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Land use effect on micro aggregate stability of water stable aggregates from an ultisol in Southern Nigeria

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Abstract

Soil micro aggregate stability indices give information on soil erodibility that has implications for soil erosion. This experiment carried out in six locations was aimed to assess soil micro-aggregate stability indices associated with water-stable aggregates (4.75-1mm, 1-.25mm, and <.25mm) in a forest (FR) and cultivated (CL) land use. Random soil sampling was used to collect soil samples from a depth of 0–20 cm. Parameters assessed were aggregated silt plus clay (ASC), Water dispersible clay (WDC), clay dispersion index (CDI), and dispersion ratio (DR) associated with water-stable aggregates (WSA). The result showed that the land use effect on micro aggregate stability indices was significant($P \leq 0.05$). There was significantly ($P \leq 0.05$) 12.4% lower ASC, 2 and 5% higher value in the CDI and DR in FR land use compared to Cultivated land (CL) use respectively. The highest amount of ASC (25.9 %), lowest CDI (45 %), and DR (58%) registered in the 1.00 – 0.25 mm aggregate fraction of the forest land use implied higher micro aggregate stability against colloidal dispersion and an enhanced capacity to store water and retain plant nutrient. The lowest ASC (12.7 %) in 4.75 – 1 mm WSA,highest CDI (58.4 %)and DR (0.73)in < 0.25 mm of CL land use suggest a decline in soil quality. The WDC increased with clay content hence may not adequately predict soil erosion in the study area. Micro aggregate stability in locations was controlled by their clay content irrespective of land use. Hence L6 in cultivated land (CL) land use with lowest clay content presented lowest ASC, WDC, highest CDI and DR while higher stability was observed in locations with relatively higher clay content (L1, L2, L4, and L5). Higher ASC, lower CDI, and DR infer higher resistance of soil aggregates to soil erosion and potential for soil organic carbon sequestration while lower ASC, higher CDI, and DR means more release of colloidal material and decline in soil functions.

Keywords: Land use; Water stable aggregates; Aggregated silt plus clay; Dispersion ratio; Clay dispersion index; Water dispersible clay

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1.0. Introduction

Soil aggregation gives information on soil resistance to erosion and its capacity to support productivity(Guo *et al.*, 2019). Wet aggregate stability measures the ability of the soil to resist disintegration under the disruptive impact of raindrop and water erosion (USDA, 2008). Micro aggregate stability is an important soil property because of its effect on processes relating to infiltration, porosity, moisture release characteristics but most importantly soil erosion. (Ruiz-Vera ., 2006; Heathwaite *et al.*, 2005). It is an essential indicator that influences soil's ability to continue to perform its required function and resist degradation (Vladimir*, et. al.,*2016). Reduction in micro aggregate stability can lead to the formation of seals, crusts (McIntyre, 1985), and environmental pollution (Emeh *et al.*, 2018) which are signs of soil degradation. Soils in southeastern Nigeria are products of parent materials that have undergone intensive tropical weathering (Igwe *et al.,* 2009a) highly acidic(Osakwe 2014), and low in organic matter. An increase in human activities in southeastern Nigeria such as deforestation for agriculture exposes these fragile soils to erratic weather events leading to the destruction of macroaggregates (>0.25mm), the release of micro aggregates (<0.25 mm), and colloidal materials. There are divergent views on erosion about micro aggregate stability and macroaggregate stability (Igwe, 2005; Igweand Agbatah, 2008; Guo *et a*l., 2019). However, Igwe and Agbatah (2008) worked on some macro aggregate and micro aggregate stability indices reported that micro aggregate predicted soil erosion more than macroaggregate stability. Many other studies have indicated that the propensity of micro aggregates to disintegrate can be used to estimate soil erosion using some indices (Essien 2013; Igwe 2009; Igweand Agbatah, 2008; Guo, et al., 2019. Igwe *et al.*2013)). Some dispersion indices commonly used are water-dispersible clay (WDC), dispersion ratio (DR), and aggregates stability indices such as clay flocculation index (CFI), clay aggregation (CA), and aggregation of silt and clay (ASC) (Igwe *et al.,* 2009; Kjaergaard *et al.*2004); Nguetnkam and Dultz, 2014; Tuo *et al*., 2017). The use of clay dispersion index and dispersion ratio was indicated byIgwe (2005) to be good indices for predicting erodibility in some soils of southeastern Nigeria.

An evaluation of micro aggregate stability under different land-use types in Nigerian tropical soil indicated that soil micro aggregation is influenced by land use (Malgwi and Abu 2011). A lower dispersion ratio and higher ASC in the forest compared to arable and plantation land use was noted by Opara (2009). Karaguul, (1996) remarked that the erodibility index measured by dispersion ratio in forest soils was relatively less than those of range soils and cultivated land. Osakwe, (2014) showed that conversion of forest land to cultivated land in some selected soils in southeastern Nigeria increased the clay dispersion index and caused declines in aggregated silt plus clay and clay flocculation index in the cultivated soil.

Though many researchers have studied land use and micro aggregate stability in bulk soil, much has not been done on these indices concerning water-stable aggregates in southeastern Nigeria.

Therefore, the objective of this research is to carry out a comparative analysis of micro-aggregate stability indices associated with water-stable aggregates in two land-use types in selected locations of Southeastern Nigeria.

2.0. Materials and methods

2.1 Experimental site description

This study was conducted in six locations in Enugu State, Southeastern Nigeria. The locations include Ugbo-Okpara (L1), Ugbo-Nabo(L2), Ugwogo- Nike (L3), Iyi-Ukwu (L4), Edem (L5), and Ngwo (L6). The study area has a tropical wet and dry climate with average annual precipitation between1600 - 1800 mm and a temperature of about 28^{o}C. The locations fall within latitudes 6^{o} 10' N to 6^{o} 24' N and longitudes 7^{o} 25' E to 7^{o} 29' E. The vegetation is derived from savannah with patches of forestsCommon crops grown are cassava (*Manihot esculenta)* cocoyam (*colocasia spp),* melon (*Citrilus viligaris)*maize (Zea mays). Organic and inorganic fertilizer was used as an amendment and they practice shifting cultivation Cultural practices include mulching, cover cropping and bush burning.

The soils of Enugu State are Ultisols and are of sedimentary origin, (Balogun, 2000). According to Jungerus (1964), LI and L2 are described as shallow brown soils derived from sandy shales, L3, L4, and L5 are red and brown soils derived from sandstone and shales while L6 is described as deep porous red soils derived from sandy deposits.

Table 1 Clay contents in locations and water-stable aggregates across land use

Aggregate sizes	>2mm		>0.25mm		<0.25mm		Mean	
Parameter			Clay (%)					
Location/land use	CL	FR	CL	FR	CL	FR	CL	FR
L1	27	15	47	25	32 27		35	22
L2	21	9	45	35	23	24	30	23
L3	21	25	29	37	22	18	24	27
L4	11	25	31	42	22	27	21	31
L5	21	36	25	45	23	25	23	35
L6	8.0	15	6	11	6.06.0		7.0	11
Mean	18	21	31	32	21	31	23	25

Adapted from Osakwe *et al*., (2017). FR – Forest, CL - Cultivated

2.2 Experimental design and soil sampling

The sampling area in the six locations was based on the identification of virgin forests and adjacent cultivated land not more than 100 m apart. The experiment was arranged as a 6x2x3 factorial experiment replicated three times in a completely randomized design. The numbers represent six locations, two land-use types, and three water-stable aggregate sizes (4.75-1mm, 1-.25mm, and <.25mm). Soil samples in each location were collected at random in triplicate from forests and adjacent cultivated land at 0 – 20 cm depth and a total of thirty-six samples (36) samples were collected for laboratory analysis.

2.3 Sample preparation and laboratory analysis

The samples were air-dried and sub-samples were passed through a 4.75mm sieve for aggregate analysis. The distribution of water-stable aggregates was determined by the wet sieving technique described by Kemper and Rosenau (1986). To separate the water-stable aggregate, 50gm of the >4.75mm of air-dried aggregates were put on top of a nest of three sieves measuring 2mm, 1mm, 0.25mm, and pre-soaked for 10 min. The sieves and their contents were oscillated vertically, once per second, in water 20 times. Care was taken to ensure that the soil particles on the topmost sieve are always below the water. The resistant aggregates on each sieve were oven-dried at 105^{o}C for 24 hr and weighed. This process was repeated severally to collect enough aggregate fractions for particle size distribution in chemical dispersant and water. The different water-stable aggregate sizes were pooled into three aggregate sizes: 4.75 – 1 mm, 1 -.25mm, and <.25mm.

Particle size distribution associated with each size fraction of the water-stable aggregates was determined in water and chemical dispersant by the hydrometer method (Gee and Bauder, 1986). Micro aggregate stability indices such as aggregated silt plus clay (ASC), dispersion r ratio (DR), clay dispersion index (CDI), and water-dispersible clay (WDC) associated with each size fraction were computed as follows:

CDI = [% clay (water) / % clay (NaOH)] ;ASC = [% clay + % silt (NaOH)] – [% clay + % silt (water)]; DR= [% clay + % silt (water)]/ [% clay + % silt (NaOH); WDC = % clay in water

2.4 Statistical Analysis

Data generated in the study were subjected to statistical analysis using the Genstat Discoveryedition 4.1. Analysis of variance test was conducted to determine the significant differences between treatment means; where the F- values are significant at P= 0.05, means were separated by the least significance difference (LSD) test.

3.0. Results and Discussion

3.1 Aggregated silt plus clay (ASC)

The effects of cultivation on ASC associated with WSA are presented inTable 2. Mean values of ASC associated with WSA in cultivated and forest land use were 18.3 % and 20.9 % respectively, presenting a significant ($P \leq 0.05$) decline of about 12.4 % in ASC due to land use. Opara (2009) worked on the effect of land use on micro aggregate stability in southern Nigeria and reported 62.69% higher ASC in the native forest compared to cassava continuous cultivated land use. The main effect of aggregate size showed the highest (24.6 %) and lowest (15.5%) amount in 1 – 0.25 mm and 4.75 - 1 mm WSA respectively. The lowest amount of ASC in the largest aggregate size may be ascribed to the adverse effect of tillage on the disintegration of aggregates held by a more transient organic matter fraction*(*Oades and Waters (**199**1) followed by loss of fine particles. The result of the combined effect of land use and aggregate size on the ASC of WSA (Table 2) indicated mean values in 4.75 – 1 mm, 1.00 – 0.25 mm, and < 0.25 mm size fraction were 12.7 %, 23.4 %, and 18.7 % for cultivated soils respectively and 18.2 %, 25.9 % and 18.5 % for the forest land use respectively. The lowest value(12.4%) was shown in 4.75 – 1 mm of the cultivated land use while the highest amount of ASC (25.9 %) was registered in the 1.00-0.25mmaggregate fraction of the forest land use. By this result 4.75 – 1 mm aggregate fraction was most affected by tillage. This is expected because water-stable aggregates at the macro level are stabilized by transient organic materials that are highly affected by the disintegrating force of cultivation hence the lower value of ASC was observed. This is in agreement with the work of Beare *et al*., (1994) and Six *et al*., (2000). The importance of organic matter and clay in large aggregate has been discussed by Tisdal and Oades, (1982) and Oades, (1984). The highest amount in 1.00 – 0.25 mm WSA, may be a result of more organo mineral complexing which favors higher aggregation.

Table 2: The effect of land use location and aggregate size on ASC associated with WSA

Parameter		ASC (%)			
Land use	Location WSA (mm)	4.75 -1	1 -0.25	<0.25	Mean
	L1	20.65	31.9	32.9	28.4
	L2	14.2	38.5	17.9	23.5
CL	L3	12.2	30.2	27.9	23.4
	L4	10.2	22.2	17.9	16.8
	L5	14.8	15.5	13.7	14.7
	L6	4.2	2.2	1.9	2.8
Mean		12.7	23.4	18.7	18.3
	L1	6.5	12.4	20.9	13.3
FR	L2	12.2	31.2	22	21.8
	L3	22.3	29.5	11.9	21.2
	L4	18.2	40.9	29	29.4
	L5	31.7	14.9	24.9	30.5
	L6	18.2	6.2	2.5	9
Mean		18.2	25.9	18.5	20.9
Grand mean		15.5	24.6	18.6	19.6

LSD (0.05)	Land use	0.31
	Aggregate size	0.38
	Land use *location	0.75
	Land use* Aggregate size	0.53
	Land use* Aggregate size *location	1.82

The interaction effect of location and land use showed significantly the lowest value in L6 (2.8 %) of the cultivated land use and the significantly highest value (30.5 %) in L5 in forest land use. The interaction of land use, aggregate size, and location showed significantly the highest amount of ASC in 1 -0.25 mm size fraction in L4 of the forest land use while the lowest value(1.9%) found in <0.25 mm size fraction in L6 of the cultivated was not significantly different from 1-0.25 of the cultivated land use and <0.25 mm of the forest land use in L6 respectively. This could be due to the sandy texture in this location (Osakwe *et al.,* 2013). It seems texture controlled ASC because L6 with the lowest clay (Table 1) presented the lowest ASC while L4 andL5 with higher clay (Table 1) also showed higher ASC. With cultivation, decomposition of soil organic matter is increased; the aggregate breakdown is enhanced and consequent loss of fine materials with water erosion. The higher the aggregated silt plus clay the less the removal of colloidal materials by water erosion. Nevertheless, the lower ASC in the cultivated locations might be due to mechanical manipulation of the soil which breaks down the aggregates, exposes the soil to high temperature reducing the activity of micro-organisms involved in aggregate formation. Added to this is the loss of organic matter through mineralization and removal of residue from the farmland after harvest. This is in agreement with other researchers who observed that cultivation resulted in the degradation of soil quality(Mbagwu and Picollo, 2004).

These results imply that lower values of ASC indicates lower resistance of the WSA to erosion and will indirectly affect other nutrient element associated with it while higher amounts, will improve stability and fertility.

3.2 Water dispersible clay (WDC)

The effect of land use on WDC was significant(P ≤ 0.05) and the result is shown in Table 3. There was a higher amount of WDC(12.1%) in forest land use which was 9% more compared to the cultivated land use. The result seems to suggest that the release of WDC is related to the amount of clay instead of land use (Table 1). Rashad and Dultz (2007) have also identified the percentage of clay particles as the major factors in the degree of clay dispersion. Esfandiarpour *et al.,*(2017)in a study on soil properties and clay dispersibility noted an increase in dispersion with depth as a result of an increase of clay with depth. This means the higher the clay content the higher the WDC.

The main effect of aggregate size indicated significantly (P ≤ 0.05) highest WDC in the 1 – 0.25 mm WSA and the order was 1.00 - 0.25mm>< 0.25mm = 4.75 – 1 mm. The combined effect of land use and aggregate size on WDC was significant (P ≤ 0.05) and demonstrated the highest WDC (13.6%) and lowest WDC (10.2%) in 1 – 0.25 and < 0.25mm WSA of forest land use respectively compared to all other aggregate sizes across the land uses. This reiterates that WDC was controlled by clay content associated with these aggregate sizes (Table 1).The interaction of location and land use (Table 3) indicated that WDC ranged between 5.8 – 15.7%. The significantly (P ≤ 0.05) highest amount of WDC in L1 of cultivated land use was not different from L5 (15.5%) in the forest land use while the lowest value (5.8 %) in the cultivated land use of L6 was numerically the same as in the forest land use of the same location. Similarly, the interaction of location, aggregate size, and land use showed significantly highest WDC (23.3%) in 4.75 – 1 mm WSA of L5 in the forest land use which was not significantly different from 1.00 - 0.25mm of L1 in the cultivated land use. It was also noteworthy that the lowest amount of WDC (5.8%) was recorded in all the aggregate sizes in L6 across both lands uses. This result demonstrated that WDC was controlled by the amount of clay. Therefore WDC with the conversion of forest to cultivated land use may not estimate soil erodibility. Contrarily, some researchers used WDC which indicates the ability of soil clay particles to be dispersed by water to estimate soil erodibility (Brubaker *et al.,* 1992; Igwe, 2005; Igwe and Udegbunam, 2008). Some noted that higher WDC indicated a higher erodibility while low WDC indicated lower erodibility (Bajracharya *et al.,* 1992; Igwe *et al.,* 2009; Nguetnkam and Dultz, 2011).

Table 3: The effect of land use, location, and aggregate size on WDC associated with WSA

Parameter		WDC (%)			
Land use	Location	WSA (mm) 4.75 -1	1 -0.25	<0.25	Mean
CL	L1	10.5	21.1	15.5	15.7
	L2	9.8	11.8	11.5	11
	L3	13.8	5.8	11.5	10.4
	L4	5.8	11.8	11.5	9.7
	L5	13.9	13.8	11.5	13.1
	L6	5.8	5.8	5.8	5.8
	Mean	9.9	11.7	11.2	11
FR	L1	10.5	17.6	11.5	13.2
	L2	5.8	11.8	11.5	9.7
	L3	15.8	16.5	11.5	14.6
	L4	13.8	15.8	11.5	13.7
	L5	21.3	13.8	11.5	15.5
	L6	5.8	5.8	5.8	5.8
	Mean	12.2	13.6	10.6	12.1
Grand Mean		11.1	12.8	10.9	11.6
LSD (0.05)	Land use	0.15			
	Aggregate size	0.18			
	Land use *location	0.36			
	Land use* Aggregate size	0.26			
	Land use* Aggregate size* Location	0.62			

In this study, though total clay content seems to play a major role in clay dispersion, the few variabilities observed in different locations may suggest an indirect effect of soil organic carbon. This result is in agreement with the result of Salako (2000) who indicated that WDC was dependent on total clay content. Igwe *et al.,* (2008) investigated WDC in a Ultisol southeastern Nigeria reported a positive correlation between WDC with clay content. ContrarilyMollina *et al.,* (2001) believed that WDC was not related to clay content but soil organic carbon and calcium while Mbagwu and Bazoffi (1998) observed that 70% of the differences in water-dispersible particles were influenced by SOM. These findings imply that the release of fine particles can cause sealing and hardening which are indicators of soil degradation.

3.3 Clay dispersion index (CDI)

A comparative analysis of the effect of land use on the CDI of forest and cultivated soils was evaluated (Table 4). Average values in cultivated and forest land use were 54.2 % and 53.3 % respectively. A significant (P ≤ 0.05) effect due to land use was observed implying increasing erodibility with forest conversion.Beare *et al.,*(1994) indicated that tillage exposes SOM to mineralization consequently reducing organic binding agents necessary for enhancing aggregation thereby increasing dispersion of clay whileBsaga *et al.,*(2018) investigated land use impact on CDI of vertisols in copped and uncropped land reported higher CDI in cropped than in un-cropped land.

The main effect of aggregate size showed the lowest dispersion on 1.00 - 0.25 mm WSA (46 %) and the highest CDI in 4.75 – 1 mm aggregate size (57.8 %) but was not significantly different from CDI associated with <0.25 mm

(57.50 %). Interaction of land use and aggregate size (Table 4) recorded significant (P ≤ 0.05) highest CDI (58.4 %) in 4.75 – 1 mm of the forest land though statistically at par with CDI (58.4) of< 0.25 mm WSA of the cultivated land use while the lowest CDI was registered in 1.00 - 0.25 mm WSA of the forest land use. The result also suggested that the amount of clay controlled the dispersion of clay (Table 1). Higher clay content may enter into more organo-mineral interaction thereby reducing dispersion. Other researchers have postulated increased aggregate stability with an increase in clay content of soils. Igwe *et al* ., (2008) reported negative correlation (r = -97) between clay and CDI.

Table 4: The effect of land use, location, and aggregate size on CDI associated with WSA

Parameter		CDI (%)			
Land use	Location WSA (mm)	4.75 -1	1 -0.25	<0.25	Mean
	L1	38.8	44.9	48.4	44
CL	L2	46.7	26.8	50	41
	L3	65.7	20	52.3	45
	L4	52.7	38.1	52.3	47.7
	L5	66.2	55.2	50	57.1
	L6	72.5	96.6	96.6	88.6
	Mean	57.1	46.9	58.3	54.1
	L1	70	70.4	42.6	61
	L2	64.4	33.7	47.9	48.6
FR	L3	63.2	44.6	63.9	57.2
	L4	55.2	37.6	42.6	45.1
	L5	59.2	30.7	46	45.3
	L6	38.6	52.7	96.6	62.6
	Mean	58.0	45	56.6	53.3
Grand mean		57.8	46.0	57.5	53.8

LSD (0.05)	Land use	0.4
	Aggregate size	0.5
	Land use *location	1.0
	Land use* Aggregate size	0.7
	Land use *location *Aggregate size	1.72

The interaction of land use and location showed the highest CDI (88.8 %) and lowest CID (41%)in L6 and L2 in the cultivated land use respectively. In line with the trend, irrespective of land use lowest CDI was indicated with the location with the highest clay content and the highest in the location with the lowest clay (Table 1). Cultivation has been identified to play a key role in soil quality degradation(Emadi *et al*., 2008). However, Adesodum, *et al*., (2007) and Spacinni *et al*., (2001) has found that the degree of variability in structural stability with cultivation was dependent on soil characteristics being higher in sandy than clayey soil. Similarly, the interaction of land use, location, and aggregate size showed that the highest CDI was recorded in L6 (96.6%) in 1.00 - 0.25 mm and <0.25 mm aggregate sizes of the cultivated land use and also in the <0.25 mm of the forest land use while significantly lowest CDI was associated with 1.00 - 0.25 mm WSA in L2 of the cultivated land use. This result shows that CDI may be a function of the characteristics of the soil. Some researchers have included clay mineralogy, the chemical composition of exchangeable cations, and organic composition of the soil solution as agents of soil stability (Krishnaswamy and Ritcher, 2002). Higher values of CDI imply less stability which under intense rainfall will cause an aggregate breakdown, loss of fine materials, and plant nutrients while lower CDI means higher stability and a better physical environment for the crops. Clay dispersion reduces the rate of water infiltration and soil aeration (Boardman, 2010), a decline of soil hydraulic conductivity, and blocking of soil pores Esfandiarpour *et al,. (2017).* These physical conditions lead to the crust and hence soil erosion.

3.4 Dispersion ratio (DR)

The land use effect on DR associated with WSA (Table5) was significant with a 22% higher value in cultivated land use compared to the forest land use. The report of higher DR in cultivated land use supports the result of other researchers that cultivation destroys aggregation and as well increases mineralization of SOC that is crucial for aggregation, Oacles, and Water, (1991) showed that with forest conversion, macroaggregates stabilized by fungal hyphae, roots and polysaccharides are easily broken down. Furthermore, the main effect of aggregate size indicated highest DR (0.68) in < 0.25 mm aggregates compared with other aggregate sizes following this order: < 0.25 mm >1 - 2 mm = 4.75 – 2 mm. The interaction of land use and aggregate size showed that the highest DR (0.73) was recorded in the < 0.25 WSA of the cultivated land use while the lowest DR (0.58) was recorded in 1 - 2 mm and 4.75 – 2 mm WSA of the forest land use. However, higher DR in <0.25 mm WSA compared to the macroaggregates was contrary to the report of Fuller *et al.* (1995) who indicated higher DR in macroaggregates compared to micro aggregates and also microaggregation theory that microaggregates are less influenced by agricultural practices (Tisdall and Oades 1982; Oades 1984; Oacles and Water1991)

The result in this study seems to suggest that the indirect effect of the amount of SOC associated with these size fractions in the study area (Osakwe *et al.,* 2017) and organo-mineral interaction known to improve macro aggregation may have reduced the DR of macroaggregates in the study locations.

Furthermore, the interaction of land use and location(Table 5) showed the highest DR (0.73) in cultivated land use of L6 while the DR (0.51) in L5 of the forest land use was significantly lower than all locations across the two land uses except L2 (0.55), L4(0.54) in the forest land use and L1(0.54) in the cultivated land use. Interaction of location, aggregate size, and land use (Table 5) showed significantly highest DR (0.91)in < 0.25 mm WSA in L6 of the cultivated land use while the lowest DR (0.45) in 4.75 – 1 mm in the forest land use of L6 was significantly lower compared to

Table 5:The effect of land use, location, and aggregate size on DR associated with WSA

		Parameter	DR		
Land use	Location	WSA (mm) 4.75 -1	1 -0.25	<0.25	Mean
	L1	0.53	0.56	0.54	0.54
Cultivated	L2	0.54	0.47	0.69	0.57
	L3	0.7	0.52	0.6	0.61
	L4	0.63	0.67	0.76	0.69
	L5	0.6	0.7	0.7	0.67
	L6	0.69	0.86	0.91	0.82
	Mean	0.62	0.63	0.73	0.66
	L1	0.73	0.77	0.62	0.71
	L2	0.56	0.48	0.62	0.55
Forest	L3	0.64	0.58	0.73	0.65
	L4	0.57	0.53	0.53	0.54
	L5	0.53	0.47	0.53	0.51
	L6	0.45	0.65	0.82	0.64
	Mean	0.58	0.58	0.64	0.6
Grand mean		0.6	0.61	0.68	0.63

LSD (0.05)_ Land use .01
Aggregate size .03
Land use *location .05
Land use* Aggregate size .04
Land use *location *Aggregate size .06

other aggregate sizes in all location across the two land uses. However, it was not significantly different from DR in 1 – 0.25 mm WSA of L2 (0.48) and L5(0.47) in forest land use and L2 (0.47) in cultivated land use. It was noted that L6 with the lowest value of clay and of a s (Table 1) surprisingly recorded the lowest DR dispersion ratio. Some researchers that worked at these locations reported that forest land use in L6 recorded the highest dithionite – citrate bicarbonate iron (Osakwe*et al.,*(2014) and highest SOC associated with 4.75-1mm fraction in forest land use compared to other aggregate sizes across all locations and land uses(Osakwe *et al.,* 2017). The result shows that aggregation of sandy soils can be enhanced by SOC and greatly by the presence of iron oxide. Soil organic carbon can act as a hydrophobic agent repelling water from interacting with aggregates. Consequently, this study seems to suggest that textural characteristics, SOC, and iron oxide influenced DR of WSA in southeastern Nigeria regardless of land use. Other workers have shown a negative correlation between DR and soil organic carbon (Igwe *et al* ., 2001; Rasheed *et al* 2016) whileBassouny(2017) in a study of aggregate stability in cultivated and uncultivated soils reported *that* organic matter showed a positive correlation with the aggregation of soil particles and, on the other hand, a negative correlation with the dispersion ratio, indicating that organic matter caused an increase in soil aggregation and decrease in the dispersion ratio.

DR has been used as an index of soil erodibility. The higher the DR the more prone the soil is to release colloidal materials which are precursors to soil sealing and crust formation. Sandy soils need agricultural practices that ensure high organic matter input for their stability.

Conclusion.

Knowledge of micro aggregate stability gives information on soil erodibility. Conversion of forests to arable land caused a decline in ASC, increased CDI and DR. The result suggests that WDCmay not be a good estimator of soil erodibilty as it was controlled by clay content irrespective of land use hence higher WDC was recorded in forest land use compared to the arable land Also increase in clay content and/or SOC enhanced ASC, reduced CDI and DR. Highest improvement in ASC, reduction in CDI and DR were indicated in 1 – 0.25mm WSA of the forest land use while the lowest ASC and highest CDI in 4.75-1 mm WSA from cultivated land use demonstrate the impact of tillage on large macroaggregates bound by transient soil organic matter. Microaggregate stability is important for the control of soil erosion, enhanced soil carbon sequestration, and environmental protection. Therefore, soil management practice that controls the loss of fine particles and increases the SOC level will be a good strategy for enhancement of micro aggregate stability in the Ultisol of Southeastern Nigeria.

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