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GRAIN SIZE CHARACTERISTICS OF OVER BANK DEPOSITS ON THE FLOODPLAIN OF THE OPA RESERVOIR BASIN, SOUTHWESTERN NIGERIA

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Little or no information exists in Nigeria on the grain size composition of the over bank deposits that dominate the river floodplains. This study examines the grain size composition of the over bank deposits of the floodplains of three rivers in the Opa Reservoir Basin, southwestern Nigeria. A total of 200 core bulk sediments were collected from the floodplain reaches of the three rivers and their grain size distribution was determined. The data were subjected to t-test statistics. The results showed variability in the grain size composition (% sand, % clay and % silt) both along (longitudinally) and within the floodplain reaches of the three rivers. The difference in grain size distribution was found to be significant at α=0.05 in two out of the three rivers. The variation in the grain size composition of the over bank deposits of the study floodplain reaches was significant at the 95% confidence level.

INTRODUCTION

Flooding occurs when water rises above the channel banks and flows across the adjacent land surface. A floodplain can be described as a broad strip of land built up by sedimentation on either side of a stream channel. When the floodwaters recede, the finer sediments are left behind as a horizontal deposit on the floodplain. River floodplains have long attracted the interest of geomorphologists both in terms of their contemporary development as readily identifiable fluvial landforms and the potential of their sediments to provide information on past catchment response to environmental change (Hudson, 2003). In recent years there has also been a growing recognition of their wider environmental significance.

Several studies exist on the grain size characteristics of sediments both within and along the floodplains of rivers in humid temperate zones (Pizzuto, 1989; Walling et al., 2004). For instance, Walling et al. (2004) observed that the variability in the floodplain sediment of some rivers in southern Britain reflects variation both within and along the individual reaches. However, apart from Adejuwon's (1974) work on the particle size characteristics of beaches along the coastal zone in southwestern Nigeria, there is virtually little or no known empirical work on the grain size characteristics of floodplain sediments of rivers in this part of the world. The present study will attempt to examine the variability of grain size characteristics of sediment in the over bank deposits of some river basins in the Opa Reservoir catchment, southwestern Nigeria. The findings of this study will further contribute to the existing body of literature on the characteristics of floodplain sediments in the humid tropics.

STUDY OBJECTIVES

The specific objectives of this study are to:

i. Evaluate and determine the grain size characteristics of deposited sediment along the floodplain.

ii. Determine within-reach and longitudinal variability in grain size composition of the over bank deposits of the study rivers.

STUDY AREA

The floodplains bordering the stream channel of some rivers such as the Ogbe, Ilode and Esinmirin rivers, which are tributaries of the Opa River in the Opa Reservoir drainage basin, southwestern Nigeria, constitute the study area (Figure 1). Both the Ogbe and Ilode are 2nd order streams and also the major tributaries of the Esinmirin (3rd order stream). The basic characteristics of the study rivers as well as their floodplains are shown in Table 1. The Opa Reservoir Basin is approximately 68 km^2 in area. The area lies between Lat. 7^{o}21'N and 7^{o}35'N and Long. 4^{o}30'E and 4^{o}40'E (Federal Survey Topographical Sheets Ilesa S.W. 243 and Ondo N.W. 263). The three study streams drain mostly through the built-up part of Ile-Ife township.

The farming practice on the floodplain of the study stream is characterized generally by small holdings. The floodplains are cultivated to field crops such as maize, vegetables and okra, especially during the dry season.

Generally, the study area is underlain by rock of the Precambrian Basement Complex which forms part of the African Crystalline Shield. Specifically, the studied streams, especially the Ilode and Esinmirin, are underlain by older granite undifferentiated schist-gneiss (Adejuwon and Jeje,

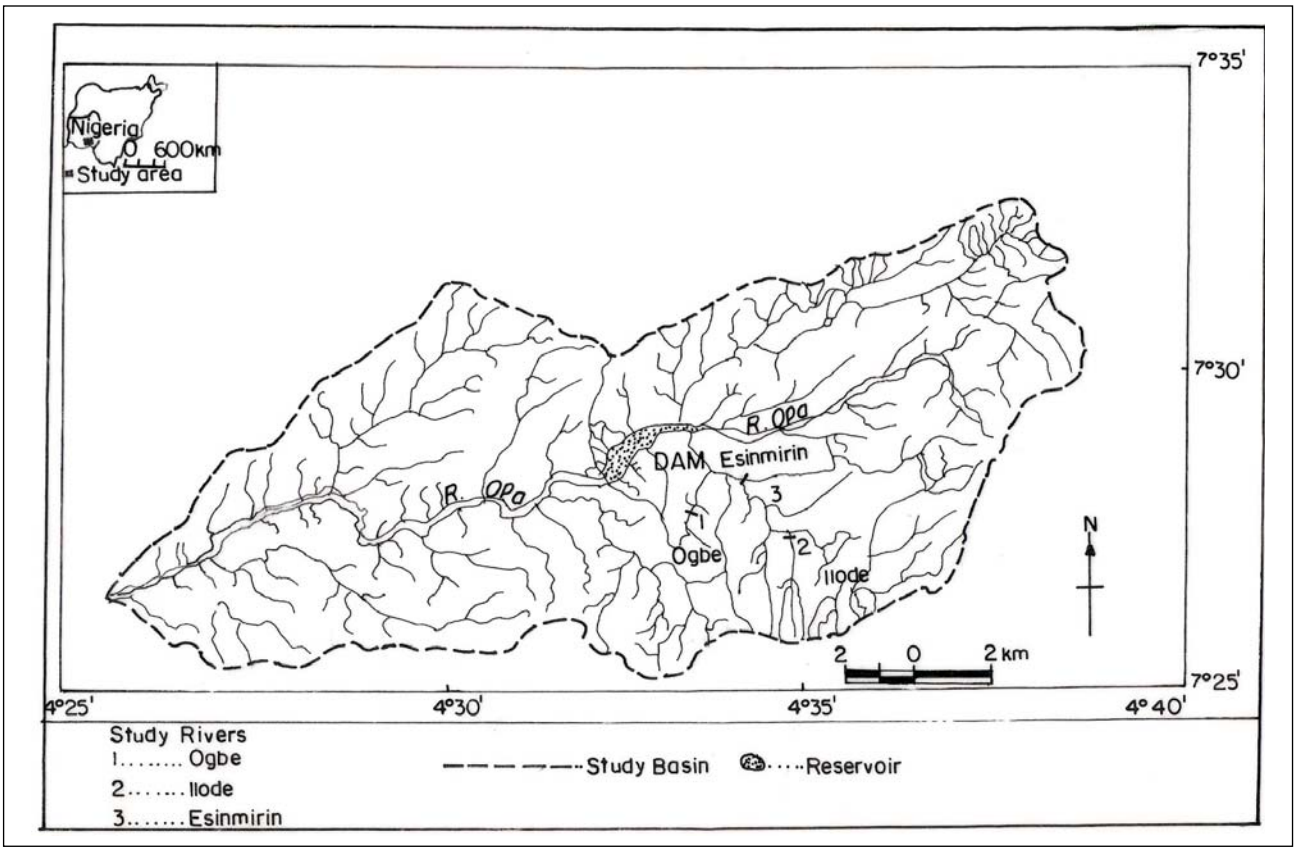


Figure 1. Study area and basins within Opa reservoir catchment.

1975). According to Smyth and Montgomery (1962), the schist and gneisses appear to be readily weathered and give rise to an undulating topography, with exposure of very few rock outcrops. These rocks give rise to a coarse sandy soil known as the Iwo Association (Smyth and Montgomery, 1962). The Ogbe stream is underlain by schists with some gneisses which give rise to sandy clayey soil of the Egbeda Association. These are well drained medium to fine texture soils, overlying orange brown, yellow brown and brown mottled clay (Smyth and Montgomery, 1962).

The study area falls under Koppen's A_f humid tropical rainforest climate. The mean annual rainfall is about 1400mm with the rainy season covering eight months (March to October). Its beginning and end is marked by torrential rains and thunderstorms. The rainy season in the area is normally characterized by two rainfall maxima with peaks occurring in July and September/ October. Temperatures are generally high and almost uniform. As observed by Adejuwon and Jeje (1975), the mean daily minimum and maximum temperature in the area is 20°C and 33°C, respectively.

Table 1. Some characteristics of the flood plains in the studied basins. Adapted from Adediji (2002).

River Basin	Area (km^2)	Drainage Density (km^{-1})	Relative Relief (H-h)	Relief Ratio (Rh)	Flood plain	
					Length (m)	Mean width (m)
Ogbe	1.40	1.73	45.73	0.027	680	39.60
Ilode	1.13	1.55	30.49	0.019	402	29.00
Esinmirin (Mokuro II)	2.75	2.07	68.59	0.047	923	38.80

MATERIALS AND METHOD

The three study streams, the Ogbe, Ilode and Esinmirin, are selected for this study because they are associated with extensive floodplains and in fact also contribute most of the dry season flow into the Opa River within the Estate of Obafemi Awolowo University, Ile-Ife. This study focused on the floodplains bordering the main channels of the three streams.

In each study stream, the floodplain was subdivided into a number of segments. The core bulk sediments of over bank deposits both along and within the floodplain reaches in each of the study streams were taken at intervals of 20m. Due to a lack of a motorized corer, the core bulk sediments were taken using a locally made corer from a galvanized pipe of 60cm (0.60m) length and 3.70cm (0.037m) diameter. The core sediment samples taken are representative of the deposited sediments with the purpose of seeing likely contrasts in sediment properties associated with both distance from the stream channel and different morphological features. For proper identification, the core bulk sediment samples are labeled A, B and C for Ogbe, Ilode and Esinmirin, respectively. For instance, the core sample taken from the channel bank (longitudinal) and individual reaches (within-reach) of the Ogbe flood plain are represented by A and A^1, respectively. The field work for this study was done in January, 2006, during the dry season when the floodplains are accessible for study.

After air-drying, disaggregating and sieving (2mm) to remove coarse organic debris, the grain size composition of sediment sample from each core was determined (Oluwafemi, 2006). The sieved sediment samples were dispersed using 5% sodium hydroxide (NaOH) with reciprocal mechanical shaker to shake the core samples for 3 hours. The hydrometer method as proposed by Bonyoucos (1951) was used to determine the particle size distribution (i.e. % clay, % silt and % sand) of the core sediment samples.

The data obtained on grain size characteristics are subjected to descriptive statistical measures such as mean, standard deviation and coefficient of variation as well as the t-test to compare the mean values, for the three measures of grain size composition using SPSS 2000 for Windows.

RESULTS AND DISCUSSION

The results of the grain size composition of the over bank deposits shown in Table 2, emphasize the fine-grained nature of the deposits. The mean percent sand varied from 31.03% for Ogbe to 43.88% for Ilode. As shown in Table 2, the standard deviation for Ogbe, Ilode and Esinmirin is 17.30%, 18.26% and 14.28%, respectively. The coefficients of variation are relatively low with values of 55.75%, 41.61% and 34.92% for Ogbe, Ilode and Esinmirin, respectively. Further, the results of t-test statistics indicated that values of % sand in the study rivers are significantly different at $\alpha = 0.05$ level of significance.

The results of analysis of variance (ANOVA) also showed that the variation in percent clay of the over bank deposits of the floodplains is significant at a 95% confidence level.

As evident from Table 2 there is relative variation in the grain size distribution of the over bank deposits of the floodplain among three study rivers.

As evident from Table 3, longitudinally, the mean % sand content ranges between 36.51 % and 51.50% for the three study rivers while within individual floodplain reaches, it ranges from 25.91% to 39.65%, indicating a significant decrease in % sand with increasing distance along the river channel (see also, Figure 2a, 2b, and 2c). The mean content value of % silt at longitudinal locations are 30.50% for Ogbe, 24.20% for Ilode and 21.76% for Esinmirin while within-reach

Table 2. Comparison of the mean, standard deviation (S.D) and coefficient of variation (C.V) of the selected measures of grain size composition of the over bank deposits of the study rivers.

River	% Sand			% Silt			% Clay		
	Mean	S.D	C.V	Mean	S.D	C.V	Mean	S.D	C.V
Ogbe (A)	31.03	17.30	55.75	33.35	10.02	30.04	35.79	9.10	25.42
Ilode (B)	43.88	18.26	41.61	28.20	11.29	40.03	28.38	9.12	32.13
Esinmirin (C)	40.89	14.89	34.92	23.66	11.60	49.02	35.45	6.82	19..23

locations for the three study rivers showed 36.21%, 32.20% and 25.75% silt, respectively. As shown in the Table 3 and Figure 2 the % silt reflects a general fining of the deposited sediment with increasing distance along the floodplain reaches.

Further, the % clay for both longitudinal and with-reach locations as evident from Table 3 appears to be increasing with distance along the floodplain reaches (longitudinally) except for the Esinmirin River, where a decrease in mean clay content at longitudinal locations was observed. The high % clay content obtained both longitudinally and within the floodplain of the Ogbe may be due to the fact the river is underlain by clayey soil of Egbeda Association. In other words, the soil association may be responsible for the fining of over bank deposits of the Ogbe as the soils are well drained medium to fine texture (Smyth and Montgomery, 1962). The high % sand content obtained from both the Ilode and Esinmirin may reflect the fact that they are underlain by coarse sandy soil of the Iwo Association. Soils of the Iwo Association are derived from schists and gneisses and are coarse textured (Symth and Montgomery, 1962).

The variation in the grain size composition of the over bank deposits of the three study rivers is shown in Figure 2a, 2b and 2c. The variability in grain size distribution of the flood plain sediments both along and within the flood plains reaches is significant at $\alpha = 0.05$ in the study rivers except the Esinmirin. In the case of within-reach variability, the variation is likely to reflect a general fining of the deposited sediment with increasing distance from the river.

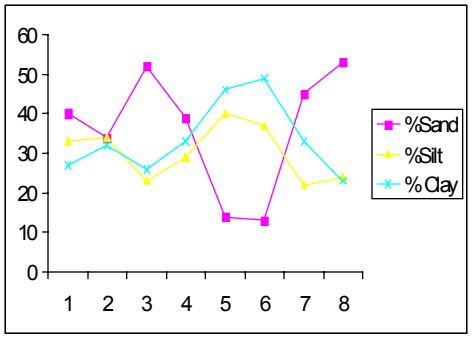
The findings of this study on the variability of the grain size composition of the floodplain sediments of the three study rivers compared favorably with the results obtained by Walling et al. (2004) in southern Britain where in spite of the difference in their study basins in terms of geology and other characteristics, relatively little variation was observed in the grain size distribution of the floodplain sediments between the six rivers studied. But, however, their findings showed that the floodplain sediments of the river Stour are significantly finer than those from the floodplains of the other five rivers in southern Britain.

The results of this study confirm the appreciable spatial variability of the grain size distribution of the over bank floodplain sediments, which reflects variation both longitudinally and within

Table 3. Comparison of the mean, standard deviation (S.D) and coefficient of variation (C.V) of the bulk sediment associated with the within reach and longitudinal section of the study rivers.

River	Location	Grain size composition								
		% Sand			% Silt			% Clay		
		Mean	S.D	C.V	Mean	S.D	C.V	Mean	S.D	C.V
Ogbe (A)	longitudinal	36.15	19.16	53.00	30.50	10.59	34.72	33.41	10.27	30.73
	within- reach	25.91	13.67	52.75	36.21	8.66	23.91	38.18	7.14	18.70
Ilode (B)	longitudinal	51.50	13.69	26.58	24.20	9.82	40.59	24.40	5.33	21.84
	within-reach	36.25	19.36	53.40	32.20	11.46	35.59	32.35	10.45	32.30
Esinmirn (C)	longitudinal	42.13	16.27	36.61	21.76	10.75	49.40	36.04	8.32	23.08
	within-reach	39.65	12.02	30.31	25.57	12.20	47.71	34.85	4.90	14.06

Fig. 2a. LINE GRAPH SHOWING GRAIN SIZE COMPOSITION OF OGBE RIVER



Segment number: Downstream
LONGITUDINAL LOCATIONS

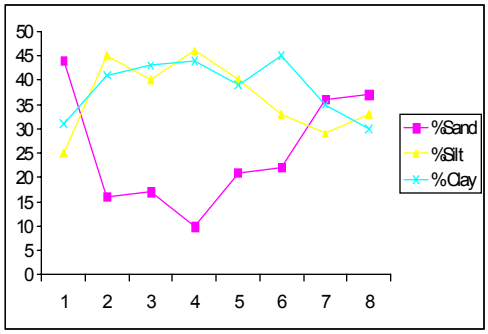


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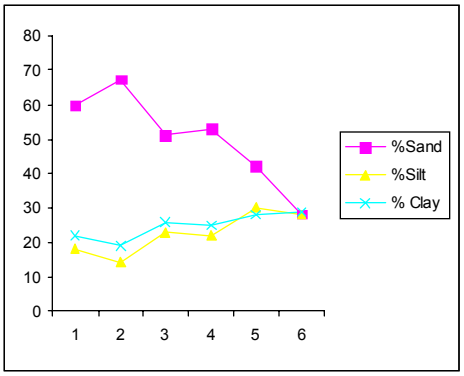
Fig. 2b. LINE GRAPH SHOWING GRAIN SIZE COMPOSITION OF ILODE RIVER



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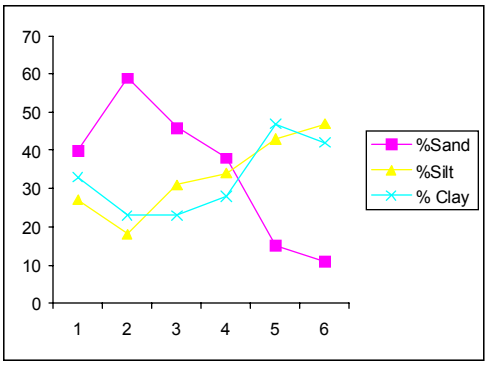

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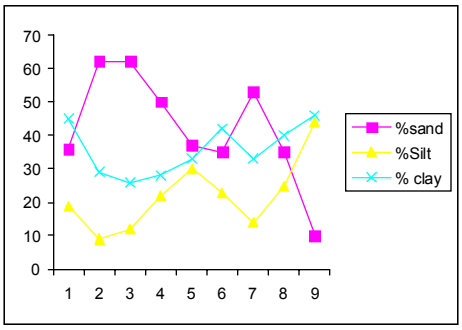
Fig. 2c. LINE GRAPH SHOWING GRAIN SIZE COMPOSITION OF ESINMIRIN RIVER



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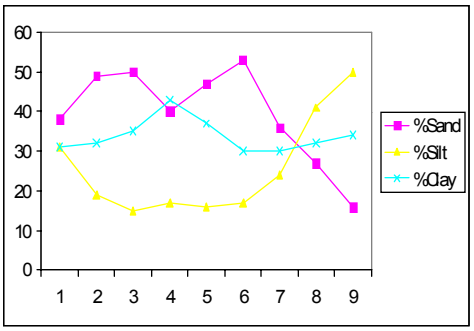

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WITHIN- REACH LOCATIONS

reach. Further, the fining of the over bank deposits sediment both longitudinally and within–reach downstream of the Ogbe river as shown in Figure 2a agrees with the finding of Walling et al. (2004) that floodplain sediments of river Stour are significantly finer with increasing distance downstream. In this regard, only the Ogbe river out of the three rivers studied appears to be significantly finer. This is supported by the high proportion of clay and silt in the grain size distribution. Also, there is some evidence that shows that the floodplain deposits of the Ilode and Esinmirin are dominated by a relatively high sand content when compared with the Ogbe. As seen in Table 3, most of the variation reflects within reach variability, rather than longitudinal because there is no clear consistent pattern for all the study rivers along the floodplains.

CONCLUSION

This study focused on the grain size compositions of the over bank deposits on the floodplains of three rivers in the Opa Reservoir Basin, southwestern Nigeria. The results showed that the variability in the grain size distribution of the floodplain sediments both along (longitudinal) and within the floodplain reaches is significant at $\alpha = 0.05$ in the study rivers except the Esinmirin. The results also indicate that the grain size distribution of the Ogbe river is finer than the two other rivers with increasing distance down stream. This is reflected by the high proportion of clay and silt in the Ogbe grain size composition. On the other hand, the over bank deposits in the Ilode and Esinmirin is coarser than that of the Ogbe, due to the fact that the two river basins are underlain by coarse sandy soils. This finding implies that there is a positive relationship between the soil type and the grain size composition of the over bank deposits of the study floodplains.

Generally, the difference in the composition of the floodplain sediments is significant at a 95% confidence level. Within–reach variability in the over bank deposits is likely to reflect a general fining of the deposits with increasing distance from the river as in the case of the Ogbe river, as the river is underlain by fine texture clay soils.

REFERENCES

Adediji, A. 2002. Sediment Delivery Ratios in Opa Reservoir Catchment, Southwestern Nigeria. Unpublished Ph.D Thesis, Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria.

Adejuwon, J.O. 1974. Soil mapping in the coastal zone of Southwestern Nigerian Agricultural Journal, 11, 14-20.

Adejuwon, J.O., and L.K. Jeje. 1975. University of Ife Water Supply Scheme: Potential environmental hazards, in: Environmental and spatial factors in Rural Development in Nigeria (eds. Adejuyigbe, O and Halleiner, F.M) Proceedings of Nigerian Geographical Association Conference, Ile-Ife, pp. 128-135.

Bonyoucos, C.U. 1951. The clay ratio as criterion of susceptibility of soils to erosion. Journal of American Society of Agronomy 27, 738-741.

Hudson, P.F. 2003. Flood Plains: environment and process. Geomorphology 56, 223-224.

Oluwafemi, O.A. 2006. Grain size characteristics of flood plains of some rivers in the Opa Reservoir Basin, Southwestern Nigeria. Unpublished B.Sc. Thesis. Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria, 24-32.

Pizzuto, J.E. 1987. Sediment diffusion during overbank flows. Sedimentology, 34, 301-317.

Symth, A.J. and R.F. Montgomery. 1962. Soil and Land use in Central Western Nigeria. Public by Ministry of Agriculture and Natural Resources. pp. 33-37.

Walling, D.E., D. Fang, A. Nicholas, and R.J. Sweet. 2004. The grain size characteristics of overbank deposits on the flood plains of British lowland rivers. Proceedings of a symposium held in Moscow, August 2004, IAHS Publ. 288, pp. 226-234.

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