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Particle Size Analysis of Sediment from Ijaye-Orile, Southwestern Nigeria

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Introduction

It is a known fact that the only thing that is constant in every human society is change. For instance, during the earliest period of human evolution, the environment provided almost (if not all) of the needs for survival for early hominids. However, as time goes by, the environment keeps changing and this has had effects on both plant and animal species that have existed during these periods. Humans from the earliest stage did not live in isolation, they lived within an environment that affected them while they also affected the environment to a limited extent. Before the discipline of Environmental Archaeology came into being, the attempt to understand humans and the cultural setting in which they live(d) was basically through the lens of the study and analyses of material culture left behind by these past societies that are recovered from archaeological sites during survey and excavation. The methodology during these times can be said to be purely classical in nature and this was due to the fact that there were no serious attempts made toward studying human culture from the perspective of the environment. However, the birth of the sub-discipline of Environmental Archaeology served as an eye-opener, in that, it made us understand that humans interacted with the environment during the period of their existence (Sowunmi 2009).

Particle size analysis is aimed at revealing the depositional environment of sediment. From sediment analysis, information on the medium/agent that is responsible for the deposition of the sediment can be determined and it can also aid in our understanding of the manner and process of sediment deposition.

Geographical Background

Ijaye-Orile is located in Akinyele Local Government Area of Oyo state, south-western Nigeria. It is located N 7°37’52” E 3°50’56” and it is about 20km northwest of the University of Ibadan campus. It is bounded to the west by Iseyin, to the east by Fiditi and to the south by Ibadan (Olayinka and Folorunso 1997). The climate of Ijaye-Orile, like every other part of Ibadan, is influenced by seasonal shifts in wind patterns of the south-westerly monsoon wind that blows from the Atlantic Ocean, and the north-easterly trade wind that blows from the Sahara Desert. The characteristics of West Africa Monsoon climate, which has a distinct wet and dry climate, is therefore experienced in Ijaye-Orile (Olukole 2006). The geology of Ibadan is made up of igneous and metamorphic rocks that form the Basement. The major rocks include quartzite of the meta-sedimentary series and the migmatite complex. The minor rock types include pegmatites, quartz, aplites, diorites, amphibolites, and xenoliths (Filani *et al.* 1994).

Generally, the soils of Ibadan display a wide variation in physical and chemical characteristics or properties depending on their location along the topographical sequences (Aweto 1994). Some soils that occur along the same section of catena, irrespective of parent materials, possess some common characteristics. The upper and middle slope soils usually have dark to greyish topsoil and brownish red subsoil (Aweto 1994). The vegetation of Ijaiye-Orile is that of a “Derived Savanna” that was formerly a lowland rainforest but because of human activities such as grazing, bush burning, etc., the forests have been degraded into a "Derived Savanna" (Hopkins 1965). However, the "Derived Savanna" in Ijaye-Orile is very thick with many palm trees (Figure 1). The abundant forest relict is characterized by *Afzelia africana*, *Militia excelsa* (Iroko) and economic trees such as *Elaeis guineensis* (oil palm) and *Butyrospermum paradoxum* (shea butter) among others.

Aim and Objectives

The environmental condition of the study area was appraised through the analysis of sediment samples from the study area. The process of carrying out this analysis entails, among other things, the following objectives:

- To determine the size class of the sediments and interpret the energy characteristics of the transporting medium/media.
- To obtain information about the characteristics of the sediments.
- To determine the depositional history of the sediment through time and space through the determination of the mode of transportation and deposition of the sediments in order to know the nature of the palaeo-environment in the study area.

Methods

The sediment samples used for the analysis were those from excavations undertaken during the field school in Ijaye-Orile, Southwestern Nigeria. The site of Ijaiye-Orile was one of the towns that flourished in the Yoruba forest kingdoms in the late 17th and early 18th centuries (Johnson 1921). It was initially an *Egba* farm settlement and part of the area presently covered by Ibadan and towards Ife was *Egba* Forest. Ijaiye is located near the northern tip of the *Egba* Forest and close to the limits of the oil palm. Before the *Egba* Yorubas congregated to found Abeokuta, Ijaiye was a member of the *Gbagura*

Figure 1: Present day vegetation of Ijaye-Orile.

Province (Smith 1962: 329).

As a result of its fertile soils and location on the caravan route, the town soon grew in size and fame. It was due to its location that economic fortune was brought to Ijaye and it grew from a farm settlement to become a major town with strong socio-economic and political powers (Biobaku 1973; Herthersett 1911). The samples were collected with the aid of a hand trowel from seven stratigraphic layers that were marked out after excavations. The samples were described on the basis of the colour, texture and structure.

Preliminary Pre-Treatment Analysis

Pre-treatment is carried out for the purposes of determining whether or not there is the presence of extraneous materials in the sample and to determine the colour and texture of the samples. A light microscope was used for the purpose of determining the presence of extraneous materials such as roots, rootlets, charcoal specks and also the description of the grain with respect to its shape and lustre. The colour of the sample was determined with the aid of Munsell colour chart simply by matching the sediments from each layer with the colours on the chart after which the appropriate description with respect to the colour was determined. The samples were described using the Munsell colour chart. The Munsell colour chart describes the sediment's colour by reference to three properties; the hue (dominant spectra colour), value (lightness), and chroma (degree of greyness). The sediment is compared with colour chips on the cards until the chip nearest in colour is found. The notation is then read off and the corresponding verbal description given.

The textures of the samples were determined using the thumb and the index finger. Grain shape was then described and considered in relation to transport, erosion, and weathering to assess transport conditions and different kinds of gravel types.

The samples were then placed in a petri dish and carefully viewed under a light microscope. Organic matter was then removed from the samples by treating the samples with 50% H_2O_2 and 50% distilled water diluted in a measuring cylinder. The dissolution process was accompanied by evidence of effervescence, which is an indication that there is the presence of organic matter in the samples (Figure 2). The beakers were then labeled and 50g of each sample was weighed and poured into the beakers. Hydrogen peroxide was added and the resulting solution was left for four days to settle, this is known as the settling technique.

After four days, the supernatant was decanted into a beaker through a <63 micron sieve. Through this, the silt and clay would escape through the sieve mesh leaving behind the particles of higher texture on the sieve. The soil particles that were retained on the sieve mesh was then transferred into a petri-dish where it was left to dry up. Five percent HCl (Hydrochloric Acid) was then prepared and added to the silt and clay solution and this was left to settle. After five days, the coarse particles that have dried-up were poured into the arranged set of sieves of the British Textural Classificatory Scheme (see Table 1) in order to determine the various size classes to which they belong. The sieves were then shaken vigorously to move the particles into their appropriate size class. Each of the sieves was then removed in an orderly manner, weighed, and put in dispensary nylons which have been labeled from 2800 - <63 microns.

Settling Technique

The objective is to obtain the percentage weight of silt and clay in the samples. Distilled water was used in the dilution of the sediment solution in the beakers while a glass rod was used to stir the mixture. This was then subjected to a net sieving. The silt and clay was then left behind as residue, while the coarse-grained particles were retained on the surface of the sieve mesh. The filtrate was then treated with 10% HCl and allowed to settle for a period of one week.

After one week, distilled water was then added to the silt and clay solution in order for it to

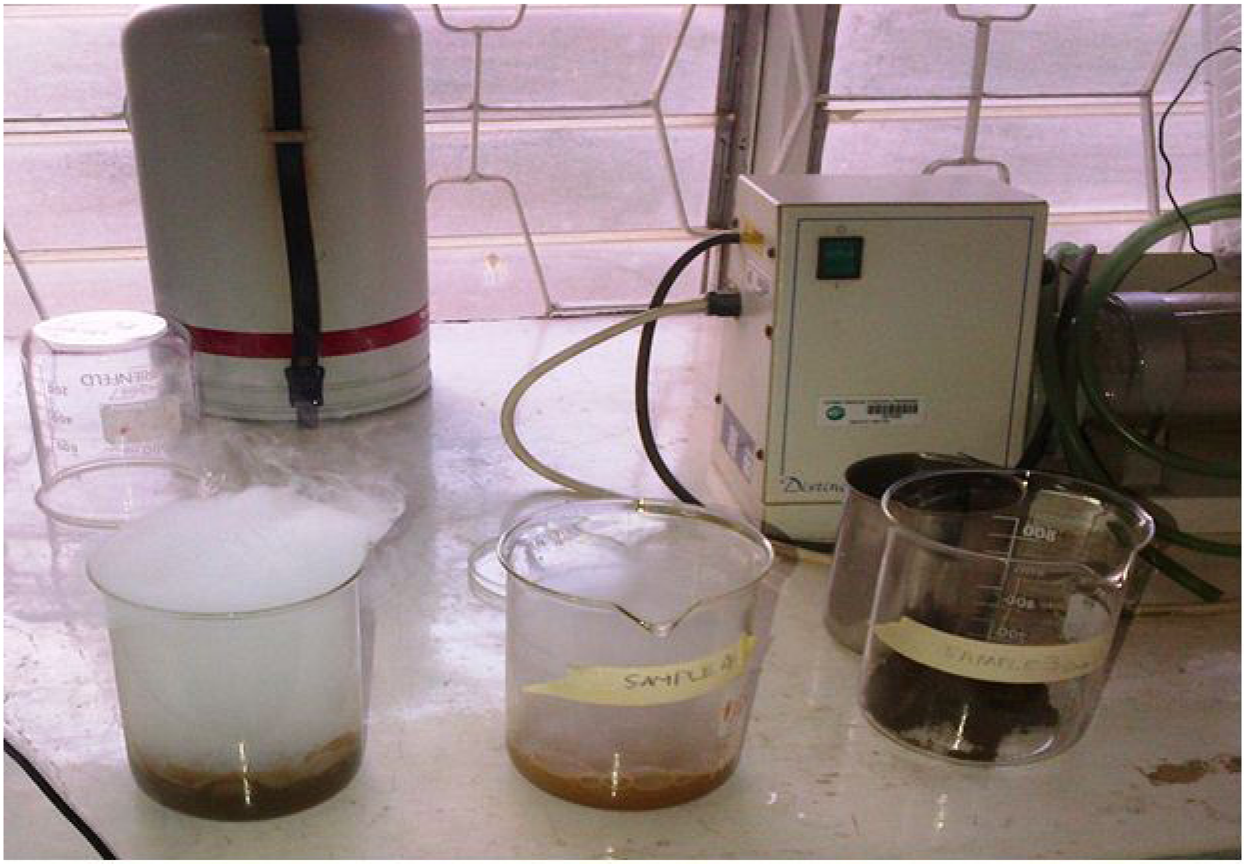

Figure 2: Effervescence after the addition of hydrogen peroxide.

Gravel	5600-2000 µm
Coarse Sand	1400-710 µm
Medium Sand	600-250 µm
Fine Sand	180-63 µm
Silt and Clay	<63 µm

Table 1: British Textural Classification.

Sample	Gravel	Sand	Silt & Clay	Description
1	1.5	75.8	17.5	Silty Sand
2	3	75.5	17.5	Silty Sand
3	18	64.5	12.75	Gravelly Sand
4	4.25	64.5	26	Silty Sand
5	1.5	73.3	23	Silty Sand
6	10.5	63.8	23.5	Gravelly Sand
7	18.75	68.5	11.25	Gravelly Sand

Table 2: Table showing results for the Wentworth Classificatory Scheme for the samples.

settle. After settling, the supernatant was decanted and the sediment was left to dry. The resultant mass was then weighed and the value added to the initial value that was determined for the sieve mesh/pan (<63 microns) from the previous exercise. The result of the analysis is presented in Table 2.

Discussion

Layer 1. The sample colour is 5YR 3/3 very dark reddish brown. There are no extraneous materials but the grains are sub-rounded in shape. As shown in Figure 3, gravel has the smallest proportion in the sample with a percentage weight of 3% and a total weight of 0.6g followed by silt and clay with a percentage weight of 17.5% and a total weight of 7g. Sand constitutes the highest proportion with a percentage weight of 75.5% and a total weight of 30.3g. The components which make up the sand are coarse sand 5.9g, medium sand 9.0g and fine sand 15.4g. The percentage loss is 4%.

Layer 2. The sample colour is 5YR 2.5/2 dark reddish brown. The extraneous materials include roots and rootlets. As shown in Figure 4, gravel has the smallest proportion with a percentage weight of 3% and a total weight of 1.2g, followed by silt and clay with a percentage weight of 17.5% and a total weight of 7g. Sand has the highest proportion with a percentage weight of 75.5% and a total weight of 30.2g. The components which make up the sand particles are coarse sand 6.4g, medium sand 17.3g, and fine sand 6.5g. The percentage loss is 4%.

Layer 3. The sample colour is 7.5YR 4/2 dark brown. The extraneous material includes sandstone inclusions. As shown in Figure 5, silt and clay has the lowest proportion with a percentage weight of 12.75% and a total weight of 5.1g followed by gravel with a percentage weight of 18% and a total weight of 6.9g. Sand has the highest proportion with a percentage weight of 64.5% and a total weight of 25.8g. The components which make up the sand particles are coarse sand 11.8g, medium sand 7.3g and fine sand 6.7g. The percentage loss is 4.75%.

Layer 4. The sample colour is 7.5YR 4/0 dark grey. The extraneous material includes stone inclusions. As shown in Figure 6, gravel has the lowest proportion with a percentage weight of 4.25% and a total weight of 1.7g followed by silt and clay with a percentage weight of 26% and a total weight of 10.4g. Sand has the highest proportion with a

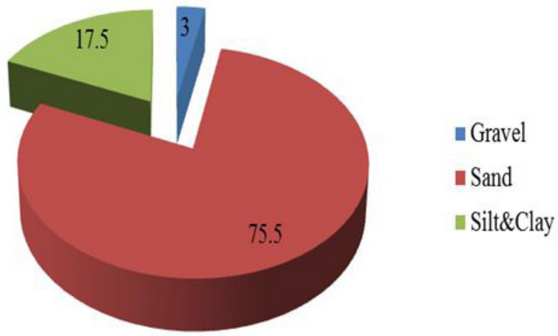

Figure 3: Layer 1.

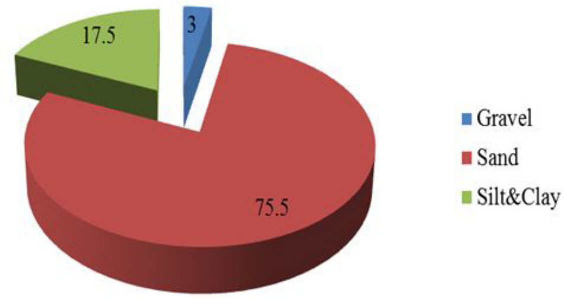

Figure 4: Layer 2.

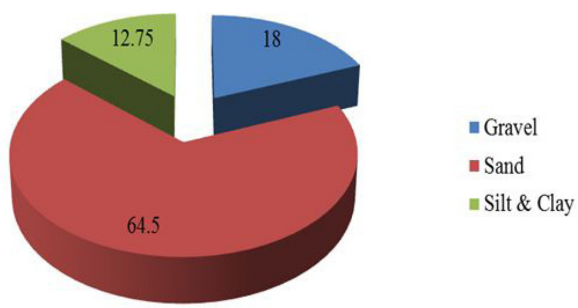

Figure 5: Layer 3.

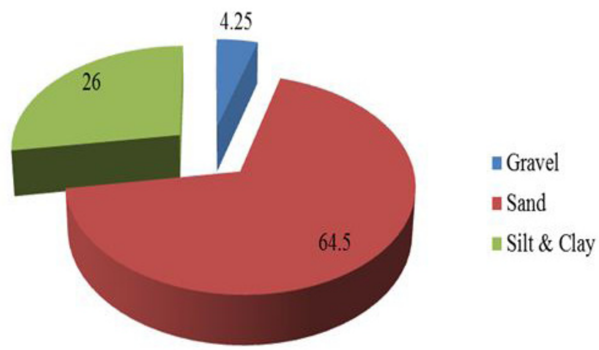

Figure 6: Layer 4.

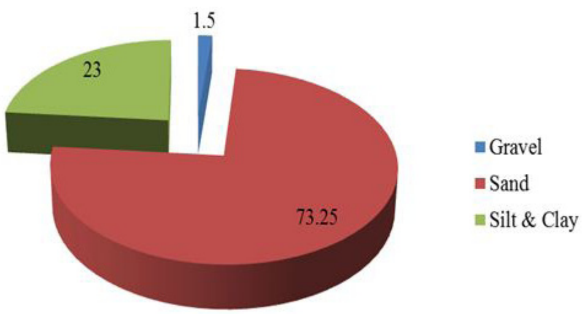

Figure 7: Layer 5.

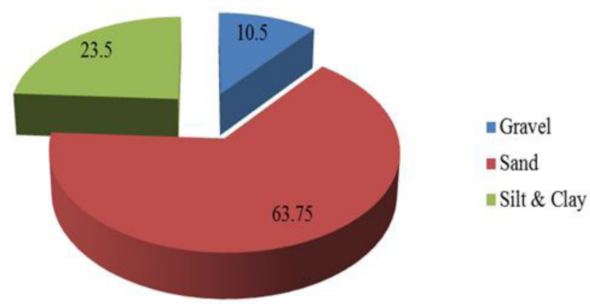

Figure 8: Layer 6.

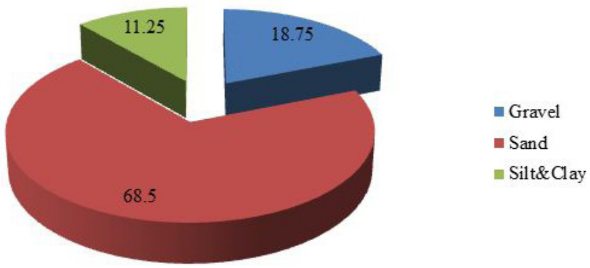

Figure 9: Layer 7.

percentage weight of 64.5% and a total weight of 25.8g. The components which make up the sand particles are coarse sand 3.6g, medium sand 10.7g and fine sand 11.5g. The percentage loss is 5.25%.

Layer 5. The sample colour is 10YR 4/3 dark brown. The extraneous material includes roots. As shown in Figure 7, gravel has the lowest proportion with a percentage weight of 1.5% and a total weight of 0.6g closely followed by silt and clay which has a percentage weight of 23% and a total weight of 9.2g. Sand has the highest percentage proportion of 73.25% and a total weight of 29.3g. The components which make up the sand particles are coarse sand 4.4g, medium sand 15g and fine sand 9.9g. The percentage loss is 2.25%.

Layer 6. The sample colour is 10YR 4/3 dark brown. There are no extraneous materials. As shown in Figure 8, gravel has the lowest percentage weight of 10.5% and a total weight of 4.2g followed by silt and clay with a percentage weight of 23.5% and a total weight of 9.4g. Sand has the highest proportion of 63.75% and a percentage weight of 25.5g. The components which make up the sand are coarse sand 9.4g, medium sand 7.7g, and fine sand 8.4g. The percentage loss is 2.25%.

Layer 7. The sample colour is 2.5YR 3/2 dark olive brown. There are no extraneous materials. As shown in Figure 9, silt and clay has the lowest proportion with a percentage weight of 11.25% and a total weight of 4.5g followed by gravel with a percentage weight of 18.75% and a total weight of 7.5g. Sand has the highest proportion with a percentage weight of 68.5% and a total weight of 27.4g. The components which make up the sand particles are coarse sand 11g, medium sand 8.1g and fine sand 8.3g. The percentage loss is 1.5%.

The first observation is that the average percentage loss for the sediment samples is about 3.28%. This can be explained against a backdrop of high organic matter content in the sediment samples which were effervesced after the addition of hydrogen peroxide. This portrays the extent to which humans have impacted the environment because the high organic matter content in almost all the samples is a result of human activities in the study area.

The sediment characteristics with respect to shape indicate that the shapes range from sub-rounded, rounded, angular and sub-angular. Using the Wentworth Classificatory Scheme, all the samples are either gravelly sand or silty sand. In all the samples, sand has the highest percentage and this is an indication of poor sorting of the sediment samples, which reflects the energy characteristic of the transporting medium to be swift running water. This can be attributed to a strong surface runoff originating from areas where the natural vegetation has been removed due to human activities. This also points to the fact that after the vegetation has been removed, high density of rainfall has caused a swift removal of the sediment samples. With respect to silt and clay, the percentage values range between 11.25 and 23.5 which is a reflection of an alternating wet and dry climate.

The palaeo-environment therefore can be probably regarded as a wet environment with thick vegetation and the area probably experienced high rainfall, which accounted for the swift runoff of sediment after the vegetation had been cleared, and that resulted in the sediment being poorly sorted.

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