INVESTIGATION OF TEXTURAL ATTRIBUTES OF SEDIMENT IN IFELODUN COUNTY, NIGERIA

Supported by tetfund TERTIARY EDUCATION TRUST FUND
ISSN: 2141 – 3290
www.wojast.org

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ABSTRACT

Stream sediments were collected from different areas in Ifelodun county within latitude 8º45¹N to 8º5¹N and longitude 4º46¹E to 5º6¹E. 13 samples of sediments were obtained from each of the eight locations totaling 108. A German standard sieve set of mesh with shaker was used for grain size analysis. The results of grain size analysis range from medium to very coarse sand as the majority of sediment composition before investigation of textural parameters. The result of textural parameters was obtained and used to differentiate the depositional environment of the sediments. The mean, sorting, skewness and kurtosis defined the sediment as very coarse, poorly sorted, vary from very fine skewed to near symmetrical with mesokurtic environment, although the other extreme tails also exist. Positively skewed and poorly sorted sediments characterized low energy environment.

KEYWORDS: Textural, Attributes, Sorting, Skewness, Kurtosis, Energy

Introduction

Sediment texture analysis is centered on the data identifying sub-populations within individual grain size distributions. Processes of rolling, suspension and saltation frequently control grain size distribution (Chauhan *et al*., 2014). Each sub-population may be connected to a different mode of sediment transport and deposition and therefore provide the extent of their significance in the genesis of a sand unit. Textural attributes of sediments and sedimentary rocks can be deduced from the textural parameters which are extensively used to reconstruct the depositional environments (Friedman *et al*., 1992). This statistic may be presented graphically by plotting each parameter with corresponding location to distinguish sedimentary environments. Sediment texture refers to the proportion of sand, silt and clay lower than 2 x 10^3 micrometers (or 2mm) in diameter in a quantity of sediment (Ivara, 1999). Spreading arrangement of grain size are highly influenced by sediment transportation mechanisms, which are energy dependent process and comprise along shore current transport, swash and backwash motion, wind deflation and tidal currents (Hall, 1987; Chauhan *et al*., 2014).

Transportation and deposition processes of sediment particles are affected by the factors such as roundness, sphericity, surface texture, detrital heavy mineral fraction, biogenic constituents and syngenetic minerals which quantify grain and help in identification of environment. Grain size distribution is controlled by the physical transportation of sediment, plus sediment aggregation and deposition, gravitational flow, tidal pumping and tidal trapping (Wai, 2004; Maity and Maiti, 2016). Sediment grain size affects flow resistance as it modifies the hydraulic features near the bed of the channel. Paleo-environment can be deduced from grain size analysis of sediments (Beal and Shepard, 1956). The coarser sediments are seen in high-energy environments; finer sediments congest at low energy regimes (Atat *et al*., 2021b). Texturally, the river sediments are sandy, silt and fine grained. Friedman (1967) in a study on numerous sand deposition environments observed that when skewness was plotted against graphic mean, the dune sand shows a perfect complete separation. Moiola and Weiser (1968) noted that kurtosis and skewness of a given sediment population when plotted against each other is an effective tool to discriminate the environment of deposition of sediments.

The parameters used to describe the particle size distribution are the mean, standard deviation (sorting), skewness and kurtosis. They can be computed by mathematical method. Mean is the average size of the sediments; it is generally, an index of energy situations. The variation in mean size is the reflection of the fluctuations in energy conditions of the depositing media and specifies average kinetic energy of the depositing agent (Manivel *et al*., 2016). Standard deviation may designate the difference in kinetic energy connected with mode of deposition or uniformity of particle size distribution. Although it reflects the energy conditions of depositional environment but does not certainly measure the degree to which the sediment has been mixed. Sorting values may continue to vary due to unceasing addition of finer or coarser supplies in differential proportions (Manivel *et al*., 2016). Skewness measures the symmetrical distribution (predominance or prevalence of coarse or fine sediments). Kurtosis is a quantitative parameter used to describe the departure from normality of distribution. More so, it is the ratio between the sorting in tails and central portion of the curve. If the tails are better sorted than the central portion, then, it is called as leptokurtic; it is platykurtic in opposite circumstance or mesokurtic if sorting is uniform both in tails and the central positions. Friedman (1967) recommended that extreme high or low values of kurtosis signify that part of the sediment achieved its sorting in a different place in a high energy environment. The variation in the kurtosis values is a reflection of the flow characteristics of the depositing medium (Seralathan and Padmalal, 1994; Baruah *et al*., 1997).

The processes of quartile, percentile and others are some of the normally used statistical procedures of grain size distribution. Seven different points (5, 16, 25, 50, 75, 84 and 95 percentiles with respect to phi scale) on the ogive are considered for the computation of the parametric

https://dx.doi.org/10.4314/WOJAST.v14i1b.97

statistics (Passega and Byramjee, 1969). Sediment transportation is the movement of organic [or inorganic] particles by water, gravity, glaciers as well as fluid in which the sediment is entrained. Most sediments are as a consequence of weathering and erosion (Passega, 1957). Transportation of Sediments is frequently accountable for the intermixing of geologic features by carrying mineral particles away from their origin (Manivel *et al.*, 2016). Our aim is to interpret sediment deposits using textural attributes obtained via grain size investigation.

Geology and Location

Ifelodun is one of the local government areas in Kwara State, Nigeria (Figure 1). It lies within latitudes $8^0 45^1$N and $8^0 5^1$N; longitudes $4^0 46^1$E and $5^0 6^1$E of the equator (Adedoyin, *et al*., 2021a; Atat *et al*., 2021b). The climatic situation of the area falls within the warm-horrid tropical climate region where the wet and the dry seasons are experienced predominantly. The dry season is mostly observed about November to March annually; the rainy or wet season is mostly experienced between April and October (Kayode *et al*., 2016; Adedoyin *et al*., 2021b; Atat *et al*., 2021a). The topographic features are unique. Within the North-eastern part is a noticeable relief which is an elongation of granite ridge from Share to Yikpata. The Eastern side has the quartzite ridges which are of lower elevation of about 1.28 x 10^2m. The geology is of crystalline pre-cambrian basement complex rocks (Yahaya et al., 2014). Ifelodun has an area of about 3,435 Km^2 with almost 43 villages and towns. The population of Ifelodun is about 204,975 as at 3rd March, 2006 (National Population Census, 2006).

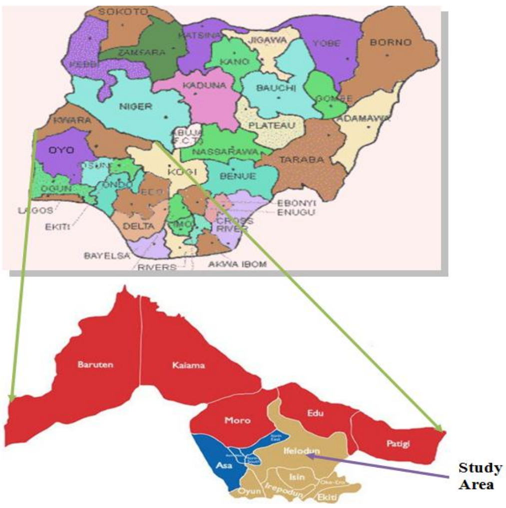


Figure 1: Map of Kwara State extracted from Nigeria indicating Ifelodun (Agba *et al*., 2018).

Basic Theory

If source sediment undergoes erosion, the subsequent sediment in the transport is deposited entirely; this deposit must be finer, better sorted and more negatively skewed than the source. The lag remaining after erosion is coarser, better sorted and more positively skewed. If sediment in transport undergoes selective deposition, the resultant deposit can either be finer or coarser than the source, but the sorting will be better and the skew more positive. Skewness sediment/deposit is the likely result of the sedimentary process (McLaren, 1981). Highly negative skewness to nearly symmetrical (although still negative) is likely as the energy of the transporting process increases. The two extremes of skewness are low-energy and high-energy transfer functions (McLaren and Bowles, 1985). The statistical parameter values such as graphic mean, graphic standard deviation, graphic skewness and graphic kurtosis are needs for grain size and statistical distribution (Akintola *et al*., 2013; Oladipo *et al*., 2018). The key parameter able to classify grain size trends is skewness (Roman and Achab, 1999). Equations 1 to 5 relate these parameters to their appropriate percentile deductions.

Graphic Mean, M (Average size of the sediment):

$$M = \frac{\varphi_{16} + \varphi_{50} + \varphi_{84}}{3} \quad (1)$$

Standard Deviation, SD:

$$SD = \frac{\varphi_{84} - \varphi_{16}}{4} \quad (2)$$

Sorting, S_r

$$S_r = \frac{\varphi_{84} - \varphi_{16}}{4} + \frac{\varphi_{95} - \varphi_{5}}{6.6} \quad (3)$$

Skewness, S_k

$$S_k = \frac{\varphi_{84} + \varphi_{16} - 2\varphi_{50}}{2(\varphi_{84} - \varphi_{16})} + \frac{\varphi_{5} + \varphi_{95} - 2\,\varphi_{50}}{2(\varphi_{95} - \varphi_{5})} \quad (4)$$

Kurtosis, K

$$K = \frac{\varphi_{95} - \varphi_{5}}{2.44(\varphi_{75} - \varphi_{25})} \quad (5)$$

(Folk and Ward, 1957; Folk, 1968; Gandhi and Raja, 2014; Oladipo *et al*., 2018; Atat *et al*., 2018; Atat *et al*., 2022).

Materials and Method

The materials used include: hammer, chisel, German Standard Sieve of sizes, sample bags (for collection of stream sediments), Weighing balance, digital camera, measuring tape, paper tape, marker, Global Positioning System, compass clinometer, electrical vibratory machine, hand lens, computer with a spread sheet program (Excel), field note and topographical map.

The technique for the analysis comprises disaggregation of the 13 samples by soaking in water for 24 hours to obtain individual grains and exposure to sun for two days to ensure the samples are water free. Weighing balance was used to measure 100g of each dried sample which was transferred into the German Standard Sieve of sizes: 2.00mm, 1.00mm, 0.85mm, 0.71mm, 0.60mm, 0.50mm, 0.30mm, 0.25mm, 0.112mm, 0.09mm, 0.075mm, 0.063mm and less than 0.063mm. It has a pan at the bottom to assemble less than 0.063mm divisions. Sieves containing different mesh sizes were stacked and arranged such that the largest mesh size is at the top and decreasing downwards to the bottom. The set up was linked to an electrical vibratory machine (sieve shaker) for 10 minutes to ease the grains separation. The fraction retained on each sieved pan was weighed, recorded and used for statistical design. This later gives rise to the values of textural parameters.

Results and Discussion

Results of textural parameters have been computed (Table 11) and interpreted (Table 12). This would not have been possible without carrying out grain size analysis which resulted in Tables 2 to 9 and lead to ogives (Figure 2 and 3) that define percentile values (Table 10). Figures 4 to 9 have been plotted for easy discussion, interpretation and graphical variations.

Table 1 shows the Scale of grade and class terms for clastic sediments.

Table 1: A Scale of grade and class terms for clastic sediments (Wentworth, 1922).

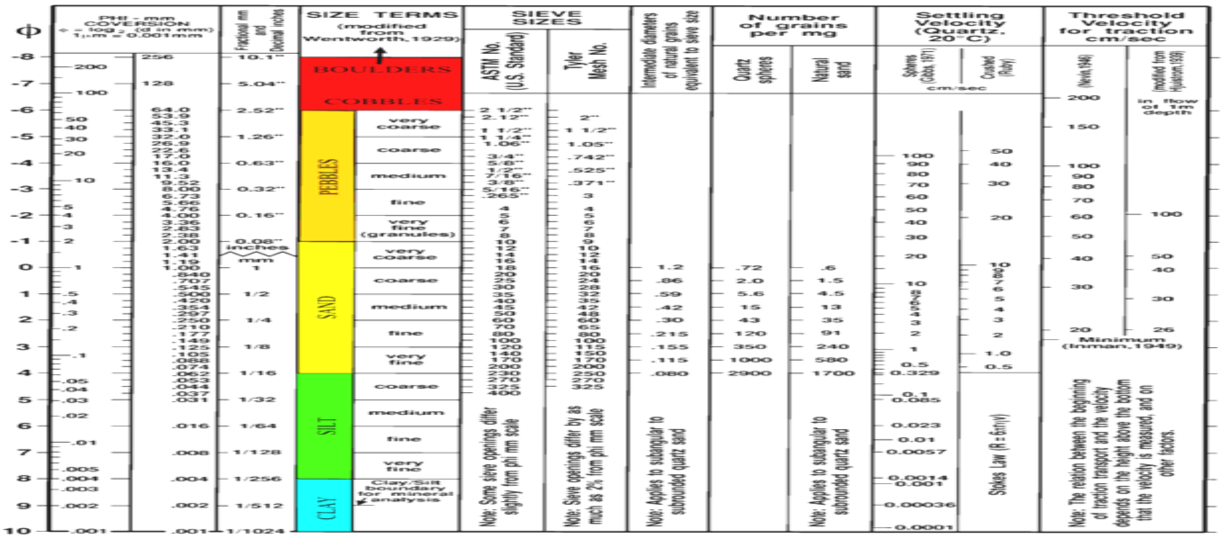


Table 2: Grain size analysis of AR 1

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	19.3	19.43605	19.43605
2	1	0	34.2	34.44109	53.87714
3	0.85	0.23	5	5.035247	58.91238
4	0.71	0.49	0.3	0.302115	59.2145
5	0.6	0.74	5.2	5.236657	64.45116
6	0.5	1	10.6	10.67472	75.12588
7	0.3	1.74	8.9	8.962739	84.08862
8	0.25	2	2.8	2.819738	86.90836
9	0.112	3.16	8.3	8.35851	95.26687
10	0.09	3.47	1.2	1.208459	96.47532
11	0.075	3.74	0.8	0.805639	97.28096
12	0.063	3.99	0.7	0.704935	97.9859
13	Pan	4	2	2.014099	100
	Total		99.3		

Table 3: Grain size analysis of AR 3

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	21.2	21.23185	21.23185
2	1	0	28.5	28.54281	49.77466
3	0.85	0.23	0.4	0.400601	50.17527
4	0.71	0.49	6.8	6.810215	56.98548
5	0.6	0.74	16.9	16.92539	73.91087
6	0.5	1	16.5	16.52479	90.43566
7	0.3	1.74	2.6	2.603906	93.03956
8	0.25	2	5.5	5.508262	98.54782
9	0.112	3.16	0.8	0.801202	99.34903
10	0.09	3.47	0.2	0.2003	99.54933
11	0.075	3.74	0.1	0.10015	99.64948
12	0.063	3.99	0.15	0.150225	99.7997
13	Pan	4	0.2	0.2003	100

99.85

Table 4: Grain size analysis of AR 5

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	0.3	0.335646	0.335646
2	1	0	2.8	3.132692	3.468338
3	0.85	0.23	2.7	3.02081	6.489148
4	0.71	0.49	0.6	0.671291	7.160439
5	0.6	0.74	3.5	3.915865	11.0763
6	0.5	1	24.3	27.18729	38.26359
7	0.3	1.74	41.3	46.20721	84.4708
8	0.25	2	1.3	1.454464	85.92526
9	0.112	3.16	11.5	12.86641	98.79168
10	0.09	3.47	0.9	1.006937	99.79861
11	0.075	3.74	0.08	0.089505	99.88812
12	0.063	3.99	0.05	0.055941	99.94406
13	Pan	4	0.05	0.055941	100
			89.38		

Table 5: Grain size analysis of AR 7

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	5.6	5.611222	5.611222
2	1	0	10.6	10.62124	16.23246
3	0.85	0.23	4	4.008016	20.24048
4	0.71	0.49	1.3	1.302605	21.54309
5	0.6	0.74	5.5	5.511022	27.05411
6	0.5	1	25.8	25.8517	52.90581
7	0.3	1.74	26.5	26.55311	79.45892
8	0.25	2	6.8	6.813627	86.27254
9	0.112	3.16	12.2	12.22445	98.49699
10	0.09	3.47	1.1	1.102204	99.5992
11	0.075	3.74	0.2	0.200401	99.7996
12	0.063	3.99	0.1	0.1002	99.8998
13	Pan	4	0.1	0.1002	100
			99.8		

Table 6: Grain size analysis of AR 16

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	34.6	34.77387	34.77387
2	1	0	28.6	28.74372	63.51759
3	0.85	0.23	2.8	2.81407	66.33166
4	0.71	0.49	0.8	0.80402	67.13568
5	0.6	0.74	4.1	4.120603	71.25628
6	0.5	1	8.9	8.944724	80.20101
7	0.3	1.74	7.8	7.839196	88.0402
8	0.25	2	3	3.015075	91.05528
9	0.112	3.16	7.6	7.638191	98.69347
10	0.09	3.47	0.7	0.703518	99.39699
11	0.075	3.74	0.3	0.301508	99.69849
12	0.063	3.99	0.1	0.100503	99.799
13	Pan	4	0.2	0.201005	100
			99.5		

Table 7: Grain size analysis of AGS 18

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	36.4	36.61972	36.61972
2	1	0	26.1	26.25755	62.87727
3	0.85	0.23	4.2	4.225352	67.10262
4	0.71	0.49	0.3	0.301811	67.40443
5	0.6	0.74	3.5	3.521127	70.92556
6	0.5	1	9.2	9.255533	80.18109
7	0.3	1.74	8.7	8.752515	88.9336
8	0.25	2	1.2	1.207243	90.14085
9	0.112	3.16	5.5	5.533199	95.67405
10	0.09	3.47	3.5	3.521127	99.19517
11	0.075	3.74	0.3	0.301811	99.49698
12	0.063	3.99	0.2	0.201207	99.69819
13	Pan	4	0.3	0.301811	100
			99.4		

Table 8: Grain size analysis of OL 6b

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	23	23.18548	23.18548
2	1	0	15.6	15.72581	38.91129
3	0.85	0.23	2.6	2.620968	41.53225
4	0.71	0.49	0.4	0.403226	41.93548
5	0.6	0.74	2.9	2.923387	44.85887
6	0.5	1	9.5	9.576613	54.43548
7	0.3	1.74	13.8	13.91129	68.34677
8	0.25	2	6.2	6.25	74.59677
9	0.112	3.16	18.5	18.64919	93.24596
10	0.09	3.47	3.2	3.225806	96.47177
11	0.075	3.74	1.3	1.310484	97.78225
12	0.063	3.99	0.8	0.806452	98.58871
13	Pan	4	1.4	1.41129	100
			99.2		

Table 9: Grain size analysis of OL 15b

S/N	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	41.6	41.72936	41.72936
2	1	0	43.1	43.23403	84.96339
3	0.85	0.23	3.5	3.510884	88.47427
4	0.71	0.49	0.2	0.200622	88.67489
5	0.6	0.74	3	3.009329	91.68422
6	0.5	1	4.4	4.413682	96.0979
7	0.3	1.74	2.3	2.307152	98.40505
8	0.25	2	0.3	0.300933	98.70599
9	0.112	3.16	1.1	1.103421	99.80941
10	0.09	3.47	0.04	0.040124	99.84953
11	0.075	3.74	0.05	0.050155	99.89969
12	0.063	3.99	0.04	0.040124	99.93981
13	Pan	4	0.06	0.060187	100
			99.69		

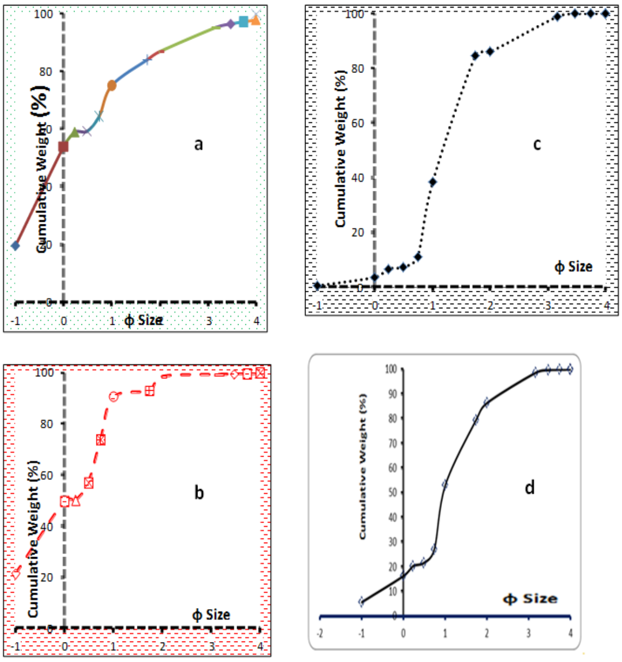


Figure 2: Ogives for Cumulative weight-ϕ variation of location (a) sample from AR1 (b) sample from AR3 (c) sample from AR5 (c) sample from AR7.

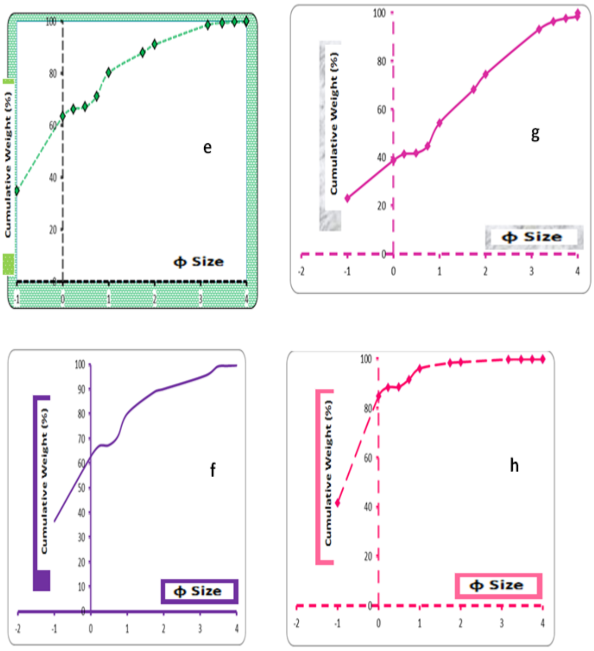


Figure 3: Ogives for Cumulative weight-ϕ variation of location (e) sample from AR16 (f) sample from Ags18 (g) sample from OL6b (h) sample from OL15b.

Table 10: Result of percentiles investigation

S/N	Locations	φ_5	φ_{16}	φ_{25}	φ_{50}	φ_{75}	φ_{84}	φ_{95}
1	AR_1	-1.45	-1.10	-0.85	-0.10	1.00	1.75	3.20
2	AR_3	-1.55	-1.25	-0.85	0.00	0.75	0.90	1.85
3	AR_5	0.10	0.80	0.90	1.20	1.60	1.70	2.85
4	AR_7	-1.00	0.00	0.65	0.95	1.60	1.90	2.90
5	AR_{16}	-2.05	-1.65	-1.35	-0.45	0.85	1.40	2.65
6	AGS_{18}	-2.20	-1.75	-1.45	-0.50	0.85	1.35	3.15
7	OL_{6b}	-2.15	-1.45	-0.85	0.90	2.00	2.60	3.40
8	OL_{15b}	-1.90	-1.60	-1.40	-0.80	- 0.20	- 0.05	0.95

Table 11: Result of corresponding textural parameters

Locations	Mean	SD	Sort	Skew	Kurt
AR_1	0.183333	0.7125	1.417045	0.3588	1.030128
AR_3	-0.11667	0.5375	1.052652	-0.03728	0.870902
AR_5	1.233333	0.225	0.641667	0.155556	1.61007
AR_7	0.95	0.475	1.065909	0	1.682485
AR_{16}	-0.23333	0.7625	1.474621	0.266132	0.875559
AGS_{18}	-0.3	0.775	1.585606	0.279017	0.953314
OL_{6b}	0.683333	1.0125	1.853409	-0.1298	0.798102
OL_{15b}	-0.81667	0.3875	0.819318	0.097906	0.973361

Discussion

From Table 1, -1ϕ (which corresponds to 2mm) to 4ϕ (corresponding to 0.062mm) is sand, which could be very coarse if it ranges from greater than 1mm to 2mm in size; may be coarse from greater than 0.5mm to 1mm; medium sand, if it varies as greater than 0.25mm to 0.5mm; fine, if it accounts for sizes greater than 0.125mm to 0.25mm and lastly very fine for sizes greater than 0.062mm but less or equal to 0.125mm.

Considering location AR1, the sediment sizes range from 0.063mm to 2mm with greater subpopulation of 34.4% of it was 1mm, 19.4% are 2mm, 0.5mm accounted for 10.8%, 35.4% of the sub-population represents others (Table 2). Only three different sizes of the sediments constitute 64.6% of the sediments obtained from this location. Therefore, the majority of the sand is about 1mm with 34.4% sub-population which is coarse.

In location AR3, we have 21.2% contribution from 2mm; 28.5% from 1mm, 16.9% from 0.6mm, 16.5% from 0.5mm (Table 3). Only four different sizes with percentage greater than 10 (> 10%) contributed 83.1%. Therefore, the major size of sediment component is from 1mm with is again coarse.

Location AR5: 0.3mm of the sediment size contributed 46.2% of its volume; 0.5mm accounts for 27.2%; 0.112mm accounts for 12.9% (Table 4). Out of the 13 sediment samples, only three sets of sizes with 86.3% of subpopulation and others have weight of 13.7%. The major sediment contribution is from 0.3mm size which is among medium sand.

The analysis of samples from location AR7 has that 10.6% comes from 1mm, 25.9% from 0.5mm, 26.6% from 0.3mm, and 12.2% from 0.112mm (Table 5). Four sets of different sizes contributed 75.3% of the weight with only 24.7% from other sizes. The major sand contribution in terms of its volume is from 0.3mm which is defined as medium.

AR16 is another location we processed the data and result shows 34.8% was from 2mm, 28.7% from 1mm giving 63.5% (Table 6) from these two sizes while the other 11 sediment samples contributed only 36.5%. The highest weight is from 2mm described as very coarse but coarse sand range from greater than 0.5mm to 1mm. Adding all the sizes (that is 1mm, 0.85mm, 0.71mm and 0.6mm) for this range resulted in 36.5%, which gives the most sand volume contribution. We say, both very coarse and coarse sand are highly involved.

Location AGS18: sediment size of 2mm accounts for 36.6%, 1mm for 26.3% (Table 7). Two sets of sizes account for 62.9% of the total volume of the 13 samples from this location. Others account for 37.1%. The most prominent sand nature is very coarse.

From location OL6b, 23.2% comes from 2mm, 1mm accounts for 15.7%, 13.9% from 0.3mm and 18.6% from 0.112mm (Table 8). Four sets account for 71.4% of its volume; the remaining 28.6% represents contribution from other samples. The major sediment comes from those of 2mm in size which suggest the sand to be very coarse and about 0.3 mm to 0.5mm combining to give 23.5% called medium.

Location OL15b: 2mm from 41.7%, 1mm from 43.2% (Table 9). This implies that only two sets of sizes contributed about 84.9% of the total volume of used sample while other 11 samples account for 15.1%. We would have said, the majority of the contribution comes from 2mm and 1mm which defined very coarse sand and coarse sand respectively, but since coarse sand also include sizes of 0.85mm, 0.71mm and 0.61mm giving 50.0%, then, we say that the major volume of sand sediment comes from coarse sand.

Mean vs location (Figure 4)

Mean size is the average of sediment influenced by the source of supply, transporting medium and the energy conditions of the depositing environment. The mean ranges from – 0.81667 to 1.2333 with average of 0.1979. This range suggests sediment varies from medium sand to very coarse sand which is the reflection of differential energy condition during deposition and volume/weight of sediments supplied.

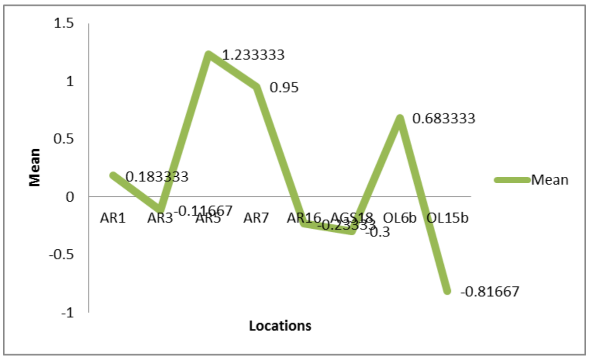
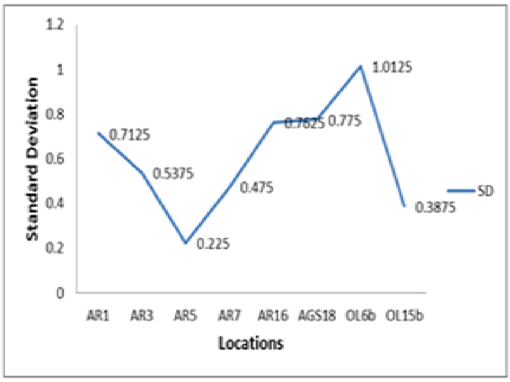


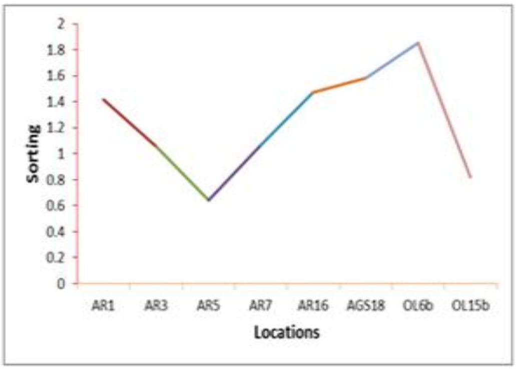
Figure 4: Variogram of mean of the sample.

SD VS location (Figure 5m and 5n)

SD measures the sorting of sediment and indicates the variations in velocity situations of the depositing agent. It also shows the variance in kinetic energy associated with the mode of deposition or uniformity of particle size distribution. SD here varies from 0.225 to 1.0125 (Figure 5m) with the average of 0.6109. This indicates that the deviation is within +1 in almost all the locations. Figure 5n values of sorting vary from 0.641667 to 1.853409. This range defines almost only poorly sorted which may be due to the short distance of sediment from the source exception of results from AR5 and OL15b. Also, may be due to continuous addition of different classes of materials of closely varying proportions. The inability to separate particles of different sizes could be due to low energy of deposition/transportation of sediments corresponding to low current velocity relating to the upstream barrages.



m



n

Figure 5: Variogram of standard deviation (m) and sorting (n) of the samples.

Skewness vs location (Figure 6)
It measures the symmetrical distribution. Negative values signify coarser material in coarser tail (that is coarse skewed); positive value characterizes more fine material in the fine tail (that is fine skewed). The skewness varies from – 0.1298 to 0.3588 which is indication of near symmetrical to very finely skew. There is excessive riverine input that aids the introduction of fine material and very fine skewed sediments. Negative skewness (coarse skewness) is correlated with high energy and winnowing action (removal of fines) and positive/fine skewness with low energy levels (accumulation of fines) which indicates the unidirectional transport (channel) or the deposition of sediments in sheltered low energy environment (Maity and Maiti, 2016). We say the sediments are from various sources since it is characterized by near symmetrical, finely skewed and very finely skewed. Finely skewed implies there is a lot of fine materials have been introduced and very finely skewed highlight the presence of riverine input (Karuna et al., 2013). Therefore, the energy associated with this environment is low.

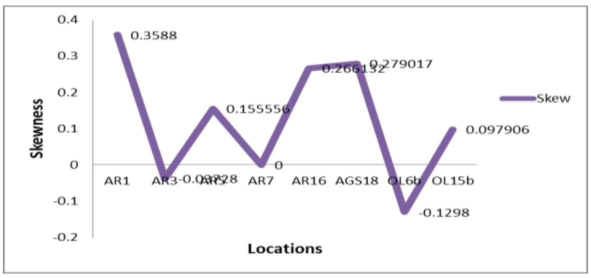


Figure 6: Variogram of skewness of the samples

Kurtosis vs location (Figure 7)
Kurtosis varies from 0.798102 to 1.350048; corresponding to platykurtic (which is negative excess kurtosis; that is, opposite case to leptokurtic), mesokurtic (uniform sorting in both tails and central position) and leptokurtic (which is positive excess kurtosis; tail is better sorted than central portion). It is a quantitative measure used to describe the departure from normality of distribution. It signifies the ratio between sorting in tails and central portion of the curve. Locations AR5 and AR7 have high values of kurtosis compared to other locations. Friedman (1962) recommended that extreme high or low values imply part of the sediment achieved its sorting elsewhere in a high energy environment. This variation is a reflection of the flow characteristics of the depositing medium (Baruah et al., 1997).

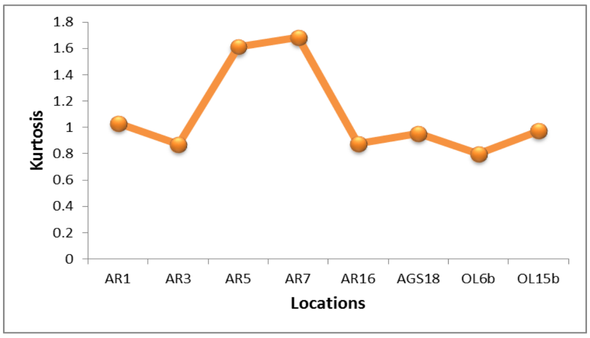
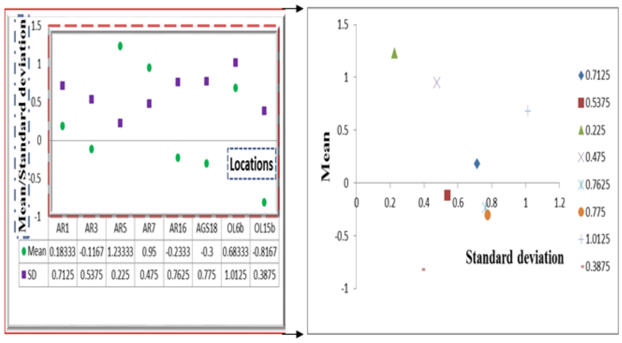


Figure 7: Variogram of kurtosis of the sample.

Mean vs SD (Figure 8)
It is used to determine the paleo-environment of deposition of the soil samples from grain size analysis. This plot depicts that all the samples analyzed were deposited by the translational environment of geological effects (Layade et al., 2020). The multiple directional patterns of the paleo-environment of deposition of the samples were suggested to be responsible for moderately sorted impact on the soil samples. This plot describes SD as the average distance between the values of the data in the set and the mean, such that a low SD indicates that the data points tend to be very close to the mean and a high SD shows data points are spread out over a large range of values. SD measures the variation or dispersion and has the same unit as the data thus easier to interpret than variance. OL 6b is the only location with SD value greater than 1 which indicates that the SD is high since it spread out away from the mean. Other values are within a low SD (that is clustering around the mean such that – 1 is less or equal to SD less or equal to 1).



y z

Figure 8: Crossplot of mean against standard deviation (z) due to Variogram of mean/standard deviation of the sample locations (y).

Skewness vs SD (Figure 9)
AR3, AR5, AR7 and OL15b have been classified into the same environment (Figure 9). AR1, AR16 and AGS18 have

the characteristics of the same source. Samples from location OL6b shows different set of sources as the deviation is not close to other points but spreads away from the skewness such that the standard deviation exceeds +1 which is high.

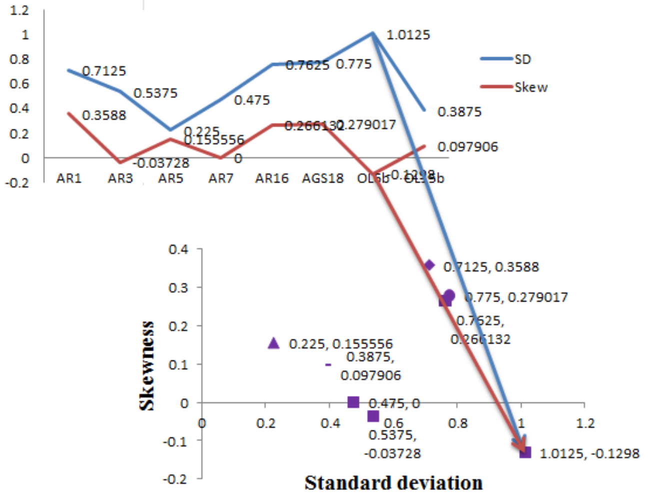


Figure 9: Crossplot of skewness against standard deviation.

In summary, textural parameters like sorting, skewness and others are of great importance in grain size studies. These parameters were computed using the result of percentiles investigation (Table 10). Kurtosis is an environmental indicator. A well sorted sediment is one in which the grains are all about the same size. Poorly sorted sediment contains a chaotic mixture of different sizes of grain. The summary of textural parameters interpretation is seen in Table 12. The deposits are majorly very coarse (that is AR3, AR16, AGS18, OL15b except AR1, OL6b which belong to coarse and AR5 matching medium), poorly sorted in almost all the locations excluding locations AR5 and OL15b which the results indicate moderately well sorted. Skewness varies from very fine skewed to near symmetrical although location OL6b matches coarse skewed. Kurtosis defines the environment as mesokurtic (almost normal) as well as two other extreme tails.

Table 12: Summary of textural parameters Interpretation

Locations	Sorting	Skewness	Kurtosis
AR1	Poorly sorted	Strongly (or very) fine skewed	Mesokurtic
AR3	Poorly sorted	Near symmetrical	Platykurtic
AR5	Moderately well sorted	Fine skewed	Very leptokurtic
AR7	Poorly sorted	Near symmetrical (almost normal distribution)	Very leptokurtic
AR16	Poorly sorted	Fine skewed	Platykurtic
AGS18	Poorly sorted	Fine skewed	Mesokurtic
OL6b	Poorly sorted	Coarse skewed	Platykurtic
OL15b	Moderately well sorted	Near symmetrical	Mesokurtic

Conclusion

The textural parameters indicate that sediment obtained from the study area is described as very coarse, poorly sorted, vary from very fine skewed to near symmetrical with mesokurtic environment although the other extreme tails also exist. Poorly sorted may be due to the short distance of sediment from the source exception of results from AR5 and OL15b. It may also include the continuous addition of different classes of materials of closely varying proportions. The inability to separate particles of different sizes in this environment could be due to low energy of deposition/transportation of sediments corresponding to low current velocity relating to the upstream barrages. Grain size analysis was conducted which shows the sediment sizes ranging from medium to very coarse sand as the majority of sediment composition before investigation of textural parameters.

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