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SOIL CHARACTERIZATION FOR TEXTURE AND MOISTURE PROPERTIES AT SPATIAL DATA RANGE FOR POTENTIAL IMPACT ON FLOODING IN OZORO, NIGERIA

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ABSTRACT: *Soil properties for seven hundred and fifty (750) on–point soil samples were obtained at a depth of 0 – 10 cm below the soil horizon and characterized for their texture type using the jar technique. Additionally, the moisture content features were determined before the microwave/oven drying technique was used to assess dehydration under both wet and dry basis conditions, as well as the variation in moisture. These value attributes were used to obtain their impact on the flooding of the area. Resultantly, it was found that the soil type of the area was sandy loam soil, while the average moisture values for the area were 5.4059% on a wet basis, 5.8116 % on a dry basis, and 0.4057% variation. The variations in the basis range between 0 – 4 %. Thus, a conclusion based on the obtained results prior to the soil properties, which significantly showed normal features attributed to sandy loam soil about water movement, indicating that the area flooding is not basically influenced negatively by the ground type.*

Keywords: Soil Classification, Soil Texture, Moisture Content, Soil Moisture Variation, Flooding, *etc*.

1. INTRODUCTION

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There is need for adequate examination of soils [24]. This is useful in soil and water conservation, environmental management, and land use demand for various purposes. The ever-growing population in the world is expected to reach 9 billion by 2050, inciting the need to produce more food to meet the increasing global demands [23]. Also, securing and managing the soil require knowledge of soil properties for various decisions making. This research work provides information that will guide scientists, engineers and local land advisers in understanding soil properties for potential productivity of fields, as well as usability.

Soil Classification: The soil is a vital asset of man. It is the base upon which various human activities are carried out. The soil is the cornerstone of an agro ecosystem and a reflection of the potential productiveness of an environment. The soil experiences threats from; soil erosion by water and wind, declines in soil organic matter (SOM) in peat and mineral soils, soil compaction, sealing, contamination, salinization, desertification, declines in soil biodiversity [13], flooding, *etc*. Soil classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes (e.g. sandy clay, silty clay) [7]. Soils are classifiable through their particle sizes using various classification systems approved by appropriate bodies. Examples are: the British Standard Institution, the International Union of Soil Science (IUSS), the United States Department of Agriculture (USDA), and the United States Public Roads Administration (USPRA). The soil classification system using their particle sizes developed by these international bodies are presented in figure one (1) below;

British Standards Institution		0.002	0.006	0.02	0.06	0.2	0.6	2.0 mm
	CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	GRAVEL
		SILT			SAND			
International Union of Soil Science	CLAY	SILT		SAND				GRAVEL
				Fine		Coarse		
	0.002			0.02		0.2		2.0 mm
	0.002		0.05	0.10	0.25	0.5	0.10	2.0 mm
United States Department of Agriculture	CLAY	SILT	Very fine	Fine	Med.	Coarse	Very Coarse	GRAVEL
			SAND					
United States Public Roads Administration	CLAY	SILT	SAND					GRAVEL
			Fine		Coarse			
	0.005	0.05	0.25		2.0 mm			

Figure 1: Classification Of Soil Particle According To Size By Four Systems [8]

Soil Characteristics: Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following:

horizons or layers that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter in a natural environment [4]. The soil is a natural resource that exists in there major particle forms which are ever available on earth (clay, sand and silt). A soil can be all sand, all clay, or all silt in rare case, though most soils are a combination of the three [9]. Soils perform vital functions to sustain plant and animal life, regulate water flow, filter and buffer pollutants, cycle nutrients, and provide physical stability and sort [4]. The soil also receives beneficial support from them. [25] noted that, the root systems of live plants act in several ways to increase slope stability and serve as a binder for individual soil particles. It is teaming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem [5]. The soil is a renewable resource. They are considered renewable because they are constantly forming [9]. Soil formation process takes decades to occur. Soil formation rates vary across the planet: the slowest rates occur in cold, dry regions (1000+ years), and the fastest rates are in hot, wet regions (several hundred years) [9]. Soils have four main components: mineral particles (sand, silt, and clay), organic matter, water, and air [10]. Soil contains these nutrients and minerals because of the physical, chemical, and biological forces that form soil, the composition of the parent material from which soils were formed, and the ability of soils to capture, retain, and transform compounds as those compounds enter and move through their environment [11].

Soil Texture: Texture affects many soil properties, such as infiltration, structure, porosity, water holding capacity, and chemistry [7]. The soil texture is associated with soil porosity, which in turn regulates the water holding capacity, gaseous diffusion and water movement that determines the soil health [21]. The soil water holding and movement influence varieties of factors in the soil environment. The smallest mineral particle in soil is clay. Clay particles are the active portion of a soil. This is because chemical reactions occur at their surface. The chemical reactions control the adsorption and many other chemicals in the environment. Sand and silt particles are less active chemically because of their mineral composition and limited surface area. This is because there particle sizes are bigger than clay. Texture affects many soil processes, including infiltration, drainage (water and air distribution), erosion, chemical processes, and biologic processes [16].

Soil Moisture Content: Moisture content is defined as the ratio of the weight of liquid in the soil to that of the solid. Moisture content is an important physical property index for evaluating the physical and mechanical properties of soil [14]. Soil moisture (SM) content can be defined as the amount of water available in the unsaturated zone [19]. In engineering practice, soil moisture content plays an important role in the safety performance evaluation of various geotechnical engineering structures (such as soil nailing wall, foundation, earth rock dam, *etc*.), slope treatment and reinforcement, landslide and debris flow early warning, ground collapse prevention and control, *etc*., [14]. Soil moisture content material has paramount importance in dictating

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engineering, agronomic, geological, ecological, bioorganical, and hydrological features of the soil mass [18]. It influences plant growth, soil temperature, transport of chemicals and groundwater recharge [23]. The two types of soil moisture measurements are the direct (volumetric, gravimetric, and methyl alcohol methods) and the indirect methods (gypsum block, tensiometer, neutron probe, and pressure gauge: pressure plate and pressure membrane). The volumetric method involves obtaining soil samples using a tube auger of a known volume and obtaining the amount of water present in the sample using appropriate formula upon oven drying. The gravimetric methods involves measurement of soil moisture from soil samples of known weight or volume through weighing, drying and reweighing to obtain the difference in amount of dryness and wetness of the soil sample. The methyl alcohol technic involves mixing a known volume of methyl alcohol and obtaining the change in specific gravity of the solution using the hydrometer. The gypsum blocks are rectangular shaped blocks of materials like gypsum, nylon fiber, glass, *etc*., made up of a ceramic or clay cup of 7.5 cm, a cap for closure, a vacuum gauge and a hollow metallic tube. They operate on the principle of conductance of electricity through the electrodes. Tensiometer is used to obtain amount of tension or the tenacity upon which water is held in by soil. Thus, upon water fillage of the tensiometer placed in the soil, the gauge records the degree of vacuum due to the dryness of soil prior moisture obtained from the cup. Neutron probe and pressure gauge involves the use of neutron meters as well as pressure gauge in obtaining the moisture in the soil through the use of radio nuclides or radioactive materials. Neutron probe of source like americium and beryllium, radium and beryllium *etc*., is lowered into access tube (basically 50 -100 cm) at the desired depth in the soil and fast neutrons are released into the soil, and upon neutrons encounter with nuclei of hydrogen atom of water, their speed is reduced and the rate meter counts the number of slow neutrons, which are directly proportional to water molecules which are used to obtain the moisture content of soil from the calibration curve with the counts of slow neutrons.

Jar Technique Analysis: Generally, mechanical analysis is a process of soil test in the laboratory. The jar test is a simple experiment that gives the relative proportions of sand, silt, and clay in the soil, which together determine the soil's texture [12]. It is one of the most important laboratory determination made in soil studies [8]. It is divided into two major types: Sieve analysis and hydrometer analysis. Sieve analysis involves the shaking of soil samples through a set of sieves of different sizes that have smaller openings of approximately 5mm and below. The sieve analysis is suitable for coarse grained soil *i.e*., the soil having particle size greater than 75 microns. Hydrometer analysis is the process of testing soil based on the principle of sedimentation of soil grains in water. Hydrometer analysis is further developed to sub - types of which the jar technique emerged from. When a soil specimen is dispersed in water, the particles settle at different velocities, depending on their

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shape, size, weight, and the viscosity of the water. This is the principle governing the jar technique in a known sized container.

Flooding: Flood otherwise inundation, deluge, flash flood, downpour, freshet, torrent, swamping, overflow, spate, cloudburst, *etc*. Flood refers to the ponding of water at or near the point where the rain fell [1]. It occur as a result of heavy rainfall, snowmelt, ocean or sea wave action on shores, water body overflow. It is regarded as flash flood when caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours [1]. Flood is a threat to lives, destroying belongings, damage infrastructures, inundate businesses and properties, hinder access to places, displaces people and residents, *etc*. These floods are threats to agriculture. Agricultural farms and crops are submerged upon the occurrence of these flood events. Moreover some crops do not have resistance to water submersion conditions, and thus suffer the effects more. In 2022, the pond news reported of the submersion of the Delta State University Of Science And Technology Ozoro. Also, in 2015, the area (Ozoro) witnessed high flooding with hundreds of person displaced from their homes with Etevie, Iyeriri and Urhuamudhu communities identified with higher damage. These highlighted flood scaneros as a problem that needs solution in the area. This solution have been delayed due to possible fund acquisition calling on government and nongovernmental bodies to interceed, as this will serve as a major community development for the area. [17] reported that the overall impact of flood varied across selected states: Bayelsa (99 percent) Jigawa (94 percent), Nasarawa (70 percent), Kogi (70 percent), Delta (57 percent) and Anambra (23 percent). This puts Delta state among the frontline of flood vulnerability in the country. In same period, [2] recommendably highlighted the need for residents in "Abraka, Agbor, Asaba, Umuakwata, Aboh, Ozoro, Oleh, Otu-Jeremi and other coastline communities, as well as persons living in floodplain areas to immediately relocate temporarily to upper land, taking with them valuable properties, children, people with disabilities and the elderly family members". In all, flood is a problem in the area.

2. MATERIALS

The study area is Ozoro in delta state of nigeria. Ozoro is located in Isoko north local government area. It is popularly known for its educationally attributed history with higher institutions (Ozoro college of education and the defunct delta state polytechnic, Ozoro) of which delta state university of science and technology have emerged from, at present known as Southern Deltan University, Ozoro. The soil and water laboratory section of the department of Agricultural Engineering of the Delta State University Of Science And Technology, Ozoro was deployed for sample analysis.

Other materials used in this study include the following: Materials used for soil test (soil auger, plastic sack, detergent, distilled water, electric oven, textural triangle, *etc*), weighing balance, and materials used for moisture experiment (soil samples, plastic sac, plastic tape, microwave, *etc*).

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3. METHODOLOGY

A total of seven hundred and fifty (750) on – point soil samples were scientifically obtained from selected fifty (50) on – site different sub – sectional locations within the study area, using the soil auger at appropriately 10 cm vertical depth meeting the collection global standard range of the 0 - 15 cm depth. The samples were bagged and labeled using black plastic sacks and paper tape, and upon grouping, taken to agricultural engineering department laboratory for necessary tests. A typical soil sampling and measurement are presented in figure two (2) below;

(a) Soil sampling (b) Soil Measurement

Figure 2: Soil Sampling And Soil Measurement Using The Weighing Balance

i. Soil Type Experimentation: The mechanical analysis technique of laboratory procedure for soil separation identification was utilized. According to [20], the percentage height of each measured soil components were used to trace their soil type (using the lines from the percentage values on the textural class diagram) presented in figure three (3) below;

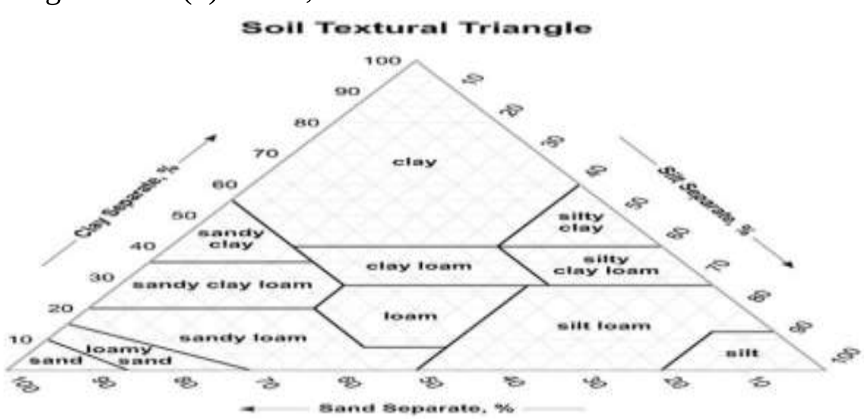

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Figure 3: Soil Textural Class Diagram [22; 20].

Prior these methods, other replicates experiments were attained for their obtained samples.

ii. Soil Moisture Content: The moisture content (%) of the soil samples were obtained upon weighing, the soil samples were dried in an oven at 105 ºC for 24 hours, and reweighed for measurements and computations. This was based on the difference in weight of the soil (wetness to dryness). Moisture content is expressed as a percentage by weight of either total product (wet basis) or dry product (dry basis). [3] mathematically explain moisture content as presented below;

Wet Basis Moisture Content: M = 100 x (Wet Weight – Dry Weight) / Wet Weight

Dry Basis Moisture Content: M = 100 x (Wet Weight – Dry Weight) / Dry Weight

The computations were done using the wet basis moisture content equation above, in alignment with the guidelines of [6] as presented below;

$$= \frac{W_1 - W_2}{W_1} \times \frac{100}{1}$$

Where: W1 = Weight of petri dish + sample before drying; W2 = Weight of Petri dish + sample after drying; W1 - W2 = Moisture Loss

Prior these methods, other replicates experiments were attained for their obtained samples. Also, obtained values were used to assess the possible or negative impact of the soil on the area flooding.

4. RESULTS

The results obtained in the course of this work are presented in tables 1 - 3 and figures 5 - 8 below;

Table 1: Soil Composition And Types

Exp. No.	Sandy Ml	Clay Ml	Silt Ml	Total Soil	% Sandy	% Clay	% Silt	Soil Type
1	30	11	5	46	65	24	11	Sandy clay loam
2	43	4	11	58	74	7	19	Sandy loam
3	52	0	6	58	90	0	10	Sand
4	39	10	2	51	76	20	4	Sandy loam
5	48	8	2	58	83	14	3	Loamy sand
6	46	12	1	59	78	20	2	Sandy loam
7	29	23	6	58	50	40	10	Sandy clay
8	32	18	8	58	55	31	14	Sandy clay loam
9	51	13	0	64	80	20	0	Sandy loam

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10	48	18	3	69	70	26	4	Sandy clay loam
11	46	1	0	47	98	2	0	Sand
12	45	2	0	47	96	4	0	Sand
13	30	20	2	52	58	38	4	Sandy Clay loam
14	41	2	0	43	95	5	0	Sand
15	48	6	0	54	89	11	0	Loamy sand
16	42	0	14	56	75	0	25	Loamy sand
17	46	2	0	48	96	4	0	Sand
18	48	2	0	50	96	4	0	Sand
19	45	2	0	47	96	4	0	Sand
20	50	2	0	52	96	4	0	Sand
21	22	20	8	50	44	40	16	Sandy clay
22	40	16	20	76	53	21	26	Sandy loam
23	53	0	1	54	98	0	2	Sand
24	48	1	21	70	69	1	30	Sandy loam
25	47	2	9	58	81	3	16	Loamy sand
26	52	0	2	54	96	0	4	Sand
27	24	1	11	36	67	3	31	Sandy loam
28	32	4	3	39	83	10	8	Loamy sand
29	24	2	12	38	63	5	32	Sandy loam
30	20	1	9	30	67	3	30	Sandy loam
31	34	4	1	39	87	10	3	Loamy sand
32	17	1	8	26	65	4	31	Sandy loam
33	17	3	8	28	61	11	29	Sandy loam
34	18	2	12	32	56	6	38	Sandy loam
35	24	1	16	41	59	2	39	Sandy loam
36	19	1	9	29	66	3	31	Sandy loam
37	29	4	1	34	85	12	3	Loamy sand
38	31	6	1	38	82	16	3	Loamy sand
39	33	6	2	41	80	15	5	Loamy sand
40	31	1	7	39	79	3	18	Loamy sand

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41	28	1	10	39	72	3	26	Sandy loam
42	32	5	2	39	82	13	5	Loamy sand
43	34	5	2	41	83	12	5	Loamy sand
44	29	7	2	38	76	18	5	Sandy loam
45	31	9	2	42	74	21	5	Sandy loam
46	22	14	1	37	59	38	3	Sandy clay loam
47	14	3	4	21	67	14	19	Sandy loam
48	13	2	4	19	68	11	21	Sandy loam
49	16	1	2	19	84	5	11	Loamy sand
50	14	2	3	19	74	11	16	Sandy loam
Av.	34	6	5	45	76	12	12	Sandy loam

The results of soil moisture properties obtained are presented in table two (2) below;

Table 2: Results Of Soil Moisture Variables

Exp. No.	**Weight Of Empty Petri Dish (g)**	**Weight Of Wet Soil Sample (g)**	**Weight Of Dry Soil (g)**	**Moisture Loss (g)**
1	35	80.5	77.7	2.8
2	38.7	89.4	85.6	3.8
3	39.1	75.1	66.5	8.6
4	36.4	74.3	71.2	3.1
5	40.7	87.0	84.0	3.0
6	39.4	83.5	81.0	2.5
7	36.1	72.0	69.2	2.8
8	38.4	71.5	69.3	2.2
9	30.0	78.1	74.0	4.1
10	40.8	75.6	75.1	0.5
11	36.7	75.4	72.8	2.6
12	39.6	81.9	79.2	2.7
13	35.3	78.0	75.6	2.4
14	39.3	73.0	71.1	1.9
15	36.2	71.5	69.3	2.2
16	38.9	79.5	77.2	2.3

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17	38.2	86.7	83.8	2.9
18	40.9	93.6	90.1	3.5
19	36.9	88.2	83.6	4.6
20	36.9	81.2	76.8	4.4
21	39.6	72.8	66.4	6.4
22	35.4	72.3	69.2	3.1
23	39.2	69.2	66.3	2.9
24	38.8	69.7	67.1	2.6
25	36.7	74.3	71.2	3.1
26	38.0	70.7	68.2	2.5
27	38.0	82.2	79.2	3.0
28	39.0	92.7	87.4	5.3
29	36.7	78.0	75.6	2.4
30	40.7	74.9	70.8	4.1
31	36.6	82.7	79.0	3.7
32	35.0	68.9	65.1	3.8
33	38.7	81.8	77.7	4.1
34	36.0	78.3	71.2	7.1
35	40.7	94.0	85.9	8.1
36	36.0	74.3	71.5	2.8
37	39.0	87.7	81.5	6.2
38	36.7	85.3	78.9	6.4
39	38.0	68.0	63.8	4.2
40	38.6	85.5	78.3	7.2
41	36.6	80.0	74.0	6.0
42	38.7	85.5	79.1	6.4
43	35.0	90.0	86.3	3.7
44	38.0	93.8	77.6	16.2
45	36.6	84.4	79.2	5.2
46	36.0	78.9	75.3	3.6
47	36.6	75.2	69.9	5.3

48	36.7	81.5	76.2	5.3
49	38.0	74.9	68.5	6.4
50	39.1	68.5	61.6	6.9
Av.	37.6	79.4	75.1	4.3

Results of moisture content values are presented in table three (3) below;

Table 3: The Results Of Moisture Content In Wet Basis, Dry Basis, And Variation

Exp. No.	**Moisture Content (%)**		
	Wet Basis	**Dry Basis**	**Basis Variation**
1	3.4783	3.6036	0.1253
2	4.2506	4.4393	0.1887
3	11.4514	12.9323	1.4809
4	4.1723	4.3539	0.1816
5	3.4483	3.5714	0.1231
6	2.9940	3.0864	0.0924
7	3.8889	4.0462	0.1573
8	3.0769	3.1746	0.0977
9	5.2497	5.5405	0.2908
10	0.6614	0.6658	0.0044
11	3.4483	3.5714	0.1231
12	3.2967	3.4091	0.1124
13	3.0769	3.1746	0.0977
14	2.6027	2.6723	0.0696
15	3.0769	3.1746	0.0977
16	2.8931	2.9793	0.0862
17	3.3449	3.4606	0.1157
18	3.7393	3.8846	0.1453
19	5.2154	5.5024	0.2870
20	5.4187	5.7292	0.3105
21	8.7912	9.6386	0.8474
22	4.2877	4.4798	0.1921
23	4.1908	4.3741	0.1833

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24	3.7303	3.8748	0.1445
25	4.1723	4.3539	0.1816
26	3.5361	3.6657	0.1296
27	3.6496	3.7879	0.1383
28	5.7174	6.0641	0.3467
29	3.0769	3.1746	0.0977
30	5.4740	5.7910	0.3170
31	4.4740	4.6835	0.2095
32	5.5152	5.8372	0.3220
33	5.0122	5.2767	0.2645
34	9.0677	9.9719	0.9042
35	8.6170	9.4296	0.8126
36	3.7685	3.9161	0.1476
37	7.0696	7.6074	0.5378
38	7.5029	8.1115	0.6086
39	6.1765	6.5831	0.4066
40	8.4211	9.1954	0.7743
41	7.5000	8.1081	0.6081
42	7.4854	8.0910	0.6056
43	4.1111	4.2874	0.1763
44	17.2708	20.8763	3.6055
45	6.1611	6.5657	0.4046
46	4.5627	4.7809	0.2182
47	7.0479	7.5823	0.5344
48	6.5031	6.9554	0.4523
49	8.5447	9.3431	0.7984
50	10.0730	11.2013	1.1283
Av.	5.4059	5.8116	0.4057

The wet basis moisture content is presented in figure four (4) below;

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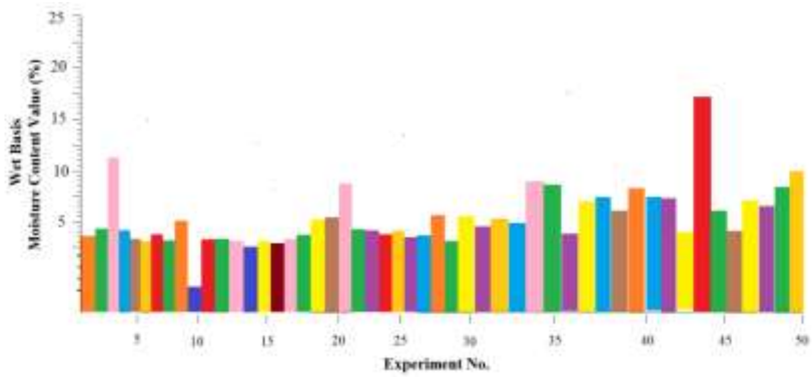

Figure 4: Wet Basis Moisture Content

The dry basis moisture content is presented in figure five (5) below;

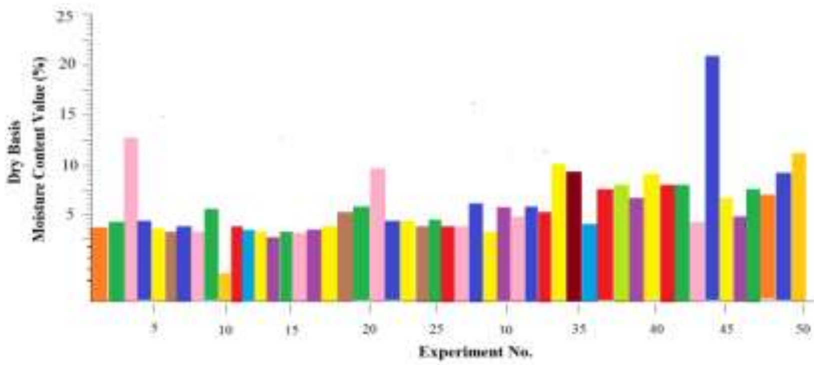

Figure 5: Dry Basis Moisture Content

The variation in basis is presented in figure six (6) below;

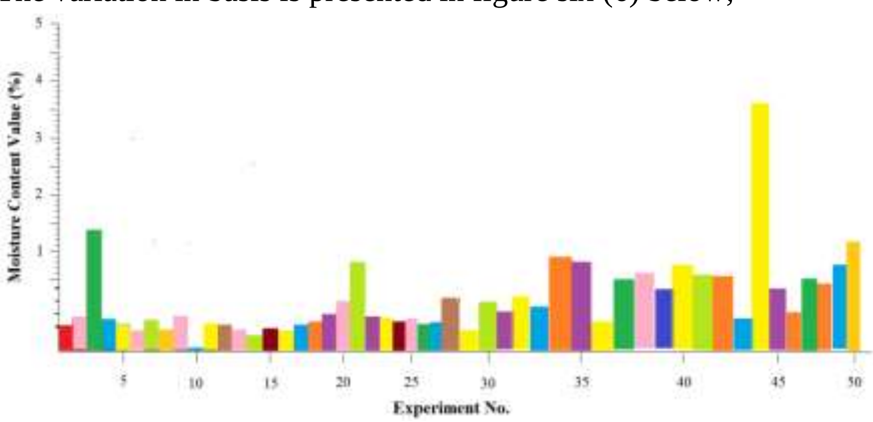

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Figure 6: Moisture Variation In Basis For All Experiments

The moisture loss for all experiments is presented in figure seven (7) below;

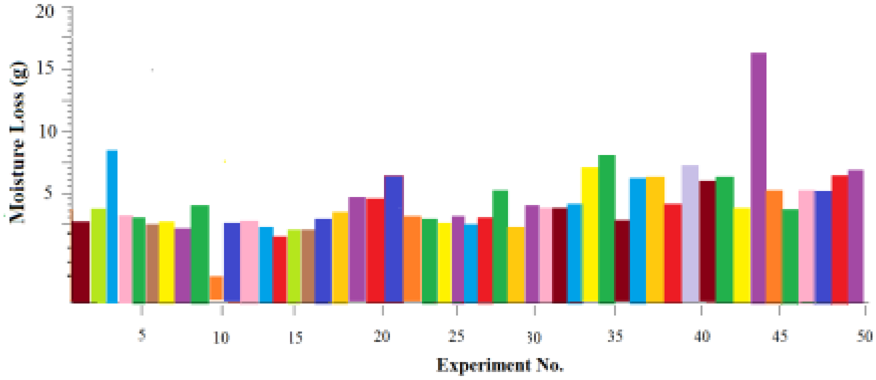

Figure 7: Moisture Loss For All Experiments

5. DISCUSSIONS

From results obtained, the area has a sandy loam soil. This is dominatively present with loamy sand. This was obtained from most occurring soil type from the products of laboratory analysis and their values in the textural triangle which is equipped with all possible combinations of soil separation results. This triangle makes it flexible for all types of soil separation experiments.

Also, sandy loam soil is regarded as the magic soil, with the sand comprising the largest amount, followed by silt, and a smaller part of clay. Sand particles are generally more solid and larger than other soil particle types, thereby possessing the capacity of allowing water to move through them more easily. Silt and clay on the other hand are good in water retaintion. Sandy loam soils possess well-balanced capacity for water holding, form a stable structure, as well provide sufficient aeration. [16] noted that these properties also affect suitability of soil for different uses, such as stormwater infiltration.

From results obtained, the moisture content were however within the range of 0 – 20 %. This is relatively characterizable to a low moisture content class. This is attributed to low water concentration in the soil pores of the area. Moreso, the results points to the soil properties at the uppermost layer of the soil. However, [15] reported that soil moisture controls the propagation of floods by delaying or accelerating the accumulation of rainwater in the runoff cycle. Soil moisture characterization over a spatial domains is a key determininant of the movement of water within the land-atmosphere continuum. In figures four (4) and five (5) above, There exist a great correlationship between the two properties of moisture presence in the soil. This can be seen from their curve patterns. These two curves also influenced the curve pattern of moisture loss in figure seven (7). [11] reported that "the texture and historical nature of soils affects how they respond to moisture extremes like floods

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and droughts". Thus, both properties posses the ability of influencing the flood behavior of the area. However with the nature of soil in the area, their influence were minimal.

From general results obtained, the soil properties does not posses significantly varying features capable of influencing the area flooding.

Finally, in addition to other significant influencable variables, installation of appropriate surface and subsurface drains is a perceived recommendable solution to this flooding incidence. Soil or land reclamation strategies for swampy regions have proven useful in various location and thus may also be deployed in required locations of the area. Moreso, this work provides the simplicity in laboratory and experimental approach of soil analysis, which may be beneficial within and farest of the study area.

6. CONCLUSION

From results obtained and discussion made, it was therefore concluded that; the soil properties of the study area was sandy loam. The area has low moisture content of 0 – 20%. At average, the soil has moisture loss of 4.3g, and moisture content of 5.4059 % on wet basis, 5.8116 % on dry basis and 0.4057 % variation. The variations in the basis were between 0 – 4 % difference.

Also, based on obtained results stated and discussed above, the soil properties possess normal features attributed to sandy loam soil with regards to water movement. Thus, it was concluded that, the soil type and moisture features contributed little or no negative impact on the area flooding. Generally, sandy loam has moderate impact on flooding, due to its attributed good drainage and reduction in waterlogging risk. Though its high infiltration rate features contribute to groundwater recharge of the area during flood events.

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