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Grain Size Analysis of Sediments From Okpoama – Brass Beach in the Niger Delta

Akpofure, Edirin* Akana, S. Tombra
Department of Geology, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

Abstract
Granulometric analysis was carried out on sixty – three sediment samples collected from the Okpoama – Brass Beach, in the Niger Delta, to determine the particle size distribution, the nature of the sediments and transport mode of the sediments. The sediment population is predominantly unimodal, with the 0.25 – 0.125 mm (fine sand) as the modal class, though, a significant population are polymodal. Sorting ranges from 0.1 (very well sorted for the unimodal samples) to 1.01 (poorly sorted for the polymodal samples). The average sorting value for the entire sampled population is 0.89 (Moderately sorted). The skewness of the population range from symmetrical to negatively skewed. The average values for the kurtosis is 1.2 (Leptokurtic). The average value for the Median (φ) is 1.92 which represents the medium sand size grade, while the average Mean value is 1.95 φ. The predominant mode of transport is by saltation for the modal class, and suspension and traction for the finer and coarser sediments respectively. The sediment load from Okpoama – Brass beach are dominantly fine sands, indicative of distant source rock and a gentle depositional slope.
Keywords: Beach. Grain size analysis, Unimodal, Mean value, Cumulative curve, Saltation.
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1.Introduction

Okpoama – Brass beach is located in Bayelsa State, which is a lowland state with a lot of tidal flats, coastal beaches, beach ridge barriers and flood plains. Features such as cliffs and lagoons are the dominant features of the state. Okpoama – Brass beach is one of the active beaches that sit at the edge of the Atlantic Ocean. It is a long narrow accumulation of sand parallel to the shore line. Figure 1 shows the map of Bayelsa State and the study area in Brass.

A typical beach is divided into several units which are: sand dune, backshore, foreshore and shoreface. The backshore represents the upper part of the beach which is normally dry except there is unusual high water condition when it can be flooded or acted upon by waves and rip current (Reineck and Singh, 1980). The Okpoama - Brass beach is an erosive beach with the prevalence of high waves and currents (Figure 2).

The climate is tropical in Okpoama, the temperature varies so little throughout the year. The wet season is warm and overcast; the dry season is hot and mostly cloudy. Sixty –three samples were collected from the beach and grain size analysis was carried out to determine the particle size distribution, the nature of the sediments and transport mode of the sediments.

2.Stratigraphy

The Okpoama – Brass beach is located in the lower section of the Niger Delta. The Niger Delta complex comprises the sediment load of Mid Eocene to Recent age. It is bordered by the Atlantic Ocean in the South and to the North by an acuate line which runs roughly through Benin, Onitsha, Umuahia, and slightly SSW of Calabar. It extends from about longitudes 3° to 9° E and Latitudes 4° 30″ to 5° 20″ N (Whiteman, 1982). The subsurface geology of the Niger Delta is made up of three lithostratigraphic units. They are: The Akata Formation, Agbada Formation and the Benin Formation. The Benin Formation is overlain with the Quaternary sediments (Table 1, Allen, 1965)

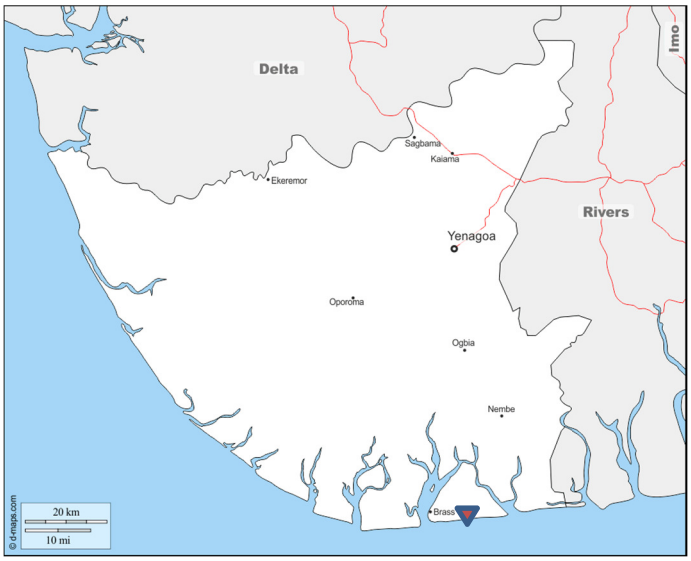

Figure 1: Map of Bayelsa State, showing Location (▼).

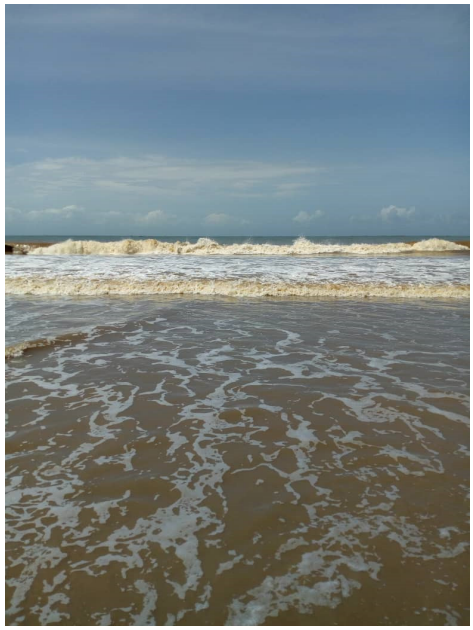

Figure 2: Ferocious waves from the Atlantic on the Okpoama – Brass Beach.

Table 1: Stratigraphic Column of the Niger Delta (after Allen, 1965)

Geologic Unit	Lithology	Age
Alluvium (General)	Gravel, sand, clay, silt	Quaternary
Freshwater Backswamp, Meander Belt	Sand, clay, some silt gravel	
Mangrove and Salt Water/Backswamps	Medium fine sands, Clay and some silt	
Active /Abandoned Beach Ridges	Sand, clay, and some silt	
Sombreiro – Warri Deltaic Plain	Sand, clay, and some silt	
Benin Formation Coastal Plain Sand	Coarse to medium sand with subordinate silt and clay lenses	Miocene
Agbada Formation	Mixture of sand, clay and silt	Eocene
Akata Formation	Clay	Paleocene

3.Methodology

Sampling of the beach was done in transects. Each transect included the sampling of the sand dunes, backshore and beach face deposits where possible, otherwise only two samples were collected from sections of the beach that was reachable in that transect. A total of sixty – three (63) samples were collected into sample bags and properly labeled. They were taken to the laboratory for granulometric analysis. Mechanical sieving by Folks and Ward (1957) was employed. Samples were oven dried to remove moisture content before pouring the loose samples through a stack of wide sieves (set of sieves) with different apertures of known sizes with a minimum time of fifteen minutes used to shake the samples contained in the sieves. This is done to separate the grains into their various sizes. The results got after sieving were used to calculate grain size parameters and to plot frequency and cumulative curves graphs. The calculated parameters include median, mean, mode, sorting (standard deviation), skewness and kurtosis of the grain population.

Median Diameter (Md):

This is the average size of the sample grain which corresponds to the second quartile associated with the 50% percentile Md=φ50.

Mean (GM):

This is the best measure of average grain size, which is best computed from size of particles spread through a range of percentile values. It is calculated from

$$M = \frac{(\varphi 16 + \varphi 50 + \varphi 84)}{3} \quad \text{.....Equation (1)} \qquad \text{Phi} = \varphi$$

Mode (Mo):
This is the size class in which the greatest percentage of grains is represented. The mode class means the commonest grain size which is got from a size frequency histogram.

Sorting Co-efficient (So) Standard Deviation (GSD):
This is a measure of spread in the size distribution. It is defined statistically as the extent to which grain spread on either side of the average diameter.

$$D = \frac{\varphi 84 - \varphi 16}{4} + \frac{\varphi 95 - \varphi 5}{6.6} \quad \text{.....Equation (2)}$$

Skewness (GSK):
It is the measure of the symmetry of the grain size distribution on a cumulative curve. It is a positively or negatively sign dimensionless number. It has neither metric nor phi value and lies between the range -1 to +1

$$GSK = \frac{\varphi 84 + \varphi 16 - 2(\varphi 50)}{2(\varphi 84 - \varphi 16)} + \frac{\varphi 95 + \varphi 5 - 2(\varphi 50)}{2(\varphi 95 - \varphi 5)} \quad \text{.....Equation (3)}$$

Kurtosis (K)
It is a measure of the peakedness of the grain distribution. It is the ratio of the spread of the falls and centre of the distribution.

$$K = \frac{\varphi 95 - \varphi 5}{2.44(\varphi 75 - \varphi 25)} \quad \text{.....Equation (4)}$$

4.Presentation And Discussion Of Results.

4.1 Presentation of Samples and Description

The sample points, brief textural description, elevations and their associated geo-references are presented in Table 2. A total of 30 transects were taken along the Okpoama – Brass beach.

Table 2: Sample Locations and Descriptions.

SAMPLE NO.	NORTHINGS	EASTERLIES	ELEVATION (m)	TEXTURE	REMARKS
OBO01	N 04° 17′ 848″	E 006° 19′ 343″	3 m	Light brown, fine grain sand	Transect 1 Vegetation
OBO02	N 04° 17′ 832″	E 006° 19′ 342″	5 m	Light brown, fine grain sand	
OBO03	N 04° 17′ 825″	E 006° 19′ 341″	7 m	Light brown, very fine grain sand	
OBO04	N 04° 17′ 828″	E 006° 19′ 207″	9 m	Light brown, fine grain sand	Transect 2
OBO05	N 04° 17′ 822″	E 006° 19′ 210″	6 m	Light brown, fine grain sand	Small debris found around
OBO06	N 04° 17′ 811″	E 006° 19′ 212″	6 m	Light brown, very fine grain sand	
OBO07	N 04° 17′ 817″	E 006° 19′ 077″	10 m	Light brown, fine grain sand	Transect 3 Massive vegetation
OBO08	N 04° 17′ 809″	E 006° 19′ 077″	10 m	Light brown, fine grain sand	
OBO09	N 04° 17′ 800″	E 006° 19′ 007″	9 m	Light brown, very fine grain sand	
OBO10	N 04° 17′ 799″	E 006° 18′ 942″	8 m	Light brown, fine grain sand	Transect 4
OBO11	N 04° 17′ 783″	E 006° 18′ 944″	4 m	Dark brown, fine grain sand	
OBO12	N 04° 17′ 782″	E 006° 18′ 810″	8 m	Light brown, fine grain sand	Transect 5
OBO13	N 04° 17′ 766″	E 006° 18′ 811″	11 m	Dark brown, very fine grain sand	
OBO14	N 04° 17′ 760″	E 006° 18′ 680″	8 m	Light brown, fine grain sand	Transect 6 Vegetation and debris
OBO15	N 04° 17′ 741″	E 006° 18′ 683″	5 m	Dark brown, fine grain sand	
OBO16	N 04° 17′ 740″	E 006° 18′ 548″	7 m	Light brown, fine grain sand	Transect 7 Vegetation and debris
OBO17	N 04° 17′ 718″	E 006° 18′ 552″	4 m	Dark brown, very fine grain sand	
OBO18	N 04° 17′ 719″	E 006° 18′ 416″	7 m	Light brown fine grain sand	Transect 8 Vegetation and debris
OBO19	N 04° 17′ 696 ″	E 006° 18′ 421″	8 m	Dark brown, very fine grain sand	
OBO20	N 04° 17′ 696 ″	E 006° 18′ 285″	6 m	Light brown, fine grain sand	Transect 9 Vegetation and debris
OBO21	N 04° 17′ 673″	E 006° 18′ 289″	7 m	dark brown, very fine grain sand	
OBO22	N 04° 17′ 679″	E 006° 18′ 156″	7 m	Light brown, fine grain sand	Transect 10 Debris observed
OBO23	N 04° 17′ 655″	E 006° 18′ 159″	7 m	Dark brown, very fine grain sand	
OBO24	N 04° 17′ 662 ″	E 006° 18′ 027″	8 m	Light brown, fine grain sand	Transect 11 Root of trees and vegetation
OBO25	N 04° 17′ 640 ″	E 006° 18′ 029 ″	6 m	Dark brown, very fine grain sand	

SAMPLE NO.	NORTHINGS	EASTERLIES	ELEVATION (m)	TEXTURE	REMARKS
OBO26	N 04° 17′ 640″	E 006° 17′ 896″	6 m	Light brown, fine grain sand	Transect 12 Debris
OBO27	N 04° 17′ 621″	E 006° 17′ 897″	7 m	Dark brown, very fine grain sand	
OBO28	N 04° 17′ 622″	E 006° 17′ 764″	9 m	Dark brown, fine grain sand	Transect 13 Debris
OBO29	N 04° 17′ 600″	E 006° 17′ 761″	9 m	Dark brown, very fine grain sand	
OBO30	N 04° 17′ 607″	E 006° 17′ 630″	10 m	Light brown, very fine grain sand	Transect 14 Whistle palm
OBO31	N 04° 17′ 579″	E 006° 17′ 632″	5 m	Dark brown, very fine grain sand	
OBO32	N 04° 17′ 588″	E 006° 17′ 496″	10 m	Light brown, fine grain sand	Transect 15 Grass and debris
OBO33	N 04° 17′ 563″	E 006° 17′ 498″	10 m	Dark brown, very fine grain sand	
OBO34	N 04° 17′ 572″	E 006° 17′ 368″	14 m	Light brown, fine grain sand	Transect 16 Debris found
OBO35	N 04° 17′ 548″	E 006° 17′ 369″	15 m	Dark brown, very fine grain sand	
OBO36	N 04° 17′ 561″	E 006° 17′ 234″	10 m	Light brown, fine grain sand	Transect 17 Vegetation and Debris
OBO37	N 04° 17′ 528″	E 006° 17′ 238″	8 m	Dark brown, very fine grain sand	Bivalves, shells and mica flakes
OBO38	N 04° 17′ 543″	E 006° 17′ 101″	9 m	Light brown, fine grain sand	Transect 18 Mining activities
OBO39	N 04° 17′ 512″	E 006° 17′ 103″	9 m	Dark brown, very fine grain sand	Bioclastic materials (Shells)
OBO40	N 04° 17′ 532″	E 006° 16′ 964″	10 m	Light brown, fine grain sand	Transect 19 Debris
OBO41	N 04° 17′ 500″	E 006° 16′ 967″	9 m	Dark brown, fine grain sand	Shells and suspected mica flakes
OBO42	N 04° 17′ 513″	E 006° 16′ 832″	11 m	Light brown, fine grain sand	Transect 20 Debris
OBO43	N 04° 17′ 487″	E 006° 16′ 834″	10 m	Dark brown, fine grain sand	Shells
OBO44	N 04° 17′ 495″	E 006° 16′ 694″	12 m	Light brown, fine grain sand	Transect 21 Debris
OBO45	N 04° 17′ 475″	E 006° 16′ 700″	11 m	Dark brown, very fine grain sand	
OBO46	N 04° 17′ 488″	E 006° 16′ 566″	10 m	Light brown, fine grain sand	Transect 22 Debris
OBO47	N 04° 17′ 466″	E 006° 16′ 568″	5 m	Dark brown, very fine grain sand	
OBO48	N 04° 17′ 478″	E 006° 16′ 432″	12 m	Light brown, fine grain sand	Transect 23
OBO49	N 04° 17′ 458″	E 006° 16′ 434″	7 m	Dark brown, very fine grain sand	
OBO50	N 04° 17′ 476″	E 006° 16′ 300″	11 m	Light brown, fine grain sand	Transect 24
OBO51	N 04° 17′ 455″	E 006° 16′ 300″	11 m	Dark brown, fine grain sand	
OBO52	N 04° 17′ 470″	E 006° 16′ 167″	14 m	Light brown, fine grain sand	Transect 25
OBO53	N 04° 17′ 454″	E 006° 16′ 168″	12 m	Dark brown, fine grain sand	
OBO54	N 04° 17′ 463″	E 006° 16′ 041″	9 m	Light brown, fine grain sand	Transect 26
OBO55	N 04° 17′ 445″	E 006° 16′ 041″	9 m	Dark brown, very fine grain sand	
OBO56	N 04° 17′ 452″	E 006° 15′ 908″	8 m	Light brown, fine grain sand	Transect 27 Debris
OBO57	N 04° 17′ 436″	E 006° 15′ 909″	7 m	Dark brown, very fine grain sand	Bioclastics (Shell)
OBO58	N 04° 17′ 441″	E 006° 15′ 772″	10 m	Light brown, fine grain sand	Transect 28 Debris
OBO59	N 04° 17′ 426″	E 006° 15′ 774″	4 m	Dark brown, very fine grain sand	
OBO60	N 04° 17′ 428″	E 006° 15′ 643″	12 m	Light brown, fine grain sand	Transect 29
OBO61	N 04° 17′ 409″	E 006° 15′ 645″	71 m	Light brown, very fine grain sand	Debris
OBO62	N 04° 17′ 408″	E 006° 15′ 522″	9 m	Light brown, very fine grain sand	Transect 30 Debris
OBO63	N 04° 17′ 393″	E 006° 15′ 522″	10 m	Dark brown, very fine grain sand	Bioclastics (shells)

4.2 Presentation of Grain Size Parameters and Discussions.

Table 3 shows the various statistical parameters for the individual sample calculated from the grain size analysis carried out. Frequency curves and cumulative curves of some of the samples, showing the distribution of the sample population are also plotted for graphical presentation in Figures 3 - 54.

Table 3: Table of calculated statistical parameters of sediments

	Mean (φ)	GSD	GSK	K	Median (φ)
OBO1	1.93	0.56	-0.10	2.25	1.9
OBO2	1.80	0.39	0.50	1.91	1.9
OBO3	2.20	0.64	0.15	1.64	2.3
OBO4	2.20	0.50	-0.25	0.61	2.2
OBO5	2.00	0.32	-0.05	1.13	2.0
OBO6	2.00	0.22	0.00	1.09	2.0
OBO7	2.10	0.36	0.10	1.23	2.1
OBO8	1.90	0.45	0.80	1.23	1.8
OBO9	2.30	0.67	-0.20	0.96	2.4
OBO10	2.03	0.53	0.08	0.87	2.0
OBO11	2.70	0.10	0.25	1.05	2.2
OBO12	2.37	0.76	-0.03	0.90	2.4
OBO13	2.50	1.01	-0.23	1.10	2.6
OBO14	2.40	0.75	-0.02	0.77	2.4
OBO15	2.50	0.80	0.07	0.85	2.4
OBO16	2.23	0.69	-0.28	0.83	2.4
OBO17	2.03	0.65	-0.32	1.57	2.1
OBO18	1.96	0.65	0.27	2.20	2.0
OBO19	2.27	0.29	0.22	1.84	2.2
OBO20	1.96	0.55	0.28	0.23	2.0
OBO21	2.10	0.53	0.17	0.77	2.0
OBO22	2.10	0.55	-0.44	1.06	2.2
OBO23	1.80	0.61	-0.04	0.27	1.8
OBO24	2.07	0.71	-0.12	1.06	2.1
OBO25	1.83	0.53	-0.09	0.51	1.8
OBO26	2.07	0.35	-0.33	3.13	2.1
OBO27	1.83	0.34	0.12	0.75	1.8
OBO28	1.90	0.37	0.03	1.54	1.9
OBO29	1.83	0.39	0.07	1.43	1.8
OBO30	1.87	0.44	0.02	1.15	1.9
OBO31	1.86	0.35	0.05	0.88	1.8
OBO32	1.93	0.44	-0.02	0.82	1.9
OBO33	1.83	0.37	0.11	1.07	1.8
OBO34	1.83	0.34	0.21	0.90	1.8
OBO35	1.87	0.42	0.09	0.89	1.9
OBO36	1.90	0.37	-0.05	0.90	1.9
OBO37	2.03	0.39	0.14	1.15	2.0
OBO38	2.00	0.47	0.29	1.09	1.9
OBO39	1.90	0.38	0.83	0.98	1.9
OBO40	2.10	0.39	-0.44	1.13	2.2
OBO41	1.80	0.30	0.00	1.02	1.8
OBO42	1.87	0.34	-0.12	0.90	1.9
OBO43	1.80	0.30	0.00	1.02	1.8
OBO44	1.83	0.26	0.16	1.23	1.8
OBO45	1.83	0.54	-0.11	1.43	1.8
OBO46	1.77	0.45	-0.29	1.48	1.8
OBO47	1.73	0.43	-0.08	1.39	1.7
OBO48	1.80	0.30	0.00	0.82	1.8
OBO49	1.70	0.39	-0.19	1.64	1.7
OBO50	1.80	0.45	-0.44	1.48	1.9
OBO51	1.70	0.41	-0.15	1.39	1.7
OBO52	1.70	0.42	-0.22	1.84	1.7
OBO53	1.77	0.42	-0.26	1.31	1.8
OBO54	1.87	0.36	-0.07	1.23	1.9

	Mean (φ)	GSD	GSK	K	Median (φ)
OBO55	1.83	0.34	0.12	0.90	1.8
OBO56	1.80	0.32	0.05	1.13	1.8
OBO57	1.73	0.45	-0.10	1.48	1.7
OBO58	1.80	0.30	0.00	1.02	1.8
OBO59	1.83	0.34	0.12	1.13	1.8
OBO60	1.80	0.41	-0.26	1.74	1.8
OBO61	1.73	0.43	-0.08	1.39	1.7
OBO62	1.60	0.43	0.13	1.39	1.5
OBO63	1.73	0.46	-0.06	1.56	1.7
AVERAGE	**1.95**	**0.89**	**-0.00016**	**1.2**	**1.94**

The grain size population of the sampled sediments shows variations in the modal presentation. Most of the samples are unimodal as can be seen from the frequency histograms, with the 0.25 – 0.125 mm as the modal class (fine sand grade), but a significant number are polymodal (Figures 3-8, 15-22, 31-54). The unimodal samples show very good sorting while the polymodal sediments exhibit poor sorting. Sorting ranges from 0.1 (very well sorted) to 1.01 (poorly sorted). The average sorting value for the entire sampled population is 0.89 (Moderately sorted). The average value for kurtosis is 1.2, which indicates the sediments are leptokurtic. The kurtosis values range from 0.51 (very platykurtic) for the polymodal sediments to 2.25 for the unimodal sediments which are very leptokurtic. The skewness of the population range from symmetrical to negatively skewed. The average value for the Median (φ) is 1.92 which represents the medium sand size grade. This does not tie exactly with the modal class, which is the 2 – 3 φ, (fine sand grade). The average Mean value is 1.95 φ.

The size distribution consists of sizes from coarse sands to silt size class. According to Visher (1969), coarse grains larger than 0.5 φ are transported by traction method, bedload between 0.5φ and 3 φ are by saltation method, whereas, those finer than 3 φ are carried by suspension. All the three modes of transportation are inferred from the cumulative curves of the sediments (Figures 9-14, 23-30).

Waves and currents are responsible for sediment transport and reworking within the beach. In a prograding coast like the Niger Delta, rivers carry sediment load from the in-land into the ocean. These sediment loads are reworked by waves and current and deposited in the beaches. Coastal sediments are usually made up of sands, and are gravelly where source rock is nearby (Reineck and Singh, 1980). The sediment load from Okpoama – Brass beach are dominantly fine sands, indicative of distant source rock.

Weigel (1964) observed that a systematic relationship exist between grain size, beach slope and exposure to wave action. For a given grain size, a beach slope will increase with decreasing wave action. Alternatively, under similar wave conditions, coarser sand will always form a steeper slope than finer sand (Reineck and Singh, 1980). Conclusively, Okpoama – Brass beach is a low lying beach composed mainly of fine sand grade.

5. Conclusion

The Okpoama – Brass beach is an active beach that sits at the edge of the Atlantic Ocean parallel to the shore line. The beach is low lying and is composed of sand, predominantly the fine sand grade. Most of the samples are unimodal with a significant number polymodal. The modal class is the 0.25 – 0.125 mm class (fine sand grade). The average value for the median (φ) is 1.92. Sorting ranges from 0.1 (very well sorted) to 1.01 (poorly sorted), the average value is 0.89 (moderately sorted). The sediments are symmetrical to negatively skew. The average value for kurtosis is 1.2, which indicates the sediments are leptokurtic.

The modal class of the sediment is transported by saltation, while, the finer and coarser sediments which occur in lower quantities are transported by suspension and traction respectively.

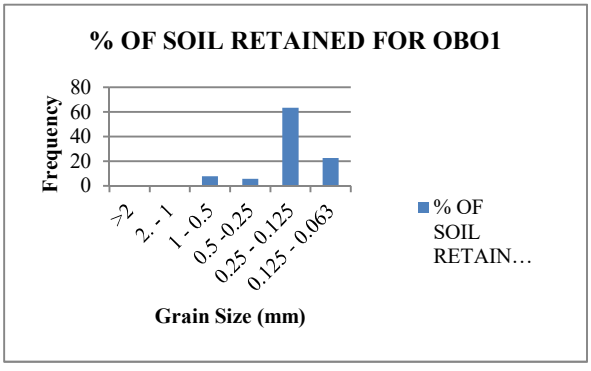

Figure 3: Histogram for sample OBO1

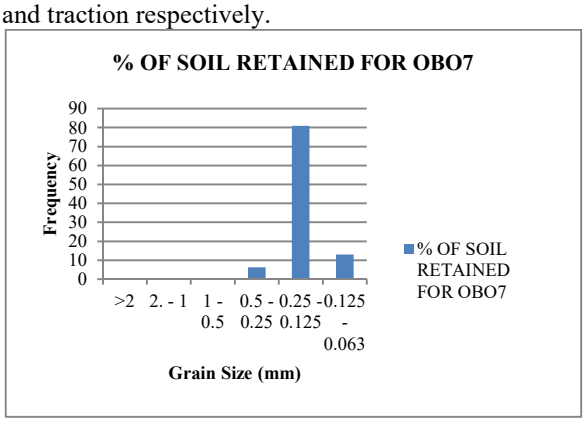

Figure 6: Histogram for sample OBO7

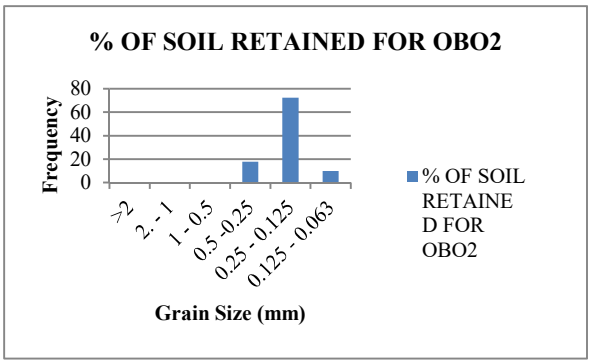

Figure 4: Histogram for sample OBO2

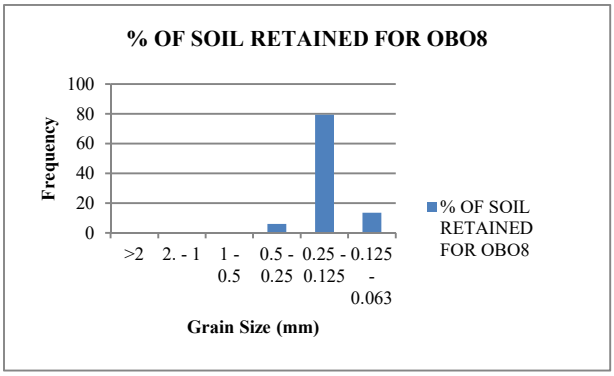

Figure 7: Histogram for sample OBO8

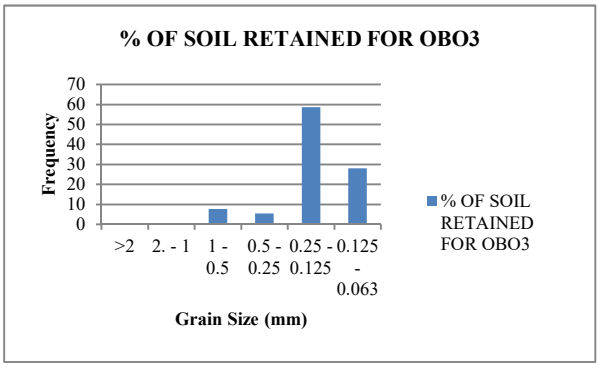

Figure 5: Histogram for sample OBO3

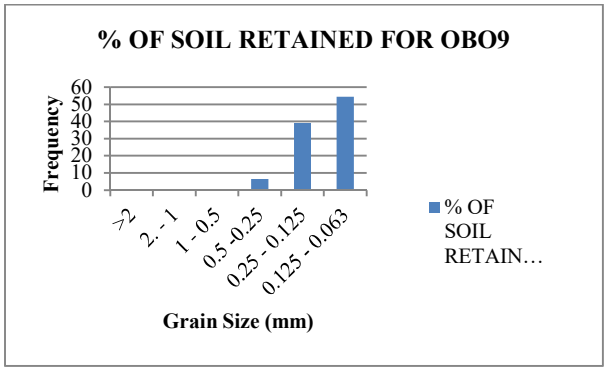

Figure 8: Histogram for sample OBO9

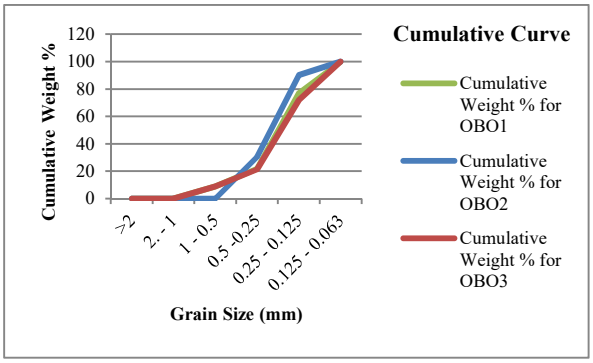

Figure 9: Cumulative curves for samples OBO1, OBO2 and OBO3

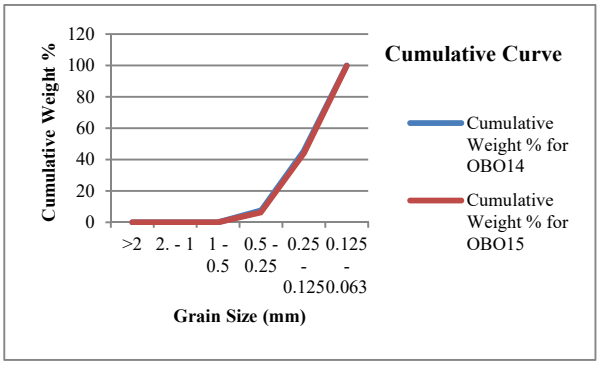

Figure 12: Cumulative curves for samples OBO14, and OBO15

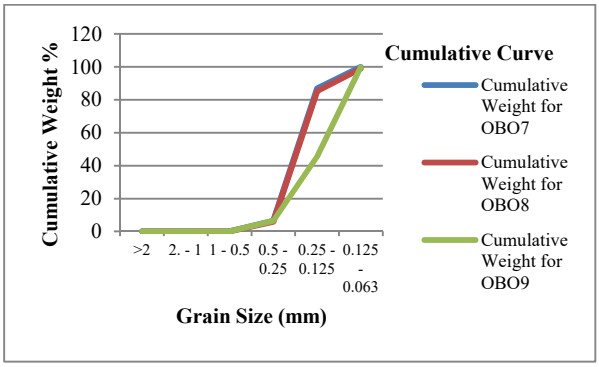

Figure 10: Cumulative curves for samples OBO7, OBO8 and OBO9

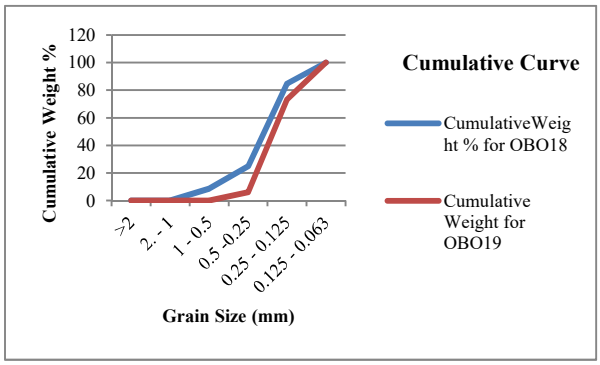

Figure 13: Cumulative curves for samples OBO18, and OBO19

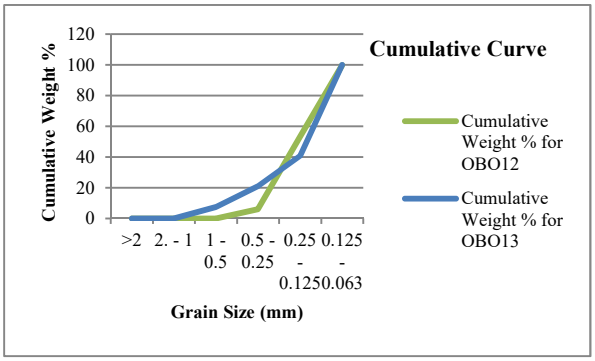

Figure 11: Cumulative curves for samples OBO12, and OBO13

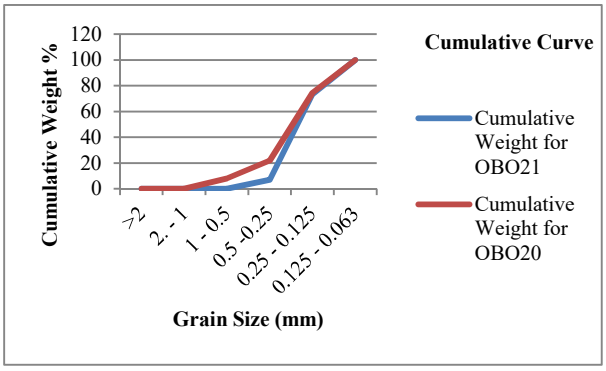

Figure 14: Cumulative curves for samples OBO20, and OBO21

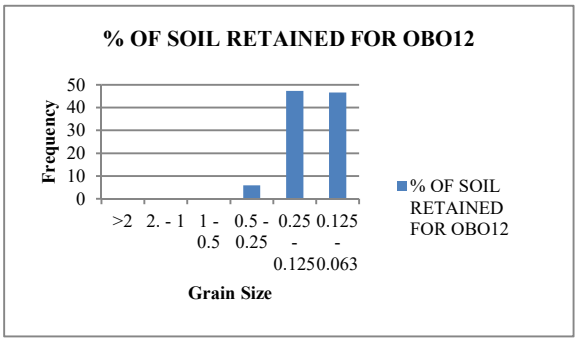

Figure 15: Histogram for sample OBO12

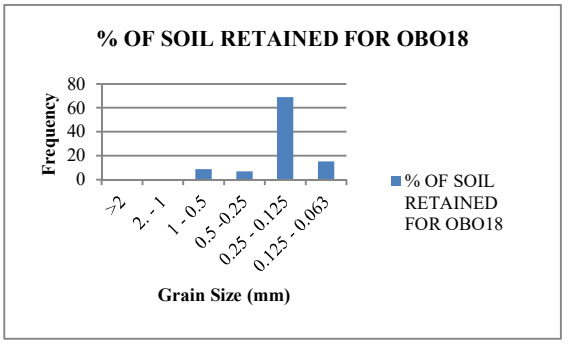

Figure 19: Histogram for sample OBO18

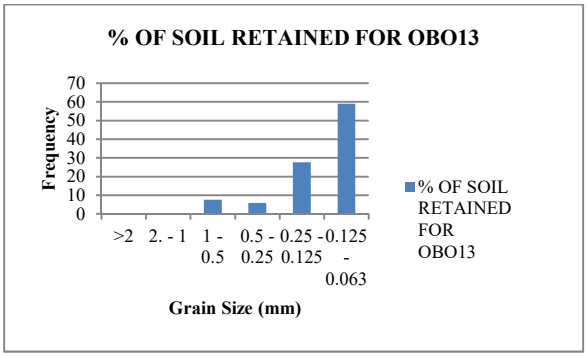

Figure 16: Histogram for sample OBO13

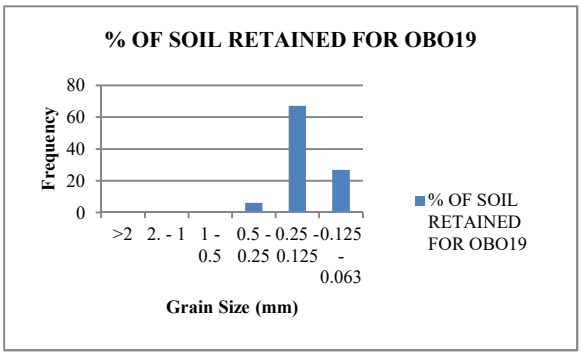

Figure 20: Histogram for sample OBO19

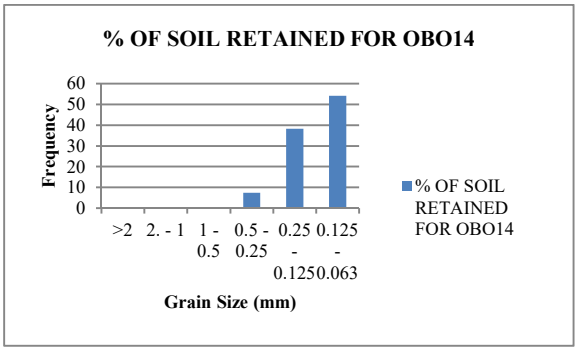

Figure 17: Histogram for sample OBO14

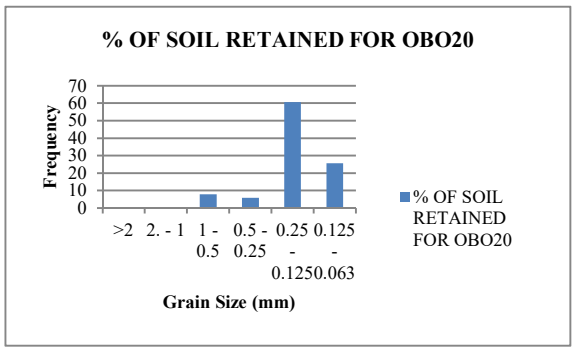

Figure 21: Histogram for sample OBO20

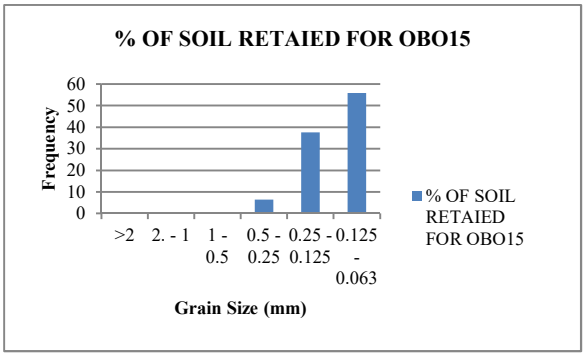

Figure 18: Histogram for sample OBO15

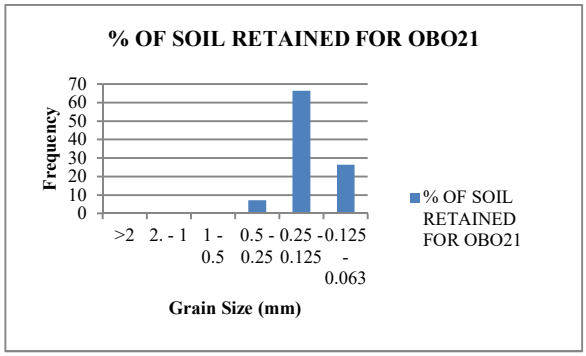

Figure 22: Histogram for sample OBO21

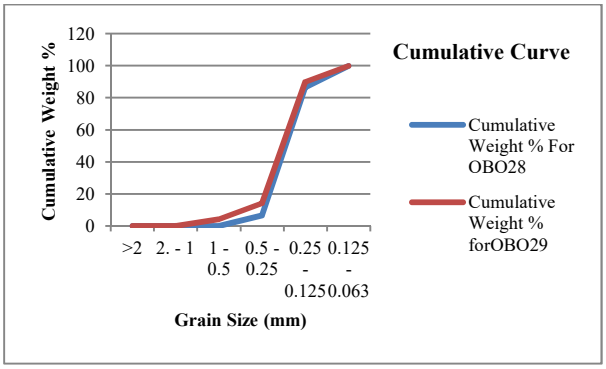

Figure 23: Cumulative curves for samples OBO28, and OBO29

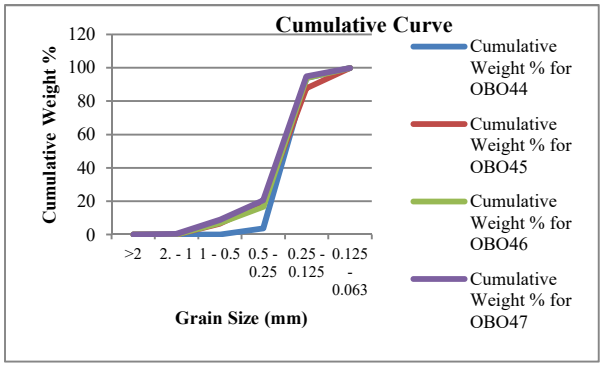

Figure 27: Cumulative curves for samples OBO44, OBO45, OBO46 and OBO47

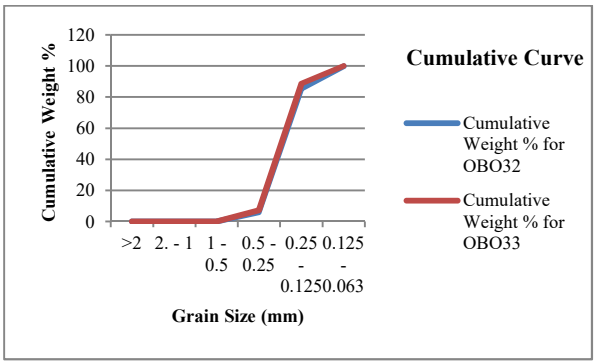

Figure 24: Cumulative curves for samples OBO32, and OBO33

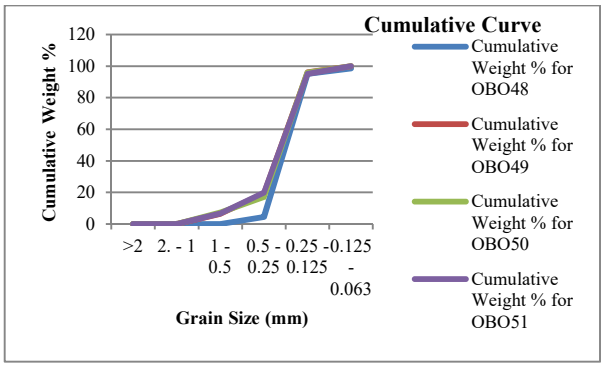

Figure 28: Cumulative curves for samples OBO48, OBO49, OBO50 and OBO51

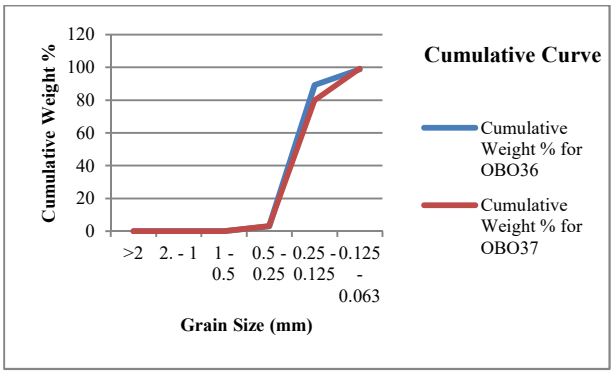

Figure 25: Cumulative curves for samples OBO36, and OBO37

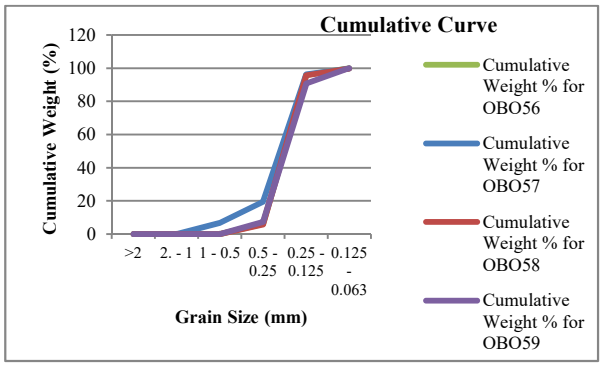

Figure 29: Cumulative curves for samples OBO56, OBO57, OBO58 and OBO59

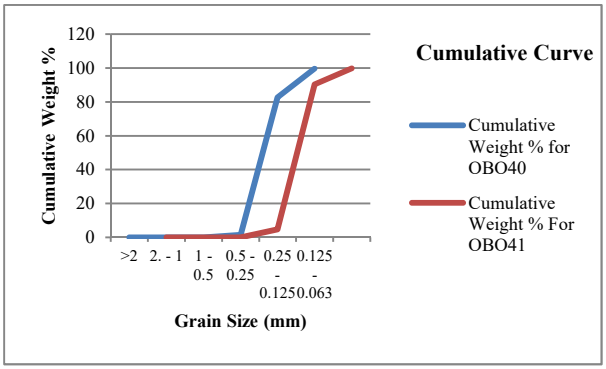

Figure 26: Cumulative curves for samples OBO40, and OBO41

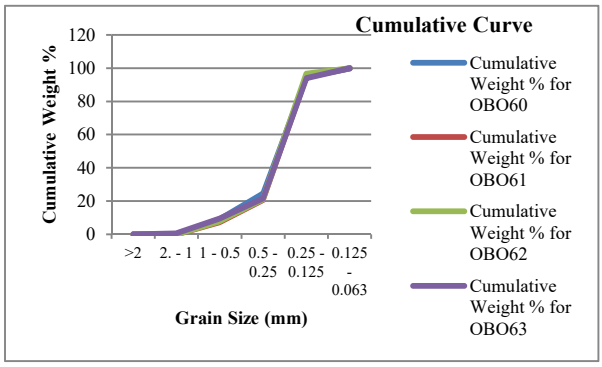

Figure 30: Cumulative curves for samples OBO60, OBO61, OBO62 and OBO63

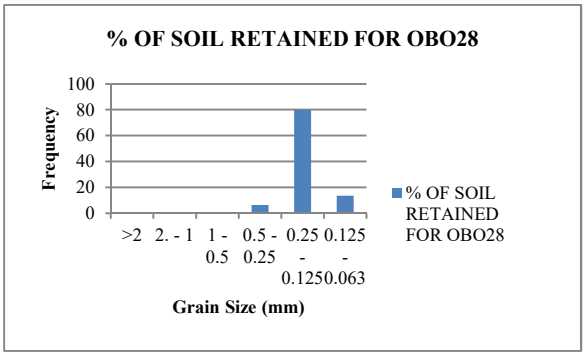

Figure 31: Histogram for sample OBO28

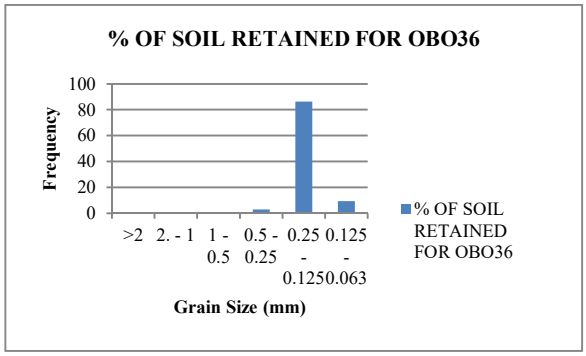

Figure 35: Histogram for sample OBO36

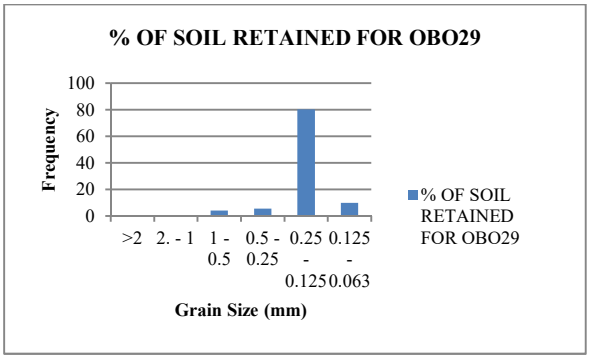

Figure 32: Histogram for sample OBO29

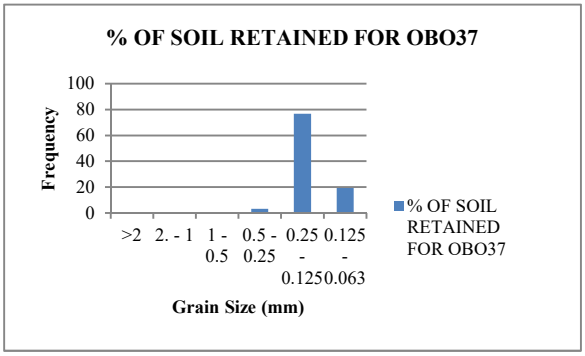

Figure 36: Histogram for sample OBO37

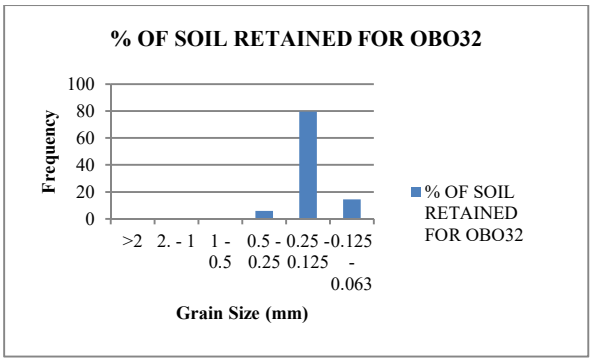

Figure 33: Histogram for sample OBO29

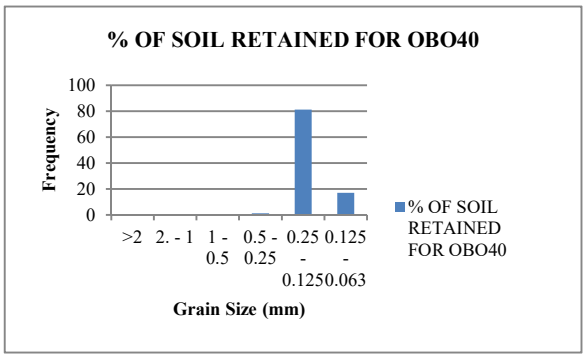

Figure 37: Histogram for sample OBO40

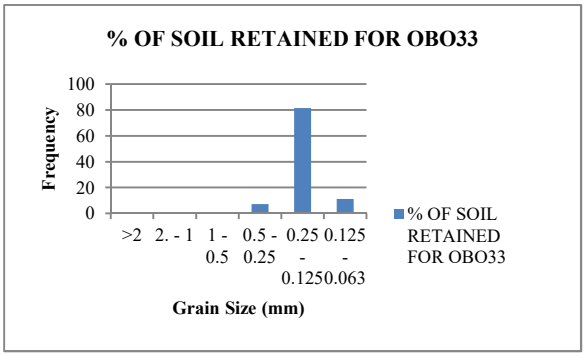

Figure 34: Histogram for sample OBO33

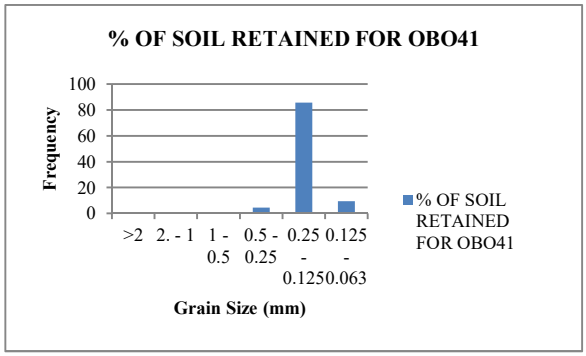

Figure 38: Histogram for sample OBO41

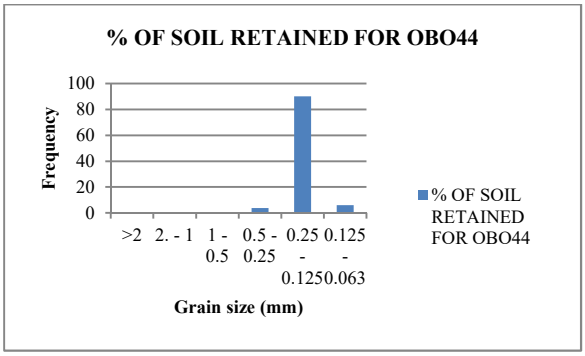

Figure 39: Histogram for sample OBO44

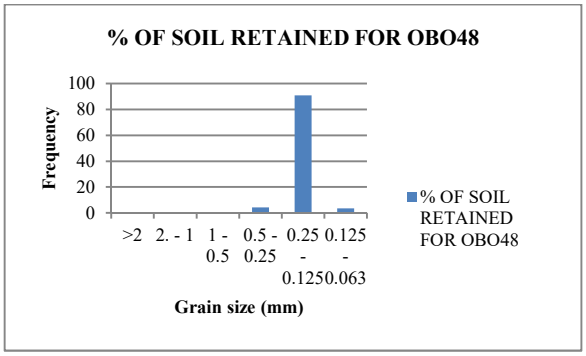

Figure 43: Histogram for sample OBO48

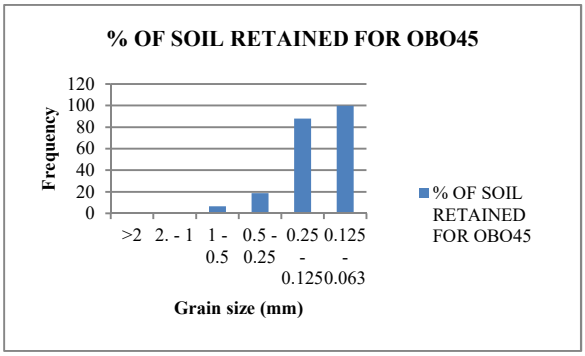

Figure 40: Histogram for sample OBO45

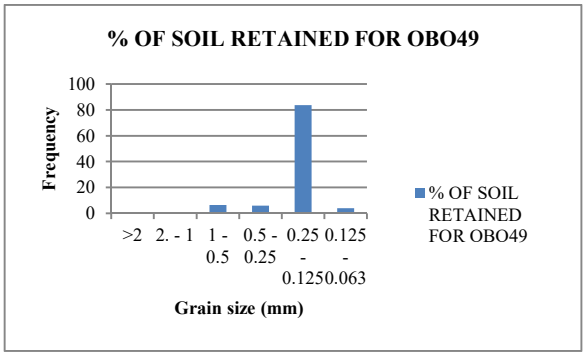

Figure 44: Histogram for sample OBO49

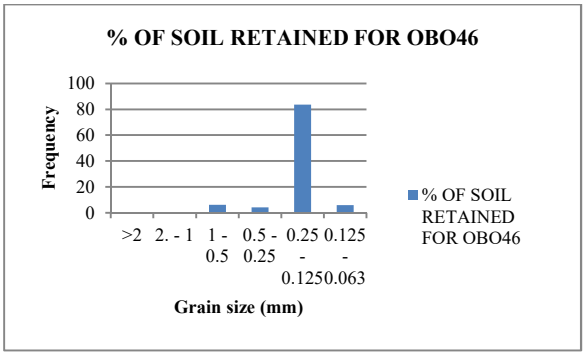

Figure 41: Histogram for sample OBO46

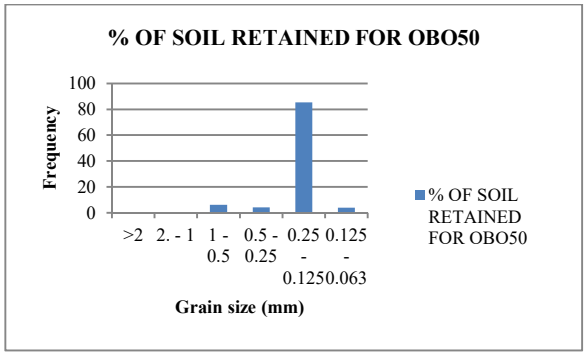

Figure 45: Histogram for sample OBO50

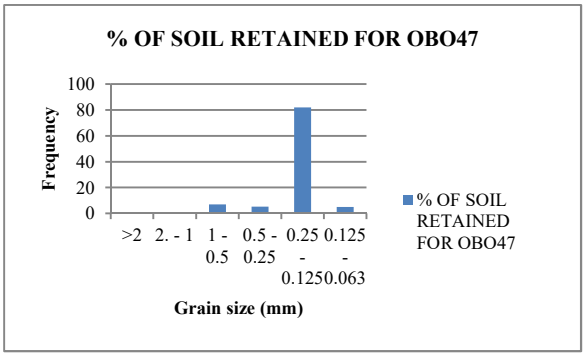

Figure 42: Histogram for sample OBO47

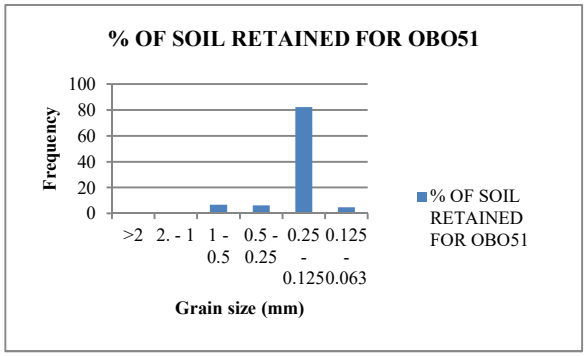

Figure 46: Histogram for sample OBO50

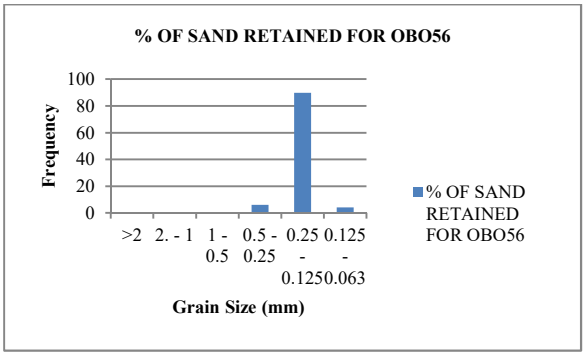

Figure 47: Histogram for sample OBO56

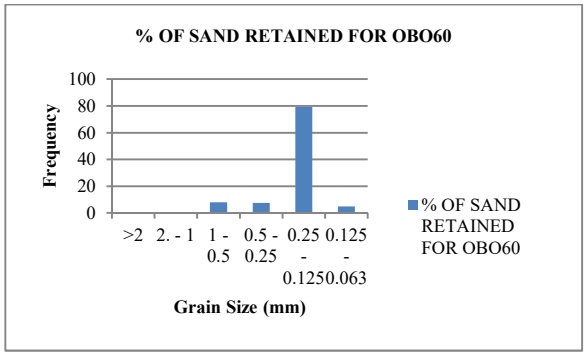

Figure 51: Histogram for sample OBO60

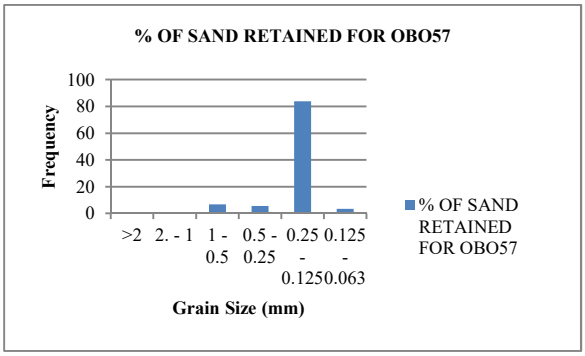

Figure 48: Histogram for sample OBO57

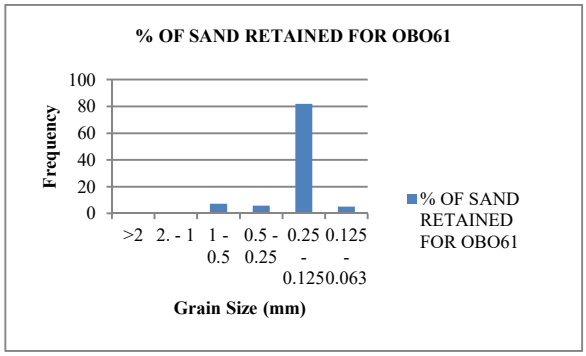

Figure 52: Histogram for sample OBO61

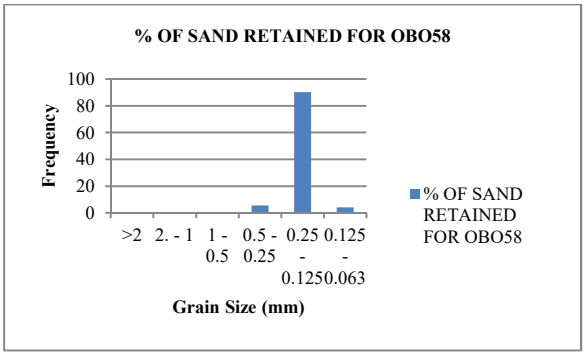

Figure 49: Histogram for sample OBO58

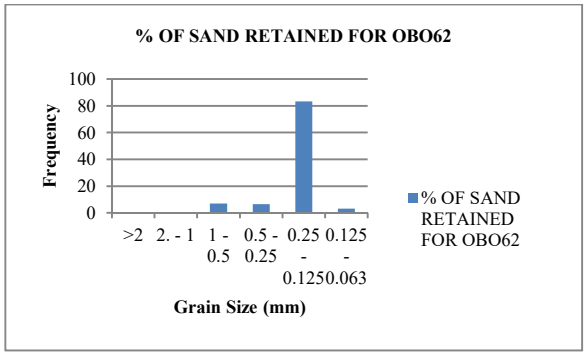

Figure 53: Histogram for sample OBO62

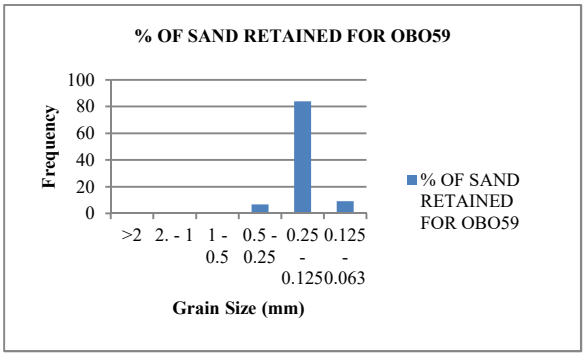

Figure 50: Histogram for sample OBO59

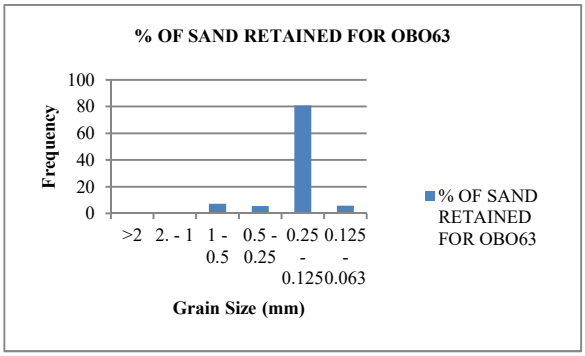

Figure 54: Histogram for sample OBO63

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