EFFECT OF SLOPE GRADIENT ON SOIL PROPERTIES AND ORGANIC MATTER QUALITY IN AGGREGATE SIZE FRACTION ON COASTAL PLAIN SAND SOILS SOUTHEASTERN NIGERIA.

ABSTRACT:
Slope gradient by approaches which described organic matter dynamic and aggregate size distribution are important in guiding management practices of the soils of coastal plain sand. Study was conducted to evaluate effect of slope gradient on soil physical properties and organic matter quality in aggregates size fraction on coastal plain sand southern eastern Nigeria. Five soil samples were collected at 20m interval from each of the twelve selected slope, based on gradient (<10%, 11-20%and >20%) A total of Sixty samples were collected and analyses in the laboratory for physical and chemical properties. Each of the Sixty soil sample were separated with the used of dry sieving methods, into four aggregate Size fractions: 4.0-2.0, -2.0 -0.25, 0.25-0.05 and <0.05mm. The separation of the 60 soil samples gave a total of 240 aggregate. Size fractions. The date generated were analyzed in terms of slope gradient, as well as nitrogenous and non-nitrogenous organic compound in aggregate Seize fractions. The result indicated that slope gradient affect nitrogen and non-nitrogenous organic compound. Humin substance with aggregate size fraction of <0.05mm of <10% slope had high mean value of 0.68%. <10% and 11-20% slope high mean variability, while >20% slope had moderate variability in humin substance with aggregate size fraction of 4.0-2.0mm with <10% slope. Humic substance of 2.0-0.25mm showed that <10% slope had low mean value, while 11-20% had high mean value of 0.31 and 0.39%, respectively. Effect of slope gradient on carbohydrate content with aggregate size fraction of 2.0-0.25mm, indicated that 11-20% slope had high of 0.96%, while >20% slope had low mean value of 0.86%. Carbohydrate substance had high mean percentage among all organic substances even with high values, they are rapid disintegrated, while humin, humic and fulvic acid have long term effect in soil aggregate stabilization.

Keywords: Soil properties, slope gradient, organic matter quality, aggregate size distribution, organic compound, coastal plan sand.

INTRODUCTION

Lal (1985) defined slope length as the distance from the point of origin of over land flow to the point where either the slope gradient decreases enough that deposition begins or the runoff water enters a well defined channel that may be part of a drainage network or constructed channel.
The topographical factors that affect water erosion are the degree of slope length of slope, and the velocity of flow increase in proportion to square root of the slope length (Boiling *et al.*, 2008) The slopes of the land also determine its erosion potential. The slope parameters that are important, in this regard, are the length, gradient (for steepness) (Udosen, 2008). further explained that the steeper the slope, the more erodible it is, this is caused by the increased runoff velocity and increased particle detachment as a result of increase tangential force (sharing) of the raindrops.

Slope gradient is one of the important slope factors that influence the process of drainage runoff and soil erosion thereby affect physiochemical properties (Farmanullah, 2013). Soil less would normally be expected to increase with increase in slope gradient, because of the respective increase in velocity of surface runoff and decrease in infiltration rate, (Amuyou and Kotingo, 2015), while Changere and Lal (1997) found variations of some soil properties that could be related to the slope gradient. The measure of the ability of soil particles to bind together and resist destabilization by various external pressure brought about by water and wind erosion, shrinking and swelling processes and tillage depends on the materials that bind soil aggregate together. Soil aggregates are consequently stabilized naturally by the accumulation of organic matters produced by microorganisms such as fungi, whose hyphae holds soils particles together and generates a glycoprotein (glomalin) cementing agent that helps bound primary soil particles (Basumhardt and Schwartz, 2004).

Shengyan and shibin Liu (2023) described soil aggregate as stable structures composed of tiny mineral particles, used as indicators of the physiochemical properties and nutrients of the soil. The author further explained that aggregate of different particles sizes features different enzyme activity, and that smaller aggregates have higher enzymes activity than larger ones.

Shengyan and shibin Liu (2023) proposed that the urease activity in black soil and brown soil was mainly concentrated on micro-aggregates, as equivalent to clay part of soil grain size, and that the larger the particle size, possibly the lower the urease activity and added that carbohydrate is chiefly absorbed powered sand particles also absorb the amount of enzymes absorbed by the clay particles and sand particles depends on the mineral composition of such soil particles. Clay particles form compound colloid together with the soil humus, also are binding agents in soil aggregation and key factor of soil resistivity to mechanical stress (Essien *et al.*, 2023). Organic matter components influences the stability of soil, these include living and death plants and animals, micro and macro organisms and products of decaying processes that have been going on over (Agbede, 2009. Okon *et al.*, 2021; Umoh *et al.*, 2021a). The latter consists of plant biopolymer residues materials such as polysaccharides, lignin, protein, fat and oil (Stevenson, 1994). Organic substances range from decomposed remains of plants and animals through their intermediate stages called humus. Humus is differentiated into humic and non-humic substances. Non-humic substances are polysaccharides; polymer that have sugar-like structures, while humic substances are classified into three chemical groups, namely fulvic, humic acid and humin substances on the basis of solubility (Donahue *et al*., 1990; Umoh *et a*l., 2021 b).

Humic substances are relatively stable in soils, because of their complexity, they are the organic materials most resistant to microbial attack (decomposes slowly) and are measured in centuries (10-50) years. Humic fractions maintain soil organic matter levels and protect associated nitrogen and other essential nutrients against rapid mineralization and loss from the soil. Non-humic (Polysaccharides) range in complexity from simple sugars and starches to cellulose and are usually the most plentiful of plant organic compounds and are easily decomposed organic component and transient in nature (Brady and weil, 2008). Clap *et al.* (2005); Essien and Umoh (2020) stated the humic and non-himic substances are important in ensuring stability of soil aggregate. Humic substances helps to form good soil structures, provides good aeration and act as binding agent in soil aggregation processes (Six *et a*l., 2000; Essien *et al*., 2022).

Furthermore, humic substances enhances protection of both anions and cation against leading and account for 50-90% of the water and nutrient absorbing power of soils (Six *et al*., 2024; Simeon *et al*., 2023). Soil organic matter is an indicator of soil quality (Lal, 1997). It strongly affects soil properties such as infiltration, erodibility and water-holding capacity, nutrient cycling and pesticide absorption (wander and yang, 2000). Ogban *et al*. (2022) pointed out that the amount of soil erosion depends on a large extent on the resistance of soil aggregates to the disruptive energy of rain drop impact, which begins with breakdown of soil, aggregate (Organic-mineral complexes)

Soil erosion constitutes a serious environmental degradation problem that threatens food security and human well-being on the coastal plain sands area in general. However little or no attempt has been made to evaluate effect of organic matter quality and physical properties of soils on aggregate stability in coastal plain sand soils. Understanding organic matter dynamics by approaches which described aggregate stability, in terms of organic matter fractions are necessary in developing a frame work that would guide the management practices of the soils in coastal plain sand parent material in Akwa Ibom State

MATERIALS AND METHODS

Study Location:

The study location situated in coastal plain sands of Akwa Ibom State. Coastal plain sands is located between Latitude 4^0 40^1 and 5^0 15^1 N, and longitude 7^0 30^1 and 8^0 15^1 E (Essien and Ogban, 2018), while Akwa Ibom State is Located in latitude 4^0 50^1 and 5^0 50^1 N, longitude 7^0 30^0 and 8^0 30^1 E. The State is small in size covering a total land mass of 8412km (petters *et al*., 1989). The climate of the area is the hot humid tropic characterized by wet and dry season occurs between the months of November to March. Rainfall varies from 3000mm along the coast to about 2000mm on the northern fringes. Temperatures are unitarily high averaging 28^0 c. Relative humidity ranged 95% (petters *et al*., 1989), while evapotranspiration ranges 4.11 to 4.95mm, partly because of high insolation and temperature (Enwezor *et a*l., 1990).

The geological formation of Akwa Ibom State is made up of the quaternary sediments. The tertiary coastal plain sand consist of beds of unconsolidated coarse-textural sand stones inter bedded with layers of firies - grained massive clay of the Benin formation (Udo, 2001). The soils are characterized by low organic matter content, poor structural stability and highly susceptible to accelerated erosion (Ogban *et al*., 2002). The vegetation of the study area has been replaced by secondary forest. The landscape comprises of cultivated, fallow lands and secondary forest. The soil texture are loamy-sand to sand materials, fragile and acidic in nature, and are susceptible to erosion (Essien et al., 2019).

Field Methods

The study was conducted in coastal plain sand parent material in Akwa Ibom State Nigeria. Five soil samples were collected at 20m interval in twelve selected slope positions, based on slope gradient (<10%, 11-20 and > 20%). A total number of sixty soil samples were collected and analyzed in the laboratory for physical and chemical properties. Another sixty set of soil samples were collected with spade for the determination of aggregate – size distribution, while the core samples were collected with metal cylinders measuring 7.5cm long and 6.8cm wide for determination of bulk density, hydraulic conductivity and total porosity was calculated

LABORATORY METHODS

Soil samples were air-dried and sieved through a 4mm sieve for determination of aggregate size distribution, and further sieved through a 2mm sieve for particle size, chemical analysis and humic and non-humic fractionation.

Physical Analysis

Particle size distribution was done with a dispersing agent (Na hexametaphosphate and Na Carbonate solution), Using the Bouyoucous Hydrometer method (Gee and Or, 2002). Hydraulic conductivity was determined using the constant head permeameter method as described by Klute (1986) and calculated using the equation:-

$$Ksat = \frac{QL}{\Delta h\ At} \quad \text{……………………………………… eqn 1}$$

where:

Q = discharge rate ($cm^3\ min^{-1}$), L = length of soil column (cm), Δh At = Change in hydraulic head (cm), (L+h (L=Length of soil containing cylinder, h = height of water above soil containing cylinder), A= Cross sectional area of cylinder (cm^2), t = time (hour).

Bulk density was determined by the method described by klute (1986). Soil samples were oven dried at 105^0 c to a constant weight and bulk density calculated using the equation:-

$$\rho b = \frac{Ms}{Vt} \quad \text{……………………………………………………eqn 2}$$

Where Ȼb = Bd (Mgm^{-3}) , Ms = Mass of oven dry soil (Mg), Vt = total volume of soil (m^3 m-^{3})

The total volume of the soil was calculated from the internal dimension of the cylinder

Total porosity was calculated from the particle bulk density relationship as follows:-

$$f = \left[I - \left(\frac{\text{Ȼb}}{\text{Ȼs}} \right) \text{x } 100 \right] \quad \text{……………………………………………eqn 3}$$

Where f = Tp (m^3 m^{-3}), Ȼb= Bulk density (Mgm^{-3}), Ȼs = Particle density (Mgm^{-3})

Chemical Analysis

Soil pH was determined in KCL Using a 1: 2.5 soil to water suspension and the pH was read with a glass electrode pH meter. Total organic carbon was measured by the dichromate wet oxidation method of Walkley and Black (Udo *et al*, 2009), Exchangeable bases: Ca, Mg, Na and K, where extracted, also Crystalline and amorphous oxide of iron and aluminum were determined as described by Udo *et al*. (2009).

Fractionation of Non-Humic substances (Soil Carbohydrate) content in each aggregate fractions was analyzed by the anthrone method (Brink *et al*., 1960). The anthrone – reactive carbohydrates (WSC). Humic acid fractionation was extracted from each aggregates size fraction using the procedure recommended by the International Humic Substances Society (Swife, 1996). A diluted solution (50 to 100 ppm) in aqueous media (such as Na pyrophosphate pH-7), and the alkaline supernatant was acidified to pH-2 with 6m HCL to obtain the Humic Acid Fraction and was Passed onto an XAD- 8 resin – soil Humic acids was separated form the fulvic acids on the basis of their different solubilities at pH 1.

Aggregate separation was determined by physical separation through the dry Sieving Methods (Nimmo and perkins , 2002), Aggregate size was separated into a nest of sieve in four sieve sizes (4.0- 2.0, 2.0-025-0.05 and <0.05mm),which represent the lager macro aggregate, small macro, micro aggregate and mineral fraction.

Statistical Analysis

The data were summarized using descriptive, statistics (mean, standard deviation and coefficient of variation). Correlation analysis was used to determined the relationship between nitrogenous and non-nitrogenous organic compound indices of soil aggregate Stability.

RESULTS

Effect of slope gradient on soil physical properties

The results of slope gradient effect on soil physical properties are presented in Table 1. Data for slope gradient revealed that coarse sand content of <10% slope had 752± 58.72 gkg^{-1} CV = 7.8%, that of 11-20% was 729 ± 90.10gkg^{-1}, a1= 12.4%, while that of >20% slope was 771± 65. 77 gkg^{-1}, CV = 8.5%. Fine sand content of <10% slope had 96±29.60 gkg^{-1}, **CV**= 27.20%, while >20% slope recorded 107± 25.88 gkg^{-1}, CV= 24.2%. The result of the total sand content in <10% was 850± 49.67 gkg^{-1}, CV=5.9%, that of 11-20% slope was 834± 79.70 gkg^{-1}, CV= 9.6%, while that of > 20% slope was 870± 68.77gkg^{-1}, CV =7.9%.

The result of silt content indicated that in gradient of < 10% slope had 50.20± 24.23 gkg^{-1}, CV =48.3%, that of 11-20% slope was 49± 30.24 gkg^{-1}, CV=62.0%, while that of 20% slope was 40± 23.34 gkg^{-1},CV=58.1%.The effect of slope gradient on clay content showed that <10% slope recorded 100± 32.47gkg^{-1}, CV=32.5%, that of 11-20% slope had 117±54.35gkg^{-1},CV=46.4%, while that of >20% slope had 80±43.10 gkg^{-1},CV=54.1%. Bulk density result revealed that <10% slope recorded 1.45± 0.15 Mgm^{-3},CV= 10.7% that of 11-20% that 1.57±0.18mgm^{-3}, CV=11.6%, while that of >20% slope was 1.52±0.10mgm^{-3}, CV= 6.3%. Total porosity result of slope gradient indicated that <10% slope had high mean value of 0.45±0.06m^3m^3,CV=12.9%, that 11-20% slope Had how mean of 0.41± 0.07m^3m^3, CV=16.9%, while that 20% slope was 0.43 ±0.04 m^3 m^{-3}, CV=8.5%.

Hydraulic conductively result indicated slope gradient of <10% had mean value of 5.3± 0.14 $cmhr^{-1}$, CV=76.2%, that of 11-20% slope was 4.5± 0.57 $cmhr^{-1}$ CV=128.7%, while that of 20% slope was 2.84± 0.12 $cmhr^{-1}$, CV=44.2%.

Table 1: Effect of slope gradient on soil physical properties

Sampling location	Cs	Fs	Ts	Si	Cl	Bd	Tp	Ksat
	←		$g\ kg^{-1}$	→		Mgm^{-3}	$M^3\ m^{-3}$	$cmhr^{-1}$
				< 10% slope				
Mean	725	96	848	50	102	1.45	0.45	0.53
Std(±)	58.72	29.60	49.67	24.23	32.47	0.15	0.06	0.41
CV(%)	7.8	30.8	5.9	48.3	32.5	10.7	12.9	76.2
				11-20% slope				
Mean	729	104	833	49	118	1.57	0.41	0.45
Std(±)	90.10	28.23	79.70	30.24	54.35	0.18	0.07	0.57
CV(%)	12.4	27.2	9.6	62.	46.4	11.6	16.9	128.7
				>20%slope				

Mean	771	107	878	40	82	1.52	0.43	0.28
Scl(+)	65:77	25.88	68.77	23.34	43.10	0.10	0.04	0.12
CV(%)	8.5	24.2	7.9	58.1	54.1	6.3	8.5	44.2
LSD	31.42	12.84	34.56	13.46	21.37	0.07	0.03	0.24
F. prob.	0.04	0.24	0.12	0.28	0.00	0.00	0.00	0.10

Cs- course sand, Fs-fine sand, Ts=total sand Si-Silt, Cl-clay, Bd-Bulk density porosity, ksat-saturated hydraulic conductively

The result shows that slope gradient was significantly affected coarse sand ($p<0.05$). Coarse sand content of > 20%slope was the same with that of < 10%, but significantly higher than that of 11-20% slope (Table1). Slope gradient ($p<0.05$) significantly affected clay content. Clay content for <10% slope was the same with 11-20% and >20% slope were same, significantly greater than <10% slope (Table1). Total porosity 7 was significantly affected by slope gradient ($p<0.05$) slope <10% had significantly mean total porosity of 0.45 $m^3\ m^{-3}$ for >20%slope, but higher than 0.41m^3m^{-3} of 11-20% slope.

Effect of slope Gradient on Selected Chemical properties

The results of effect of slope gradient on soil chemical properties are presented in Table 2. Effect of slope gradient on soil pH (KCL) showed that <10% slope had high mean value of 6.33+0.25,CV=3.9%, that of medium steep (11-20%) slope had 6.26+ 0.41, CV=6.6%, while that of steep slope (>20%) recorded low mean value of 2.89+ 0.33, CV=5.7%.slope gradient affect organic matter with high mean value of 1.89+ 0.86%,CV45.7% been recorded with (11-20%),<10%had mean of 1.84+ 1.10%, CV=54.8%,while steep (>20%) recorded the lowest mean value of 1.76+ 0.95%, CV=54.1%.

The result of gradient affect Ca content revealed that slop of <10%recoverd low mean value of 4.90+ 0.70cmolkg^{-1}that of >11-20% recorded high mean value of 4.92 + 0.85cmolkg^{-1-} while that of >20% recovered 4.91 + 1.34 cmolkg $^{-1}$,Cv=27.2%. The result of mg showed that <10%slope had mean value of 1.71+0.23 cmol kg^{-1}, cv= 13.5%, 11-20% recorded high mean value of 1.73 + 0.38 Cmol kg $^{-1}$ cv = 22.2%, while that of > 20% slope recorded 1.51 + 0.31 cmol kg^{-1} CV = 20.4%

Table2: Effect of slope gradient on soil Some chemical properties

Sampling Location	pH (kcl)	OM	Ca	Mg	Na	K	TEB	ECEC	Bsant	Am. Fe	Cry Fe	Am. Al	Cry Al
		←			Cmolkgg-	→				←	mgkg-1	→	
					<10 % Slope								
Mean	6.33	1.84	4.90	1.71	0.05	0.14	385.06	537.95	223.65	36			
Std (+)	0.25	1.01	0.70	0.23	0.01	0.02	82.56	156.76	82.32	104.19			
Cv(%)	3.9	54.8	14.2	13.5	17.3	17.9	21.4	28.4	36.8	28.			
					11-10% Slope								
Mean	6.26	1.82	4.92	1.73	0.05	0.12	394.51	607.11	238.75	413.65			
Std (+)	0.41	0.86	0.05	0.38	0.01	0.01	104.73	118.59	63.83	79.46			
Cv(%)	6.6	45.7	17.3	22.2	14.0	7.9	26.6	19.5	26.7	19.2			
					>20% Slope								
Mean	5.89	1.76	4.91	1.51	0.07	0.14	355.65	562.77	201%	383.38			
Std (+)	0.33	0.95	1.34	0.31	0.03	0.03	67.37	131.57	70.90	148.33			
Cv(%)	5.7	54.1	27.2	20.4	39.7	23.9	18.9	23.4	35.1	38.7			
LSD	0.12	0.55	0.55	0.19	0.01	0.01	43.56	54.80	35.13	64.60			
F.prob <.	001	0.90	1.00	0.05	<.001	0.90	1.00	0.05	0.12	0.28			

Om- organic matter, Ca-calcium, mg – magnesium, Na-sodium,

K - Potassium, TEB – Total exchangeable basas, ECEC- Effective cation exchange capacity, Bsat – Base Saturation, Am Fe – Amorphous of iron, cry Fe.- crystalline of iron, Am. Al – Amorphous of Aluminum, cry Al – crystalline of Aluminum

Slope gradient effect on Na content showed that <10% and 11-20% slope recorded same mean value of 0.05 + 0.01 cmolkg-1, CV=17.3% and 0.05 + 0.01 cmolkg^{-1} CV = 14.0%, 11-20%, respectively. Slope had low variation, while that of > 20% had mean value of 0.07 + 0.03 Cmolkg-1 cv = 39.7% with high variation. Potassium was affected by slope gradient, the result obtained indicate that <10% and 20% slope recorded same mean value of 0.14 + 0.02 cmol Kg^{-1} cv =17.9% and 0.14 + 0.03 cmol kg-1, CV = 23.9%, while 11-20% slope recorded low mean value of 0.12 ± 0.01, slope had moderate variation, while 11-20% slope had low variation. The results of amorphous of Fe mobile veiled that <10% had mean value of 385.1± 82.56 mgkg^{-1},cv=21.4% that of 11=20%, had high mean of 394.5± 104.73 mgkg-^{1},Cv= 26.6%, while that of >20% had low mean of 355.7± 67.37mgkg^{-1},CV=18.9%. The result of Cry Fe (immobile Fe) indicated that Cry Fe were higher compared to values of Am. Fe. Crystalline Fe content of <10% slope had low mean of 538.0± 152.76mgkg^{-1}, CV=28.4%, that of 11-20% had high mean of 607.1± 118.59mgkg^{-1}, CV=19.5%, while that of >20% had 56.28± 131.57mgkg^{-1},CV=23.4%

Effect of slope gradient on Am. Al showed that<10% had mean value of 223.7 ± 82.32 mgkg^{-1},CV=36.8%, 11-20% slope had high mean of 238.8± 63. 83mgkg^{-1}, CV=26.7%, while that of <20%recored 202.0± 70.90 mgkg-1, CV = 35.1%, 11-20% slope moderate variation, while <10% and >20% slopes had high variation. Cry Al. (immobile Al) result indicated that <10% slope had low mean of 362.1 ± 104. 19 Mgkg^{-1}, CV = 19.20%, while that of >20% slope had 383.4 ± 148.33 Mgkg- CV 28.7%, that of 11-20% had high mean of 413.7 ± 79.5 Mgkg-1, CV = 19.205, while that of > 20 % slope had 383.4 ± 148.33 Mgkg- CV= 38.7%

Effect of slope gradient on nitrogenous and non nitrogenous organic compound on aggregate size fractions

Effect of slope gradient on nitrogenous and non nitrogenous organic compound result shown in Table 3, indicated that, humic substance with aggregate size fraction < 0.05mm of <10% slope had 0.68 ± 0.29%, Cv = 43.5% that of 11-20 slope had high variation, while 11-20% slope had moderate variability. Slope gradient effect on humin substances with aggregate size fraction of 2.0-0.25mm result revealed that, <10% slope had low mean value of 0.48 ± 0.24%, cv = 50.0%, that of 11-20% slope had high mean value of 0.56 ± 0.29%, Cv=51.0%, while that of >20% slope had 0.49 ± 0.15% Cv = 31.4%. Slope gradient <10% and 11-20% slope had high variation while > 20% slope had moderate variation.

Humic substance with aggregate size fraction of 4.0-2.0mmwas affected by slope gradient with <10% slope recorded mean value of CV = 36.1%, that of 11-20% slope had high mean value of 0.53 ± 0.25%, CV=47.4%, while that of >20%slope recorded low mean value of 0.41± 0.08%, CV=20.5%. slope Gradient with < 10%and 11-20% slope had high had moderate variation.

Effect of slope gradient on humic substances with aggregate size friction <0.05mm showed that <10%slope had lowest mean value of 0.34± 0.14%,CV=39.6%, that of 11=20% slope had mean value of 0.38%± 0.18%,CV=48.4%, while that of >20%slope had high mean value of 0.41± 0.15, CV=36.8%.All the slopes in humic substances <0.05mm had high variability. Effect of slope gradient on humic substances with aggregate size friction of 0.25 -0.05 mm < 10% slope had mean value of 0.34± 0.14%, CV=41.0% that of 11-20% slope had high mean value of 0.35± 0.13%, Cv=37.1%, while that of >20% slope had low mean value of 0.32± 0.10%, CV=31.2%. slope gradient <10%slope had high variation, while 11-20%and >20%slope had low Variation . HUN of 0.46 ± 0.17%-

Table 3: Effect of Slope gradient on nitrogenous and 7. Nitrogenous organic compound in aggregate size fractions

Sampling	0.05	0.05	0.25	2.0	0.05	0.05	0.25	2.0	0.05	0.05	0.25	2.0	0.05	0.05	0.25	2.0
location	←					mm										→
		HUM				HUC				FUN				CHO		
						10% slope										
Mean	0.68	0.53	0.48	0.46	0.34	0.34	0.31	0.32	0.26	0.15	0.17	0.13	0.92	0.90	0.92	0.94
Scl (+)	0.29	0.19	0.24	0.17	0.14	0.14	0.13	0.11	0.16	0.06	0.10	0.09	0.33	0.26	0.34	0.36
Cv(%)	43.5	34.8	50.0	36.1	39.6	41.0	41.5	34.1	61.1	41.2	60.8	67.4	36.4	29.1	37.3	57.9
						11-20% slope										
Mean	0.60	0.58	0.56	0.53	0.38					0.14	0.18	0.18	1.14	0.83	0.96	0.88
Scl (+)	0.21	0.27	0.29	0.25	0.18	0.13	0.4	0.13	0.12	0.06	0.11	0.08	0.41	0.30	0.30	0.19
Cv(%)	34.5	47.0	51.0	47.4	48.4	37.1	36.0	36.9	62.1	40.2	58.8	44.8	36.1	36.5	31.5	21.6
						>20 slope										
Mean	0.64	0.48	0.49	0.41	0.41	0.32	0.38	0.33	0.26	0.17	0.19	0.21	1.02	0.85	0.86	0.88
Sd(+)	0.35	0.21	0.15	0.08	0.15	0.10	0.15	0.09	0.13	0.07	0.09	0.09	0.36	0.29	0.24	0.33
Cv(%)	54.6	25.1	31.4	20.5	36.8	31.2	38.4	27.7	49.4	38.5	48.3	43.2	34.9	33.7	27.3	37.6
LSD	0.17	0.12	0.13	0.11	0.11	0.07	0.07	0.07	0.08	0.04	0.06	0.06	0.26	0.18	0.20	0.19
F. prob.	0.68	0.22	0.40	0.12	0.40	0.68	0.08	0.67	0.25	0.32	0.79	0.03	0.23	0.71	0.58	0.78

Humin, HUC- humic, FUN –Fulvic, CHO-carbohydrate

Effect of slope gradient of humic substance with aggregate size fraction of 2.0-0.25mm result showed that <10%slope had low mean value of 0.31± 0.13%,CV=41.5%, that of 11-20% had high mean value of 0.39± 0.14%,CV=36.0%, while that of >20% slope recorded 0.38± 0.15% slope had low mean value of 0.32 ± 0.115 CV = 34.1% CV=38.4%. Humic substance with aggregate size fraction of 2.0 – 0.25mm had high variation among the slopes. Slope gradient affected humic substance with aggregate size fraction of 4.0-2.0mm shows that <10%, that of 11-20%slope recorded high mean value of 0.35± 0.13%,CV=36.9%, while that of >20%slope had 0.33± 0.09%, CV= 27.7%. slope gradient 11-20% had high variability, while <10% and >20% slope had moderate variability.

Effect of slope gradient on fulivic acid with aggregate size fraction of <0.05mm, indicated that slope gradient with <10% had mean value of 0.26± 0.16%,cv=61.1%, that of 11-20% had low mean value of 0.20 ± 0.125, CV = 62.0%, while that of > 20% recorded 0.26 ± 0.135, CV = 49.4%. ,10% and > 20% slope had same high mean value. There was high variation among the slopes. Effect of slope gradient on fulvic acid with aggregate size friction of 0.25 -0.05mm, indicated that slope gradient with <10% had mean value of 0.26 ± 0.16%, Cv 61.1% that of 11-20% had low mean value of 0.20 ± 0.12% cv = 62.0%, while that of >20% recorded 0.26 ± 0.13%, cv 49 .4%. <10% and >20% slope had same high mean value. There was high variation among the slopes. Effect of slope gradient on fulvic acid with aggregate size fraction of 0.25-0.05mm, indicated that <10% slope, had 0.15 ± o.o6%, Cv = 41.2%, that of 20% slope recorded low mean value of 0.14 ± 0.06%, Cv = 40.2%, while that of >20% recorded high mean value of 0.17 ± 0.07%, cv=38.5%. Fulvic acid with aggregate size fraction of 2.0-0.25mm revealed that <10% slope had 0.17 +_0.10%, CV = 60.8%, that of 11-20% slope was 0.18 ± 0.11%, CV = 58.8%, while > 20.0 had mean value of 0.19 ± 0.09% CV – 48.3% . Fulvic acid with aggregate size fraction of 4.0-2.0mm, indicated that aggregate size fraction of 4.0 - 2.00mm indicated that <10% slope recorded low mean value of 1.13 ± 0.09% cv = 67.50%, that of 11-20% slope had 0.18 ± 0.08% cv= 44.8%, while that of .20% slope recorded 0.21 ± 0.09%, cv = 43.2%.

Effect of slope gradient on carbohydrate content with aggregate size fraction of <0.05mm (Table 3). The result showed that the slope gradient with <10% recorded low mean value of 0.92 ± 0.33%, cv = 36.4%, that of 11-20% slope had high mean value of 1.14 ± 0.41%, cv=36.1%, while >20% slope recorded mean value of 1.02 ± 0.36%, cv = 34.9%. >10% and 11-20% slope had high variation. Carbohydrate content of aggregate size fraction 0.25 – 0. 0.05mm with <105 slope recorded high mean value of 0.90 ± 0.26%, cv = 29.1%, that of 11-20% slope had 0.83 ± 0.30%, cv = 36.5%, while that of 11-20% slope had 0.85± 0.29%, cv = 33.7%. slope gradient <10% and >20% slope had moderate variability, while that of 11 – 20% slope had high variability.

Effect of slope gradient on carbohydrate content with aggregate size fraction of 2.0 – 0.25mm showed that <10% slope recorded mean value of 0.92 ± 0.34%, CV = 37.35, that of 11-20% had high mean value of 0.96 ± 0.30%, cv = 31.5%, while that of >20 slope had 0.86 ± 0.24%, cv = 27.3%. <10% slope had high variation, while 11- 20% and >20% had moderate variability. Effect of slope gradient on carbohydrate content with aggregate size fraction of 4.0-2.0mm resultindicated that <10% slope had high mean value of 0.94 ± 0.36%, cv =37.9%, that of 11-20% slope was 0.88 ± 0.19%, cv = 21.6%, while that of >20% slope had 0.88 ± 0.33%, CV=37.6%. There was a high variability with <10% and >20% slope, while 11-20% slope had moderate variability.

DISCUSSION

The result of effect of slope gradient on soil physical properties shows that the lowest coarse sand content was recorded in medium steep slope. While the highest mean was recorded with steep slope. Coarse sand had low variability. Coarse sand increased with increase in slope. This could be addressed to high intensity of erosion and soil loss occurring on the steeper slope. Fine sand had moderate variability and decreases with decrease in slope in slope gradient and increases with increase in slope gradient. Similarly to mohammed *et al.* (2005) reported the fine soil material are deposited at the steeper slope. Total sand result revealed that the higher the slope gradient, the higher the total content. This may be due to high velocity of water flow and high volume of water that causes, detachment and depositions of sand in the area.

The result revealed that, bulk density in the three slope gradients recorded low variability. The variation of soil bulk density among the slope gradients might be attributed to the variation of soil particle distribution and disturbance of soil particle with erosion. The low total porosity recorded in medium steep slope area could be attributed to high bulk density, and low organic matter content. There was irregularity in re distribution of soil particles along the slope, the result revealed that hydraulic conductivity decreases as slope gradient increases. The decrease (> 20%) in Ksat can be explained because it shows a relatively high percentage of silt and fine sand that seal up the pore space resulting in low Ksat , also may be severely impeded by compacted slope, become limiting barriers for deep percolation and drainage of excess infiltrated rainfall, this increases the risks of water logging, water runoff losses and soil erosion. The soil pH according to Tekalign (1991) cited in Aytenew (2015) rating the soil pH as slightly acidic. The result revealed that Ca and Mg were the dominant TEB, in line with Folorunsho and Kargbo (1986). The author explained that it is largely due to the tenacity with which the ion are held in the exchangeable complex.

Amorphous of Fe content affected by slope gradient. According to stone house and Arnaud (1971), soil with Fe ratio of less than 0.35 were classified as being poorly drained, whereas well drained soils had values greater than 0.35. The dominance of Fe amorphous (mobile) were irregularly displaced within the slope. Cry Fe (immobile Fe) fraction were high compared to values of Am. Fe. It could be as a result of deposition of Cry. Fe that have been washed down along with eroded water (Tahir *et al*., 2006). Furthermore, the low mean value (<10%) may be as a result of high weathered affected by soil of the area, while the high mean (11-20%) could be due to high content of organic matter.

Effect of slope gradient on nitrogenous and non-nitrogenous organic compound shows that in decrease slope gradient, humic substances with aggregate size fraction of <0.05mm increases, this could be as a result of reduction in the rate of transportation and deposition of minerals in the lower slope gradient, also the mineral fraction with humin substances participate in long-term stabilization of soil aggregates (caron *et al*., 1992). Humin substances with aggregate size fraction of 0.25-0.05mm, 11-20% slope, could also participate in long-term stabilization of soil aggregates. In this way, aggregate here are better protected from microbial degradation, because they are not labile and can also be less susceptible to slaking and dispersion because of their associated high cohesion. The result of high accumulation of humin substances in aggregate size fraction of 2.0 – 0.25mm in 11-20% slope observed, was that, there was less disintegration of soil aggregate, as a result of non-nitrogenous organic compound that bind the soil aggregate together (humic) that help reduce impact of water, either by rain drop, rain splash, detach, runoff and transportation on aggregate.

Generally the result of humic shows that irrespective of the slope gradient aggregate size fraction with <0.05mm were more stable than 4.0-2.0mm, due to non-nitrogenous organic compound (Humic) that bind aggregate together, which were not easily decomposed and persistence to degradation.

Humic substance with aggregate size fraction of 0.25 -0.05mm, 2.0-0.25mm and 4.0-2.0mm had high accumulation in 11-20% slope and in 0.05mm in>20%. The result indicated that with these aggregate size fractions, stability are enhanced, which is determined by their decomposability (not labile) and résistance to erosive forces within the soils of the area. Fulvic acid with all the aggregate size fraction increase with increase in slope gradient , therefore high proportion of fulvic acid in this soils in an indicative of less physical disturbance of soil aggregate by acceleration of erosion, while decrease in slope gradient, decreases fulvic acid. The high accumulation of carbohydrate content in

11-20%slope indicated that, the soils of the area are more transient (labile).The mineral fraction (<0.05mm) are easily degraded by micro-organisms, which cannot participate in long-term stabilization of soil aggregate, this was confirmed by piccolo and Mbagwe (1999). However, the mineral fraction can participate on long-term stabilization of soil aggregates when acting in conjunction with the humic , humic and fulvic substances i.e. humified soil organic matter pools (Spaccini *et al.,* 2001), there is resistance from force of slaking when water is applied

CONCLUSION

Slope gradient and the type of organic matter that bind aggregate together to some extent led to long or short term stabilization, and the amount and distribution of stable and unstable aggregate in the soil used to know the stability and instability of soil aggregates.

Carbohydrate substance only have short term effect on soil aggregation, because of its rapid disintegration of the organic component. There is general trend of the smaller aggregate to be preferentially enriched with humin, humic, fulvic and carbohydrate content for long-term stabilization of aggregates. A possible explanation could be that, carbohydrates in smaller aggregates are more strongly absorbed as polymer of various forms and dimension to either clay humin, humic and fulvic fractions abound in the micro aggregate.

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