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KINETIC ENERGY AND TRANSPORTATION HISTORY OF SEDIMENTS IN OGUNNIYI, WESTERN NIGERIA.

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ABSTRACT
The analysis of grain-size sediments was carried out to determine the grading of textural parameters which result in the description of the energy environment, that of deposition and information on sediment transport. A German standard sieve set of mesh with shaker was used for the analysis. 12 sets of sediment sizes resulting in 84 samples from seven locations. The results of grain size analysis indicates that almost all the sediments are poorly sorted which is due to short distance of transportation of sediment from the source (only locations OG12 and OG18 show moderately well sorted sediment), fine to coarse skewed with dominance of leptokurtic. Positively skewed sediment represents finely skewed and describes the kinetic energy of the sediment as low and therefore, far from the source. Negatively skewed considers as coarse skewed with high energy of the environment or medium of transportation because it is greater than that experienced where fine particles are deposited though the distance of travel is closer to its source. Fine materials presence may encourage dredging for sand in the appropriate locations; coarser materials subjected to cementation could contain some minerals in them and exploration for these targets may be carried out over a period of time.

INTRODUCTION
Depositional environment is the portion of the earth's surface that has some chemical, physical and biological features where sediments are laid on. Different depositional environments have different structure and texture of sediments. When the tidal energy is greater than the wave energy, the deposits are categorized by ripple mark structure, cross breeding and flaser. A high energy environment may be seen as a fast flowing stream, capable of carrying coarse-grained sediments (like gravel and sand). Sedimentation in a low-energy environment (like an abyssal plain) frequently comprises very fine-grained clay or mud.

When the energy of the transporting current is not sufficiently strong to move particles, the particles drop out in the process of sedimentation. It would have been another type of sedimentation process if sedimentary deposition happens when material is dissolved in water, then chemically precipitates from the water (this type of sedimentation is called chemical sedimentation). A third development can occur where living organisms extract ions dissolved in water to make such things as shells and bones; called biochemical sedimentation. The accumulation/buildup of plant matter at the bottom of a swamp is called organic sedimentation. This gives rise to four major types of sedimentary rocks which are clastic, chemical, biochemical and organic sedimentary rocks.

Paleo-environment can be realized from grain size study of sediments (Beal and Shepard, 1956). The major factor able to identify grain size trends is skewness (Roman and Achab, 1999). The coarser sediments are seen in high-energy environments; finer sediments congest at low energy ones. Negative skewness (coarse skewness) is correlated with high energy and winnowing action 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 (Friedman, 1961; Brambati, 1969; Maity and Maiti, 2016).

Grain size can be a pointer of the energy of the environment. Higher energy water or wind currents are essential to move larger grain sizes. Grain sorting can also be an indicator of the energy of the environment. Well-sorted sediments are deposited in high energy environment.

Particles become sorted on the basis of density because of the energy of the transporting medium. As the energy decreases, heavier particles are deposited and lighter fragments continue to be transported. Currents sort the grains by size. Poorly-sorted sediments may indicate weak currents or transport by glaciers. We can categorize this size sorting based on well sorted to poorly sort. Sorting gives hint to the energy conditions of the transporting medium from which the sediment was deposited. Other statistical/textural parameters such as graphic mean, graphic standard deviation, graphic skewness and graphic kurtosis are requirements for grain size and statistical distribution (Akintola *et al.*, 2013).

When the grains are poorly sorted, large and small grains mixed-up together which suggest the particles have not been transported far. In well sorted, all the grains have equal sizes. Effect of distance from the source of sediment is shown in Table 1.

Table 1: General trends of distance of sediment from the source

	At source	Near source	Intermediate from source	Far from source	Farthest from Source
Largest grain sizes	boulder	Pebble to sand	sand	silt	clay
Angularity	angular	Sub-rounded	rounded	Well rounded	
Sorting	poor	Poor to moderate	Moderate to well	well	well
Typical clastic rock	breccia	Conglomerate, arkose	Quartz sandstone	siltstone	shale

The energy environment of sediment is based on some textural factors. It relates with the velocity of the medium responsible for the transportation and deposition of this sediment. The phi values of the sieves mesh size correspond to the grain diameter (D) in millimeter (mm) for each sieve fraction. A phi (ϕ)may be converted to millimeter using Equation 1.

$$\phi = -\log_{10} 2D \quad (1)$$

(Ayodele and Madukwe, 2019).

The mean (M) determination was carried out using Equation 2 based on their relation with some of the percentiles (ϕ16, ϕ50 and ϕ84) deduction. The graphic mean is the best way to determine the average size of sediment. Table 2 offers the interpretation/classification of mean values from the Wentworth scale and others.

$$M = \frac{1}{3}(\phi_{16} + \phi_{50} + \phi_{84}) \quad (2)$$

Other parameters such as standard deviation, sorting, skewness and kurtosis can be obtained using Equations 3 to 6 (Folk and Ward, 1957; Gandhi and Raja, 2014; Oladipo *et al.*, 2018) and possible interpretation as in Table 2.

Standard Deviation (S_d) (or Sorting (S))

It shows the difference in kinetic energy connected with mode of deposition and the velocity of the depositional agent (Ayodele and Madukwe, 2019).$\mathbf{S_d}$ is a measure of sorting. The sorting of a given population is a measure of the range of grain-size present and the magnitude of these sizes around the mean sizes. Sorting can be homogenous [if it occurs when there is a very negligible level of deviation from the mean] or heterogeneous [if there is high deviation from the mean]. S_d and S are expressed in Equations 3 and 4 respectively.

$$S_d = \frac{1}{4}(\phi_{84} - \phi_{16}) \quad (3)$$

$$S = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6} \quad (4)$$

Skewness (S_k)

It measures the symmetry of a curve by marking the position of the mean in relation to the median (Sahu, 1964). A given size population that has a tail of excess fine particles is said to be positively skewed while one with tail excess is negatively skewed. Equation 5 is for determining skewness as it considers not only the tails of the curve but also the central portion. Negatively skewed (which is coarse skewed) defines high energy environment and positively skewed (which is finely skewed) corresponds to low energy environment

$$S_k = 0.5\left(\frac{\phi_{84}+\phi_{16}-2\phi_{50}}{\phi_{84}-\phi_{16}} + \frac{\phi_5+\phi_{95}-2\,\phi_{50}}{\phi_{95}-\phi_5}\right) \quad (5)$$

Kurtosis (K_s)

Kurtosis measures the sorting ratio at the extremes of the distribution (Folk and Ward, 1957). If kurtosis is defined as platykurtic, its value is negative excess kurtosis (that is, opposite situation to the case of leptokurtic); if it is mesokurtic, kurtosis curve is observed to have uniform sorting in both tails and central position and finally leptokurtic, if its value is positive excess kurtosis (tail is better sorted than central portion) (Manivel *et al.*, 2016). 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.

$$K_s = \frac{\varphi_{95}-\varphi_5}{2.44(\varphi_{75}-\varphi_{25})} \quad (6)$$

Table 2: Classification of textural parameters (Blott and Pye, 2001; Oladipo *et al*., 2018).

S/N	Parameters	Range of values	Interpretation/Classification
1	Mean	Phi -1 to phi 0	Very coarse sand
2	Mean	Phi greater than 0 to phi 1	Coarse sand
3	Mean	Phi greater than 1 to phi 2	Medium sand
4	Mean	Phi greater than 2 to phi 3	Fine sand
5	Mean	Phi greater than to phi 4	Very fine sand
6	Sorting	Less than 0.35	Very well sorted
7	Sorting	0.35 to 0.50	Well sorted
8	Sorting	0.51 to 0.70	Moderately well sorted
9	Sorting	0.71 to 1.00	Moderately sorted
10	Sorting	1.01 to 2.00	Poorly sorted
11	Sorting	2.01 to 4.00	Very poorly sorted
12	Sorting	Greater than 4.00	Extremely poorly sorted
13	Skewness	Less than - 0.30	Very coarse skewed
14	Skewness	- 0.30 to - 0.11	Coarse skewed
15	Skewness	- 0.10 to +0.10	Near symmetrical
16	Skewness	+0.11 to +0.30	Fine skewed
17	Skewness	Greater than +0.30	Very fine skewed
18	Kurtosis	Less than 0.67	Very platykurtic
19	Kurtosis	0.67 to 0.90	Platykurtic
20	Kurtosis	0.91 to 1.11	Mesokurtic
21	Kurtosis	1.12 to 1.50	Leptokurtic
22	Kurtosis	1.51 to 3.00	Very leptokurtic
23	Kurtosis	Greater than 3.00	Extremely leptokurtic

Our aim is to investigate the energy environment, kinetic energy of deposition and transport information of sediment. Fine materials presence may encourage dredging for sand to boost economy; coarser materials subjected to cementation could contain some minerals in them and exploration may be carried out over a period of time.

Location and Geology

Ogunniyi is a small village in Kwara State, Western part of Nigeria, (Figure 1) within latitudes $08^0 27^1$N and $08^0 30^1$N and longitudes $04^0 55^1$E and $04^0 59^1$E. It covers an area of about 46.98km^2. Settlements within the study area include Ago, Aiyekale, Arowo, Araromi, Magbon, Ajilete, Ekudaji, Ajoko, and Ojutaiye. The major occupation of the people of the area is farming; mostly cereal crops are planted such as like guinea. The average rainfall in the area is between 20-50 inches annually. The average temperature is about 27^{0}C and peaks at 30^{0}C in October. The dry season always begin from November to March which is always with little or no rainfall. The wet season is characterized with rainfall which is about 1300mm and its distribution is bimodal within hydrologic year. The first peak occurs in June to July, while the second peak occurs in September to October rainy season. The two wet seasons are normally separated by draught (August-break), while the dry season is defined by little or no rainfall between November and April.

Nigeria lies within the Pan-African mobile belt to the east of West Africa Craton. The belt was affected by Pan-African orogeny of the late Peterozoic to Cambrain, 500±100MA. Nigeria has been divided into three main geological provinces: the basement complex, the younger Granite and the sedimentary basins

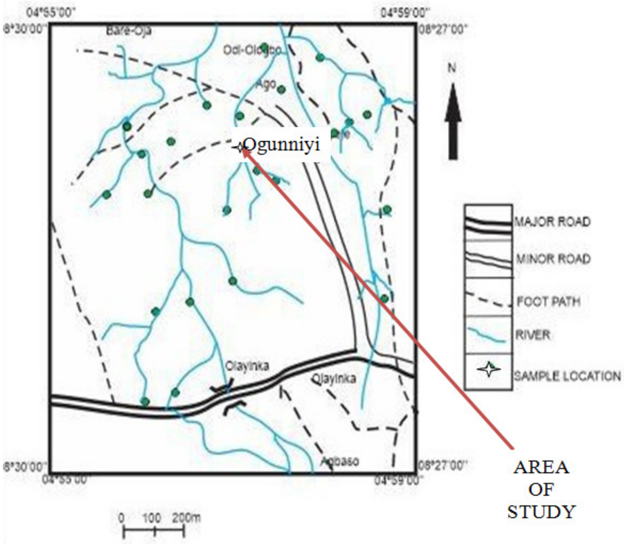

Figure 1: Oguniyi located in Western region of Nigeria.

The basement complex occurs in three main areas of Nigeria. These are the North Central Segment, the Eastern Segment and the Western Segment. The basement complex underlines the entire area and includes all rocks older than the late Proterozoic meta-sediments and lies within a zone of ancient African Craton, which bears the imprint of 600MA-Pan-African Tectonic Gneiss. The vegetation is typical of tropical and guinea savannah. It is characterized by short grasses, scattered trees, vegetation and shrubs indicating vegetation of guinea savannah. The area has an undulating relief, indicating highland which form most of the hills and lowlands which form most of the valley through which river flows. The highest altitude is about 400 meters above sea level; the lowest altitude is about 251 meters above sea level.

MATERIALS AND METHOD

The geological materials used include: hammer, chisel, German standard sieve of sizes (Figure 2), sample bags (for collection of stream sediments), measuring tape, paper tape, marker, global positioning system, compass clinometer, weighing balance, digital camera (to capture the stream sediments collected), electrical vibratory machine, hand lens, computer with a spread sheet program, field note (to record necessary the observation) and topographical map.

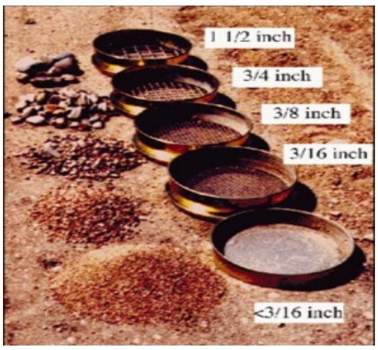

Figure 2: Standard sieve of sizes

The procedure for the analysis involves disaggregation of eight samples by soaking in water for 24 hours to obtain individual grains and was exposed to sun for two days to ensure the samples are free of water. Weighing balance was used to measure 100g of each dried sample and poured 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 carries a pan at the bottom to collect the less than 0.063mm fractions. The set up was linked to an electrical vibratory machine (sieve shaker) for 10mins to facilitate the grains separation. The fraction retained on each sieved pan was weighed, recorded and used for statistical calculation.

The measure of quartile, phi scale among others is the frequently used statistical measures of grain size distribution. Seven different points on the cumulative frequency curve were directly selected (at 5, 16, 25, 50, 75, 84, and 95 percentiles) for the computation of the parametric geostatistics (Passega and Byramjee, 1969).

RESULT AND DISCUSSION

The grain size analysis results are in Tables 3 to 9. Kurtosis and skewness are important parameters in describing environment and energy of transportation and deposition of sediments. The results and interpretation of these two factors and other textural parameters are presented in Tables 11 and 12 respectively. The cumulative frequency curves with percentile values (Table 10) were deduced (Figures 3 and 4). Figures 5 to 10 show variations and interpretations.

Table 3: Grain size analysis of OG 5

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	30.4	30.48505	30.48505
2	1	0	24.1	24.16743	54.65248
3	0.85	0.23	4	4.011191	58.66367
4	0.71	0.49	0.6	0.601679	59.26535
5	0.6	0.74	3.1	3.108673	62.37402
6	0.5	1	12.8	12.83581	75.20983
7	0.3	1.74	13.4	13.43749	88.64732
8	0.25	2	4.1	4.111471	92.75879
9	0.112	3.16	7.1	7.119864	99.87866
10	0.09	3.47	0.1	0.10028	99.97894
11	0.075	3.74	0.008	0.008022	99.98696
12	<0.063	3.99	0.013	0.013036	100
			99.721		

Table 4: Grain size analysis of OG 7

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	5.2	5.226131	5.226131
2	1	0	17.5	17.58794	22.81407
3	0.85	0.23	4.8	4.824121	27.63819
4	0.71	0.49	0.9	0.904523	28.54271
5	0.6	0.74	5.7	5.728643	34.27136
6	0.5	1	17.9	17.98995	52.26131
7	0.3	1.74	18.5	18.59296	70.85427
8	0.25	2	7.3	7.336683	78.19096
9	0.112	3.16	18.6	18.69347	96.88442
10	0.09	3.47	2.4	2.41206	99.29648
11	0.075	3.74	0.3	0.301508	99.59799
12	<0.063	3.99	0.4	0.40201	100
			99.5		

Table 5: Grain size analysis of OG 11

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	2.3	2.306921	2.306921
2	1	0	11.2	11.2337	13.54062
3	0.85	0.23	4.9	4.914744	18.45537
4	0.71	0.49	1	1.003009	19.45838
5	0.6	0.74	6.8	6.820461	26.27884
6	0.5	1	21.8	21.8656	48.14443
7	0.3	1.74	21.4	21.46439	69.60883
8	0.25	2	5.9	5.917753	75.52658
9	0.112	3.16	19.4	19.45838	94.98496
10	0.09	3.47	3.4	3.410231	98.39519
11	0.075	3.74	0.9	0.902708	99.29789
12	<0.063	3.99	0.7	0.702106	100
			99.7		

Table 6: Grain size analysis of OG 12

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	0.3	0.302676	0.302676
2	1	0	5.2	5.246378	5.549054
3	0.85	0.23	3.4	3.430324	8.979378
4	0.71	0.49	0.3	0.302676	9.282054
5	0.6	0.74	4.3	4.338351	13.6204
6	0.5	1	22.2	22.398	36.0184
7	0.3	1.74	33.5	33.79878	69.81718
8	0.25	2	9.9	9.988297	79.80548
9	0.112	3.16	18.5	18.665	98.47048
10	0.09	3.47	1.4	1.412486	99.88297
11	0.075	3.74	0.08	0.080714	99.96368
12	<0.063	3.99	0.036	0.036321	100
			99.116		

Table 7: Grain size analysis of OG 17

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	9.3	9.403438	9.403438
2	1	0	13.8	13.95349	23.35693
3	0.85	0.23	2.8	2.831143	26.18807
4	0.71	0.49	0.8	0.808898	26.99697
5	0.6	0.74	3.4	3.437816	30.43478
6	0.5	1	14.3	14.45905	44.89383
7	0.3	1.74	21.7	21.94135	66.83519
8	0.25	2	8.3	8.392315	75.2275
9	0.112	3.16	19.4	19.61577	94.84328
10	0.09	3.47	3.1	3.134479	97.97776
11	0.075	3.74	0.8	0.808898	98.78665
12	<0.063	3.99	1.2	1.213347	100
			98.9		

Table 8: Grain size analysis of OG 18

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	1.1	1.101211	1.101211
2	1	0	18.5	18.52037	19.62158
3	0.85	0.23	7.6	7.608369	27.22995
4	0.71	0.49	1.1	1.101211	28.33116
5	0.6	0.74	11.8	11.81299	40.14416
6	0.5	1	36.4	36.44008	76.58424
7	0.3	1.74	17.2	17.21894	93.80318
8	0.25	2	1	1.001101	94.80428
9	0.112	3.16	4.5	4.504955	99.30924
10	0.09	3.47	0.5	0.500551	99.80979
11	0.075	3.74	0.1	0.10011	99.9099
12	<0.063	3.99	0.09	0.090099	100
			99.89		

Table 9: Grain size analysis of OG 24

S/n	Sieve size	Phi (ϕ)	Weight retained (g)	Percentage weight retained	Percentage cumulative weight retained
1	2	-1	4.7	4.723618	4.723618
2	1	0	26.3	26.43216	31.15578
3	0.85	0.23	7	7.035176	38.19095
4	0.71	0.49	0.7	0.703518	38.89447
5	0.6	0.74	9.4	9.447236	48.34171
6	0.5	1	24.5	24.62312	72.96482
7	0.3	1.74	15.8	15.8794	88.84422
8	0.25	2	2.4	2.41206	91.25628
9	0.112	3.16	7.9	7.939698	99.19598
10	0.09	3.47	0.4	0.40201	99.59799
11	0.075	3.74	0.2	0.201005	99.79899
12	<0.063	3.99	0.2	0.201005	100
			99.5		

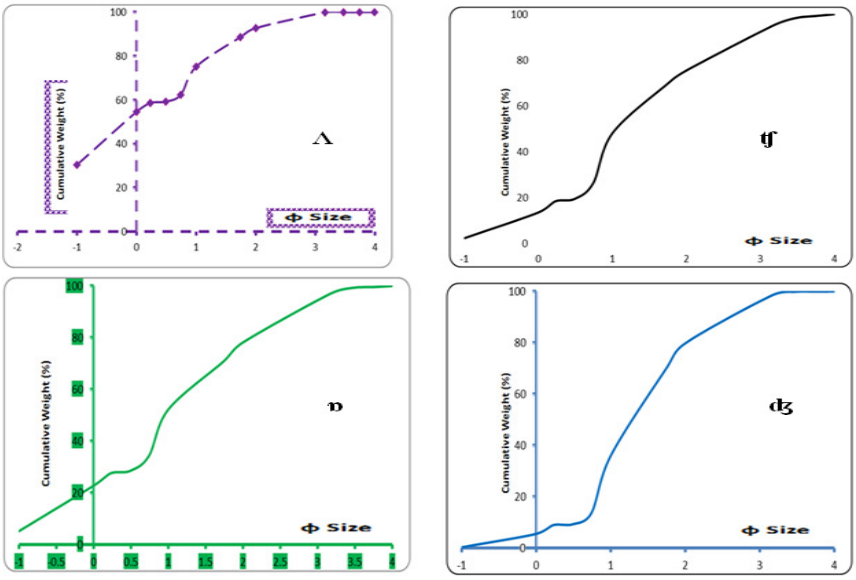

Figure 3: Ogives for Cumulative weight-ϕ variation of location (ʌ) sample from OG5 (ɒ) sample from OG7 (ʧ) sample from OG11 (ʤ) sample from OG12.

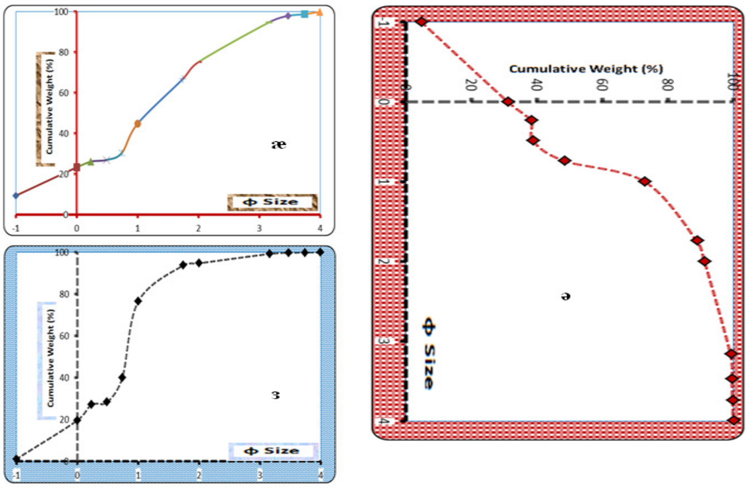

Figure 4: Ogives for Cumulative weight-ϕ variation of location (æ) sample from OG17 (ɜ) sample from OG18 (ə) sample from OG24.

Table 10: Result of percentiles investigation

S/n	Locations	φ_5	φ_{16}	φ_{25}	φ_{50}	φ_{75}	φ_{84}	φ_{95}
1	OG_5	-2.05	-1.55	-1.20	-0.20	1.00	1.50	2.40
2	OG_7	-1.00	-0.40	0.10	0.95	1.90	2.35	3.10
3	OG_{11}	-0.70	0.10	0.70	1.10	2.00	2.50	3.20
4	OG_{12}	-0.10	0.75	0.90	1.30	1.90	2.25	2.95
5	OG_{17}	-1.30	-0.50	-0.15	1.20	2.00	2.55	3.20
6	OG_{18}	-0.80	-0.20	0.15	0.80	1.00	1.30	2.00
7	OG_{24}	-1.00	-0.55	-0.15	0.75	1.10	1.55	2.60

Table 11: Result of corresponding textural parameters

Locations	Mean	S_d	Sorting	Skewness	Kurtosis
OG_5	-0.08333	0.7625	1.436742	0.141647	0.828987
OG_7	0.966667	0.6875	1.308712	0.033481	0.933515
OG_{11}	1.233333	0.6	1.190909	0.121795	1.229508
OG_{12}	1.433333	0.375	0.837121	0.174317	1.25
OG_{17}	1.083333	0.7625	1.444318	-0.11293	0.857796
OG_{18}	0.633333	0.375	0.799242	-0.2381	1.350048
OG_{24}	0.583333	0.525	1.070455	-0.10516	1.180328

DISCUSSION

The sets of sizes of the sediment considered varied from 0.063 to 2mm and the number of samples in each location is 12. The standard Wentworth scale (Wentworth, 1922) describes -1ϕ (which corresponds to 2mm) to 4ϕ (corresponding to 0.062mm) as composed of sand. This implies that it could be interpreted as very coarse if it ranges from > 1mm to 2mm in size; may be coarse from > 0.5mm to 1mm; medium sand, if it varies as > 0.25mm to 0.5mm; fine, if it considers sizes > 0.125mm to 0.25mm and finally, very fine for sizes > 0.062mm but less or equal to 0.125mm. The summary of the area description due to textural interpretation is seen in Table 12.

Table 12: Summary of textural factors with respect to each location

Locations	Sorting	Skewness	Kurtosis
OG5	Poorly sorted	Fine skewed	Platykurtic (flat)
OG7	Poorly sorted	Near symmetrical	Mesokurtic (normal)
OG11	Poorly sorted	Fine skewed	Leptokurtic (highly peaked)
OG12	Moderately well sorted	Fine skewed	Leptokurtic (highly peaked)
OG17	Poorly sorted	Coarse skewed	Platykurtic (uniform)
OG18	Moderately well sorted	Coarse skewed	Leptokurtic (highly peaked)
OG24	Poorly sorted	Coarse skewed	Leptokurtic (highly peaked)

Location OG5: The size of 2mm represents 30.5% of the total weight of the sediment, 1mm contributes 24.2%, 0.5mm accounts for 12.8%, and 0.3mm produces 13.4% (Table 3). These sets of sizes contributed 80.9% of the volume of the sediment used out of the 12 samples. Only 19.1% represents other sizes. The major sand contribution is from 2mm described among very coarse and coarse since coarse sand size ranges from 1mm to > 0.5mm (that is 31.9%).

Location OG7: 17.6% was obtained from the size of about 1mm, 18.0% from 0.5mm, 0.3mm accounts for 18.6% and 0.112mm added 18.7% (Table 4). Four sets of sediment sizes account for only 72.9% of the total volume while others account for only 27.1%. This clearly describes the sand sediment majority from 0.3mm and 0.112mm as medium and very fine respectively but 0.3mm and 0.5mm are in the same class of size, therefore gives the major sand contribution as medium with the percentage weight of 36.6%.

Location OG11: 1mm supplies 11.2% of the used sediment, 21.9% was obtained from 0.5mm size, 0.3mm gives 21.5% and 0.112mm contributes 19.5% (Table 5). Four sets of sizes of sediment contributed 73.9%; others account for 26.1%. The major sand volume is from 0.5mm and 0.3mm sizes defined as medium sand. Both sizes are classified under medium sand with 43.4% subpopulation of sediment.

Location OG12: The size of 0.3mm enables 33.8% of the fraction of sediment, 0.5mm allows 22.4%, and 0.112mm constitutes 18.7% (Table 6). The major group of sand sediment is medium sand.

Location OG17: 1mm enables 14.0% of the used sediment, 0.5mm from 14.5%, 21.9% comes from 0.3mm, 19.6% from 0.112mm (Table 7). Four sets of sizes of sediment give rise to 70.0% of the sediment volume considered in analysis; others contributed only 30%. Since the range of sand with sizes of greater than 0.25mm to 0.5mm is the highest volume contribution, we say the major sand is defined as medium.

Location OG18: 1mm contributes 18.5%, 0.6mm accounts for 11.8%, 0.5mm gives 36.4%, and 0.3mm allowed 17.2% (Table 8). These four sets of sizes of sediment account for 83.9% of its total volume considered; 16.1% was contribution from the other remaining sizes. The leading sand is medium.

Location OG24: 26.4% have been computed from 1mm class, 24.6% from 0.5mm and 15.9% from 0.3mm (Table 9). These three sets of sizes account for 66.9% and the remaining nine samples accounted for 33.1%. The major sand sediment here is from greater than 0.5mm to 1mm class which is 43.6% and greater than 0.25mm to 0.5mm which is 40.5%. Therefore, the most sand used is coarse, though medium is also highly involved.

Mean against location

Mean value ranges as in Figure 5 from – 0.08333 to 1.43333 with the average value of 0.8357. This indicates that the sediments vary from medium to coarse sand. This variation may be caused by the change in their energy of deposition (Karudu *et al*., 2013).

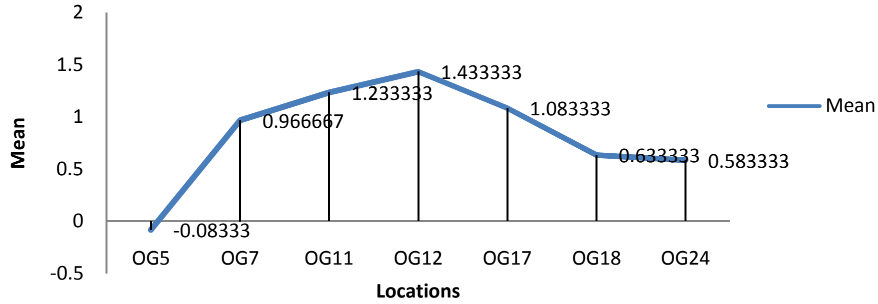

Figure 5: Variation of mean with locations

SD against location (Figure 6a)

SD varies from 0.375 to 0.7625 (with the average of 0.5839). It shows moderately well sorted to moderately sort although the most dominant is moderately well sorted. The more the sediment is transferred from the source, the more the sample is moderately sorted and closer the sediments to the source the poor the samples are sorted. Therefore, this result is due to long distance of the sediment from the source; it is moderately well sorted. Variogram of Sd (or sorting (Figure 6b)) vs sample locations indicate how effective the depositional medium is separating different classes of grains. Coarse sediments tend to show deterioration in sorting; fine sediments are well sorted. The energy and transportation of sediment distance are all functions of the distance of sorting values. This variation in sorting values is likely due to continuous addition of fine or coarser materials in different proportion (Manivel *et al.*, 2016).

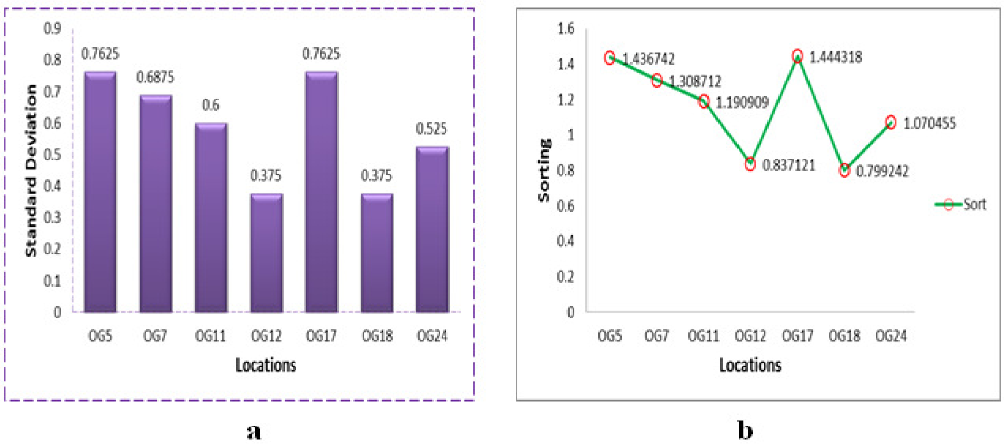

Figure 6: Variation of (a) standard deviation (b) sorting with locations

Skewness vs location (Figure 7)

It ranges from – 0.2381 to 0.1743 which indicates coarse skewed to fine skewed. Skewness measures the symmetrical distribution. The negative values denote coarser tail (coarse skewed) which is correlated with high energy and winnowing action (removal of fines); the positive values represent more fine material in the fine tail (that is fine skewed) and have to do with low energy levels (accumulation of fines) (Maity and Maiti, 2016). The sediments are from two sources since it has to do with coarse skewed and fine skewed.

Kurtosis vs location (Figure 8)

Kurtosis distinguishes various environments and its value here varies from 0.828987 to 1.350048. Over 50% of the sediment is leptokurtic. We also have two sample locations (OG5 and OG17) as platykurtic and OG7 indicates mesokurtic. Extreme high and low values of kurtosis imply that part of the sediment achieved its sorting elsewhere in a high environment. The variation in kurtosis values is a reflection of the flow characteristics of the depositing medium. Kurtosis measures the ratio between the sorting in the tails and the central portion in the curve. The range of values of kurtosis corresponds to platykurtic, mesokurtic and leptokurtic.

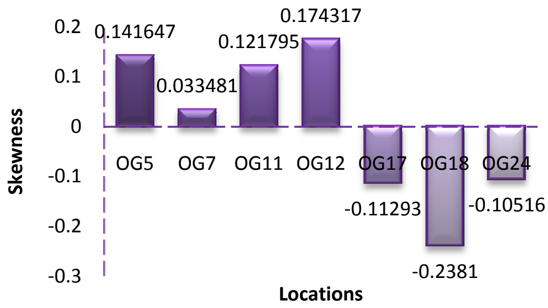

Figure 7: Variation of skewness with locations

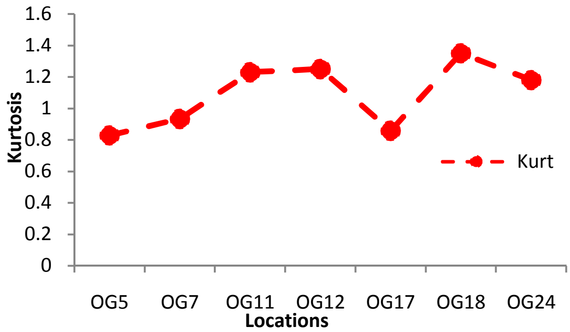

Figure 8: Variation of kurtosis with locations

Mean vs SD (Figure 9)

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. All the locations have SD values less than 1 which indicates that the SD is low though these points spread out away [negligibly] from the mean.

Skewness vs SD (Figure 10)

The plot is scattered but does not exceed SD of 1. Positively skewed sediment represents finely skewed and describes the kinetic energy of the sediment as low. Negatively skewed considers as coarse skewed with high energy of the environment or medium of transportation. Skewness of samples from location OG7 is nearly zero (nearly symmetrical) but with a positive value, so it is skewed positively.

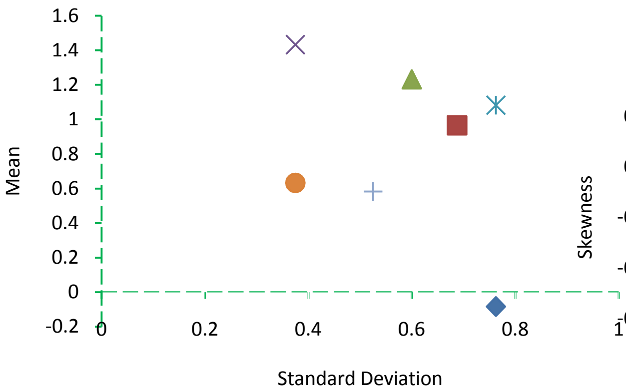

Fig. 9: Scatter plot of mean against SD

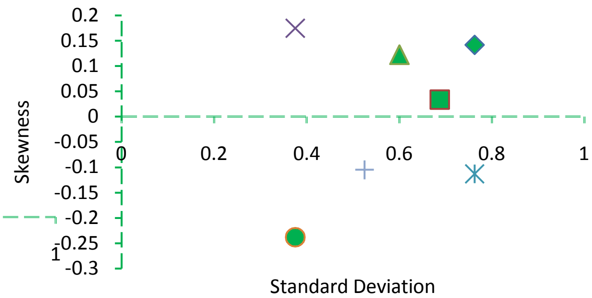

Fig. 10: Scatter plot of skewness against SD

Therefore, locations OG5, OG7, OG11 and OG12 are skewed positively with fine materials indicating low kinetic energy of transport and deposition; locations OG17, OG18 and OG24 are negatively skewed with coarse materials confirming high energy of deposition and transport. High current has high velocity which associates with high energy to move or displace lighter (fine) materials away from this environment allowing only coarser ones due to their weight and sizes.

CONCLUSION

Positively skewed sediment represents finely skewed and describes the kinetic energy of the sediment as low. Negatively skewed considers as coarse skewed with high energy of the environment or medium of transportation because it is greater than that experienced where fine particles are deposited. Skewness of samples from location OG7 is nearly zero (nearly symmetrical) but with a positive value, so it is skewed positively. Locations OG5, OG7, OG11 and OG12 are skewed positively with fine materials indicating low kinetic energy of sediment transport causing deposition which is found farther away from the source; locations OG17, OG18 and OG24 are negatively skewed with coarse materials confirming high energy of deposition which is where the high energy environment of coarse sand is no longer sufficient to transport them farther away from its source. High current has high velocity which associates with high energy to move or displace lighter (fine) materials away from this environment allowing only coarser ones due to their weight and sizes. Fine materials presence may encourage dredging for sand in the appropriate locations; coarser materials subjected to cementation could contain some minerals in them and exploration for these targets may be carried out over a period of time. The coarser sediments left behind by the transportation process are closer to its source. However, the area as described by grain size analysis indicates almost poorly sorted which is due to short distance of sediment from the source, fine to coarse skewed with dominance of leptokurtic.

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