysis, had a modal class of 1 φ to 2 φ (middle sand size), AI 4 is polymodal, with a modal class in the -1 to -0 φ class. With more than 80% of the grains falling into the modal class, 40% of the sediments are unimodal; the remaining sediments display distributions that range from bimodal to polymodal

Samples can be classified in three different ways: well, moderately, and poorly. 1.26 σ is the average sorting value, indicating a weakly sorted result. Ten percent are positively skewed, thirty percent are symmetrical, and sixty percent are adversely to extremely negatively skewed. Sixty percent of the sediments are mesokurtic, ten percent are very platykurtic, ten percent are platykurtic, and sixty percent are leptokurtic to extremely leptokurtic. Since all of the sizes fell within the granules and fine grain sands, the cumulative curves of the sediment demonstrate that traction and saltation were the primary modes of transport.

Additionally, it is noted that little to no fine sand is present in the sediments from locations AI 1 to AI 6, while fine sand penetration happens from AI 7 to AI 10. This observation suggests that the grains get finer downstream.

|  |  |  |
| --- | --- | --- |
| DEPTH | SAMPLE | DESCRIPTION |
| 4 |  | Reddish brown top surface sand(Alluvium) @ 9M |
| 8 |  |
| 12 |  |
| 16 |  | Brownish fine to medium grained sandstone with dark brown intercalations. |
| 20 |  |
| 24 |  |
| 28 |  |
| 32 |  | Whitish gray fine-medium grain sandstone with hard surfaces at 52m |
| 36 |  |
| 40 |  |
| 44 |  |
| 48 |  |
| 52 |  |
| 56 |  | Whitish gray wet clay mixed fine grain sandstone and a thick lignite bottom. |
| 60 |  |
| 64 |  |
| 68 |  |
| 72 |  |
| 76 |  |

**Figure.1: Lithologic Description of the sampled area.**

**3.3 Textural Attributes of Sediment**

Fine, medium, coarse, and gravel sands are among the several textural facies found in the fluvial deposits of Ogwashi-Asaba Formation. It's interesting to note that downstream places that were enriched with fine sand did not follow any regular pattern. Couples of samples fall into the category of poorly sorted, but overall, the majority of the sediments have quite high sorting values and are classified as extremely poorly sorted. The extremely platykurtic curves are caused by the fact that all samples (except from SK1) are better sorted at the tail than the core regions, according to kurtosis analysis. Because of the detected kurtosis values' mature nature, which is thought to be caused by compaction aggregating sediment particle size and sorting value variation, the sands are (Ramanathan, 2010).

**Table.1: Summary of Particle Size Distribution Result**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **DEPTH**  **M** | **SIEVE DIAMETERS (mm)** | | | | | | | | | | |
| **2** | **1.4** | **0.7** | **0.5** | **0.355** | **0.25** | **0.18** | **0.125** | **0.09** | **0.063** |
| 1. **1** | 3-9 | 100 | 100 | 95.1 | 88.0 | 77.2 | 62.1 | 45.8 | 37.3 | 35.1 | 34.5 |
| 1. **2** | 9-12 | 100 | 99.8 | 55.3 | 41.8 | 32.0 | 27.2 | 20.7 | 17.3 | 16.4 | 16.1 |
| 1. **3** | 24-27 | 99.7 | 86.3 | 47.2 | 32.3 | 21.6 | 19.9 | 10.0 | 6.8 | 4.9 | 3.2 |
| 1. **4** | 36-39 | 99.4 | 92.5 | 61.9 | 38.9 | 23.4 | 14.5 | 6.7 | 3.8 | 2.5 | 1.3 |
| 1. **5** | 39-42 | 95.3 | 79.3 | 45.0 | 30.9 | 18.7 | 10.0 | 6.2 | 3.7 | 2.5 | 1.2 |
| 1. **6** | 42-45 | 97.8 | 88.5 | 56.8 | 37.6 | 17.1 | 11.5 | 4.5 | 2.7 | 1.9 | 0.7 |
| 1. **7** | 45-48 | 93.3 | 86.7 | 55.7 | 39.4 | 18.8 | 12.6 | 5.2 | 3.3 | 2.3 | 1.2 |
| 1. **8** | 48-51 | 93.9 | 83.4 | 50.0 | 33.3 | 21.9 | 19.7 | 12.1 | 8.0 | 6.1 | 4.2 |
| 1. **9** | 51-54 | 98.5 | 92.8 | 60.5 | 38.1 | 21.2 | 10.0 | 5.6 | 3.2 | 1.9 | 0.2 |
| 1. **10** | 54-57 | 98.6 | 92.6 | 62.8 | 41.3 | 19.1 | 8.6 | 4.6 | 2.9 | 2.1 | 1.3 |

**Table.2: Grain Size Analysis Parameters**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **S/n** | **Depth (m)** | **% Gravel** | **% Sand** | **% Fines** | **Cu** | **Cc** | **K (cm/sec)** |
| 1. 1 | 3-9 | 0 | 65.5 | 34.5 | - | - | - |
| 1. 2 | 9-12 | 0 | 83-9 | 16.1 | - | - | - |
| 1. 3 | 24-27 | 0.3 | 96.5 | 3.2 | 5.0 | 1.42 | 4.86X10 -4 |
| 1. 4 | 36-39 | 0.6 | 98.1 | 1.3 | 3.5 | 1.06 | 6.615 X 10 -4 |
| 1. 5 | 39-42 | 4.7 | 94.1 | 1.2 | 5.0 | 1.13 | 8.64 X 10 -4 |
| 1. 6 | 42-45 | 2.2 | 97.1 | 0.7 | 5.0 | 0.70 | 8.64 X10 -4 |
| 1. 7 | 45-48 | 6.7 | 92.1 | 1.2 | 4.0 | 0.85 | 7.935 X10 -4 |
| 1. 8 | 48-51 | 6.1 | 89.7 | 4.2 | 7.0 | 0.13 | 3.375 X10 -4 |
| 1. 9 | 51-54 | 1.5 | 98.3 | 0.2 | 3.0 | 0.94 | 9.375 X10 -4 |
| 1. 10 | 54-57 | 1.4 | 97.3 | 1.3 | 3.0 | 0.83 | 1.0935 X10 -3 |

**3.3 Environmental and Facies Interpretation**

The plotting of the systematic variances in the variables of the grain size distribution suggested by Folk (1991) with each other permits one to look into, among other things, adjustments and variations in the depositional surroundings, transportation history, and the energy of the depositional energy and carrying agent. The bivariate skewness vs. kurtosis plots in Figure 2 can be utilised for investigating the distribution of facies and depositional energy. The sediments of the Odi River are deposited within a dynamic spectrum of energy, as Figure. 2 indicates. There are both high and low energy phases where the sediments are accumulated.   
  
A thorough analysis of the first segment of the graph in Figure. 2 indicates that roughly 60% of the sand particles are leptokurtic to severely leptokurtic, with considerable kurtosis at peak A suggesting unusually effective sorting. High energy can create a considerable degree of kurtosis due to it can winnow sediments depending on size to aid effective sorting. The relationships between the mesokuric and platykurtic sediments, exhibiting moderate and poor sortings, respectively, as well as the low and moderate energies are indicated by graphs B and C.   
  
The coarseness of the sediments, which vary from coarse sand facies to approximately granules, is represented by Figure. 2, which reveals that 80% of the sediments are symmetrically to severely negatively skewed. This is inadequate (Folk, 1966). He felt that river sediments are leptokurtic, positively skewed, and predominantly formed of saltation loads penetrated by some suspension loads

C

C

B

B

A

Figure.2. Plot of skewness vs kurtosis illustrating changes in the depositional environment's energy Ashaba Ikiti sediment

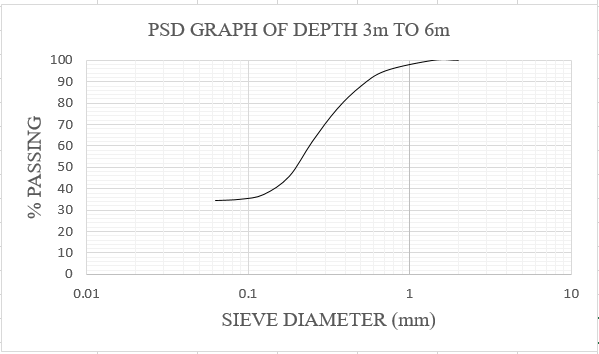
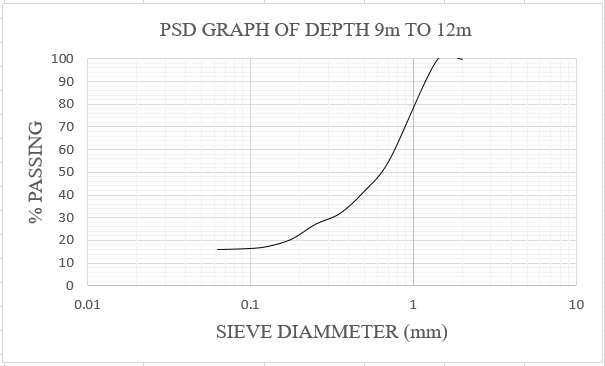
 

Figure.3 Figure.4

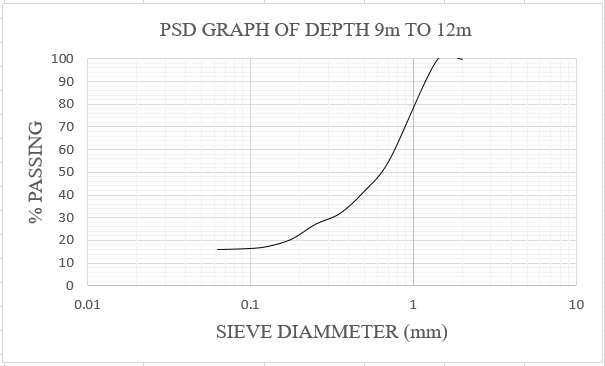
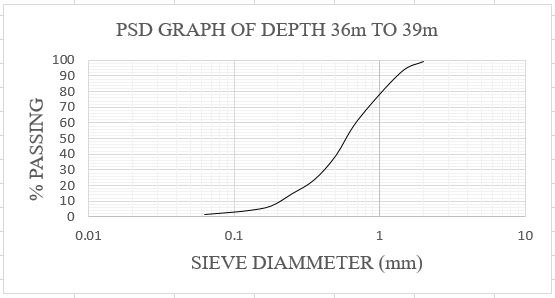
 

Figure.5 Figure.6

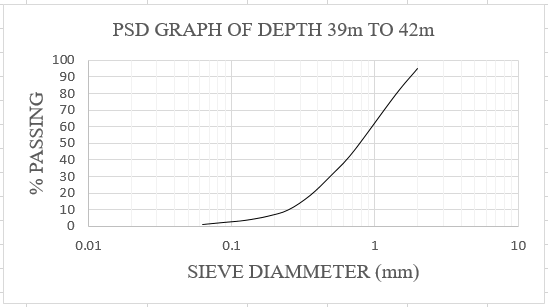
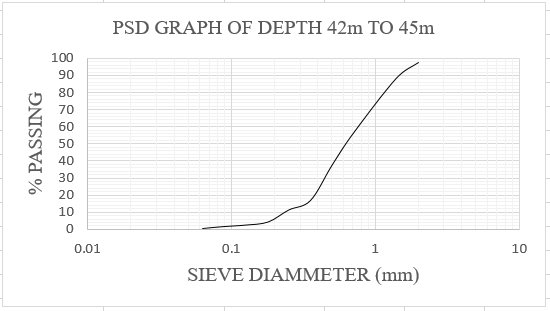
 

Figure.7 Figure.8

Figure 3-8: PSD graph in illustrating variations in the particle size distribution

The way that changes in the surrounding environment impact the mean grain size is demonstrated by the link between the mean (φ) and sorting (σ). While the average sorting of the sediments is 1.26 σ, indicating poorly sorted, which is typical of river sediments, the average mean of the sediments is 0.98 φ, which is within the coarse sand size range. An environment with a significant variance in transport energy, associated with a decrease in sorting (σ) and an increase in mean grain size, is what distinguishes fluvial and fluvioglacial channels. According to Harasimiuk (1991) and Ludwikowska-Kędzi (2000), in this scenario, coarse materials are deposited while energy is declining and low energy transport alternates with high energy, resulting in poorly sorted materials. Sorting happens at low energy.

An analysis of the sediments from the bed of the Ashaba Ikiti River reveals a range of high and low energies that are connected to particle sizes that range from fine sands to granules. Ninety percent of the sediments are sorted from moderately to poorly, according to the map.

The sediments are divided into two facies by the skewness vs. sorting plot in Figure 2: the fine sands with poor sorting on the right, and the coarse, moderately well-sorted to poorly-sorted sands on the left negative side. Even though channel bed sediments are present in both facies, lower stream energy locations are home to the finer sands. The zone where skewness equals zero, which denotes the boundary between the two facies, has the best-sorted grains (Ludwikowska-Kędzia, 2000). The sediments in the river deposits domain are depicted in Figure. 2 by a bivariate plot of the median and skewness, as per Stewart's (1958) directions.

**3.4 Discrimination of Environmental Boundaries**

Friedman (1967) found that the best plot for distinguishing between river and beach sands is one that shows skewness against standard deviation. However, Moiola and Weiser (1968) noted that another plot that works well for this purpose is one that shows mean size against standard deviation. According to Friedman's (1967) border, the beach environment is the sample environment deposition, as shown by Fig. 2's mean size and standard deviation. The availability of fine particle size indicates the influence of the river, whereas the better sorting character on beaches due to energy wave motion indicates the influence of the beach environment. As a result, the beach environment close to a river mouth is common due to deltaic processes. According to research by (Moiola and Weiser, 1968), the superior sorting and finer grain size of the sand deposits account for the coastal dune environment's dominance over river and beach settings.

**3.5 Energy and Hydrodynamic Conditions**

The sediments are best sorted and inside shallow agitated water based on Y2 values, and are distributed in the aeolian process based on Y1 values, where energy fluctuations are least, according to the cross correlation between Y1 and Y2 values. Based on Y3 readings, shallow marine water is suggested as the

**Conclusion**

The presence of uniformly fine sand layers with a particle size distribution of 2.5 Φ throughout all three profiles indicates that the studied region was deposited by a consistent mechanism and mostly contains clean sand from the Nile. The fine sand dominating population mode with various subsidiary inhabitants tends to be fine near the backshore, wherein a tiny tail of silt is noticeable. The enrichment of shell pieces along the beach and the winnowing action of waves and currents, which eliminates tiny particles provided there is no riverine supply, may explain for the tendency towards the coastline, which is somewhat coarser.   
  
The eastern half of the Rosetta mouth is normally smoother than its western portion coastal drift of current action that pushes the released particles east of the mouth. The coastal sediments along profile A are characterized by generally well-sorted, mainly negative values of skewness and lopsided nature of sediments, suggesting a high energy environment. This is probably because to the screening action of waves and currents and the ongoing rebuilding of beach ridges. The mesokurtic backshore dry region along profile C, which represents riverine/aeolian inputs within a single-directional transport governed by comparatively low energy conditions compared to the coastline, and the reasonably organised positive skewness values are its key features. Initially, sand promontories were created by the accumulation of finer particles.   
  
In the semi-wet regions of profile B—the transition zone between the coastline and the backshore—there is a comparable pattern of the most positively skewed values, the most well-organized nature, and the most mesokurtic nature across the research area. Sediment accumulation from riverine/aeolian and marine processings exhibit these patterns, which are thought to be the result of the equal blending of the subordinate population with the principal sediment mode, as specified by energy conditions.   
  
The river bed sample has mostly well-sorted fine sand, and its relatively high energy conditions, near-symmetrical skewness, and leptokurtic kurtosis distribution all point to a unidirectional river supply and transport channel, as do the local influences of the depositional environment and the presence of fishing enclosures and the vibrant Rosetta mouth environment. The study reveals how sensitive grain size characteristics are to small modifications in the compositional formulation of the sediments mixture. In a shallow and turbulent marine environment, the two principal methods of transport for sediments accumulated and processed by turbidity and marine phenomena are suspended with rolled mode (saltation) and suspensions with graded mode.

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