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Macro-Aggregate Stability of Soils under Selected Parent Materials in Imo State, Nigeria

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ABSTRACT

We investigated the effect of macro-aggregate stability of soils formed under selected parent materials at three locations in Imo State: Ihiagwa, Egbema and Okigwe representing the three parent materials (Coastal Plain Sand, Imo Clay shale, false-bedded sandstone respectively). Target soil survey sampling technique was used for location of pedons. Two pedons were dug in each of the locations (six pedons) and soil samples were taken for routine analysis of some soil physico-chemical properties and aggregate stability. Soil data were subjected to mean and analysis of variance (ANOVA). Means were separated using least significant difference at 5% and 1% levels of probability. Two indices were used to determine the macro-aggregate stability: water stable aggregate (WSA) and mean weight diameter (MWD). Results showed significant differences ($p \leq 0.05$) on the effect of parent materials on soil physico-chemical properties. While WSA>0.3mm positively correlated with ECEC (r=0.789), P=0.01) and TEB (r=0.720, P=0.01). MWDw correlated positively with clay (r=0.504, P=0.05) and negatively with pH (r=0.56, P=0.05). The locations studied required conservative practices and more efficient management to ensure greater soil stability.

Keywords: *Aggregate Stability, Pedon, Parent Materials, Mean Weight Diameter.*

INTRODUCTION

Aggregates stability refers to the ability of soil aggregates to resist disruption when outside forces (usually associated with water) are applied, NCRS (1999).

Soil aggregate stability influences a wide range of physical and biochemical processes of agricultural soils especially in the tropics. It is a crucial and valuable soil property affecting soil sustainability and crop production (Amezketa, 1999).

The physical and chemical properties of soil individual aggregate size fractions differ from one another. The contents of clay, organic matter and exchangeable cations for example, often differ from one aggregate size fraction to those in another (Cambardella and Elliot, 1993; Cruvinel *et al*., 1999)

The stability of macro aggregates varies with the changes in organic matter content or in management practices (Chenu*et al.*, 2000; Boix-fayoset al., 2001; Six et al., 2004; Noellemeyer*et al*., 2008). This is because macro aggregates are stabilized by such transient or temporary binding agents as roots; hyphae and microbes as well as plant-dried polysaccharides.

Consequently, the stability of the soil aggregation is very reliant on the type of minerals that are present in the soil. Parent materials have a great influence on soil formation, through their mineralogical composition, texture and their stratification as well as other soil properties (Brady and Weil, 1999; Akamigbo, 2001; Esu, 2005). Each parent material has property that reflects on the relative soil. Certain clay minerals form very stable aggregates while others form weak aggregates that fall apart very easily.

Tropical soils are highly weathered, erodible and instable. Most of the soils are therefore poorly structured.

Previously research works on aggregate stability are mostly in relation to aggregation of Mediterranean soil and the use of aggregates size (Osuji and Onwrenmadu, 2005) in enhancing the water stable aggregate of tropical soils (Opara, 2009), but not much has been done in aggregate stability based on the different parent materials.

Therefore, the objectives include to investigating the macro-aggregate stability of soils under different parent materials in the three zones of Imo State. To determine the physico-chemical properties of the soils in relation to aggregate stability. To compare the stability of the different aggregate sizes of the soil.finally, to determine which aggregate size fraction of the soil would provide more stability.

Materials and Methods

Study Area

This study was carried out in the three zones of Imo State, Nigeria: Ihiagwa (Owerri) which lies on latitude $5^0$24'N and longitude $7^0$1'E; Egbema (Ohaji/Egbema) on latitude 5054'N and longitude 6072'E and Okigwe which lies on latitude $5^0$87'N and longitude $7^0$30'E. The main geological material of Ihiagwa is coastal plain sands Benin formation (Orajaka, 1975); Egbema is of Imo-Clay Shale (Enwezor*et al.*, 1990) and Okigwe soil is formed from false bedded sand stone. The study area lies within the lowland area of Eastern Nigeria (Ofomata, 1975). It is of a humid tropical climate characterized by a bimodal rainfall peak ranging from 2000 – 2500mm annually. Temperatures are usually high and ranges from 26-30^{0}C.

The area is dominated by rainforest vegetation whose density has been altered by anthropogenic activities such as oil activities, automobile related serving centres, deforestation, farming etc. The socio-economic activities of the area include hunting, fishing, farming, oil business etc.

Field Studies

Two profile pits were dug at each selected site to give a total of six (6) profile pits from the three different geological materials. Coastal plain sands (Ihiagwa), Imo Clay-Shale (Egbema) and False bedded sand stone (Okigwe). Profile pits were dug, examined following the guideline according to FAO (2006). Sampling was done based on horizon differentiation.

Soil samples were air-dried, crushed and sieved using 2-mm sieve, preparatory to laboratory analysis and the remaining samples for macro aggregate stability determination.

Particle Size distribution was determined by hydrometer method according to the procedure of Gee and Or (2002)

Moisture Content was determined gravimetrically by Cater method (1993) thus: $\theta MS = \frac{WetSoilSample \quad -DrySoilsample}{DrySoilSample} x \frac{100}{1}$

Where θMS gravimetric moisture content (saturated) %.

Bulk Density was determined using core sample method (Grossman and Renish, 2002). Soil pH was measures in 1:2:5 soil-water suspension methods using a standard pH meter (Thomas, 1996). Organic carbon was determined by Walkley and Black wet digestion method (Nelson and Somners, 1982), while the organic matter was obtained by multiplying the result from organic carbon with the Van Bemmele factor of 1.724. Exchangeable bases were estimated by the neutral ammonium acetate procedure (Thomas, 1982).

Exchangeable acidity H^+ and Al^{3+}) were determined using titrimetric method (Mclean, 1982). Total nitrogen was determined using microkjedahl digestion method (Bremner, 1996).Available phosphorus was estimated according to the method of Olson and Somner (1990). Macro aggregate stability was determined using modified methods by Kemper and Rosenau (1986) and NCRS (1996). Wet and dry sieving methods were carried out using a nest of five sieves with aperture sizes of: 4.75, 2.0, 1.1, 0.85 and 0.3mm. Two indices were used to express the aggregate stability;

Mean weight diameter: MWD= $\sum_{i2}^{n} xiWi$ —

Where x_i = the mean diameter of aggregate size fraction i $(i = 1 \; to \; n)$

Wi = the proportion of aggregate size fraction 1 to the total sample weight.

Water stable aggregate (WSA) >0.3mm

WSA (>0.3mm) = $\frac{\text{Weight of dried aggregate} \; -\text{sand}}{\text{weight of Sample} \; -\text{Sand}} \times \frac{100}{1}$

Higher values of the WSA >0.3mm and MWD indices indicate greater stability.

Data Analysis

Soil data generated were subjected to statistical analysis using analysis of variance (ANOVA), correlation and regression analysis to estimate the relationship between different aggregate sizes and some soil properties. The LSD method of mean separation was also used to determine the levels of significance of the parameters at P <0.01 and 0.05) with the Gen State Statistical package (Baye *et al.*, 2004).

RESULTS AND DISCUSSION

Table 1 shows the physical properties of the studied soils. The sand content was highest in Ihiagwa with a mean value of 909.6gkg-1 and lower in Egbema (639.0gkg^{-1}) and least in Okigwe with a mean value of 629.0 gkg^{-1}. The sadiness of the soil is attributes to the sandy nature of the parent material, being derived from coastal plain sand which according to Ogbanet al., (2001) are characterized by the dorminance of sandy textured fragment.

The lowest value of clay content was found in Ihiagwa soils with a mean value of 63.2 gkg^{-1}, while the highest value was found in Okigwe with a mean value of 283.0 gkg^{-1} and Egbema has a mean value of 238. gkg^{-1}.

The silt content was highest in Egbema with a mean value of 123. 0g kg-1 and was lowest in Okigwe soils with the mean values of 8.8g kg^{-1} while Ihiagwa has a mean value of 27.2g kg^{-1}.

The low clay and silt contents were as a result of high rainfall status of the area which favoured high rate of leaching and the influence of pedogenic process of translocation in which clay and silt contents were moved down the profile (Onweremadu *et al*., 2007).

Akamigbo (1999) also opined that climate factors such as high precipitation and temperature in the soils of southeastern Nigeria could lead to low clay and silt contents of the soils.

The moisture content of all the soils were slightly different with the highest mean values recorded in Okigwe and Ihiagwa (l82.9g kg-1) and Egbema recorded the lowest mean value of 123.9 kg.

This could be due to their textural differences. This observation is in line with NCRS (1996) who states that a soil's ability to hold water is affected by soil texture, presence and abundance of rock fragments, soil depth and restrictive layers, also organic matter increases a soil's ability to hold water both directly and indirectly. Meanwhile, the result in table 1 showed that water moisture content increased with depth. This could be as a result of increase in clay content down the soil layers and clay attracts and absorbs water (Caleroet al., 2008; Dikinya *et al*., 2006).

Bulk density values were highest in Egbema soils with a mean value of 1 .54g/crn^3 and low in both Okigwe and Ihiagwa with a mean value of l.l1g/cm^3. The high value of bulk density in Egbema soils could be as a result of the geological formation of Imo Clay Shale which according to Hiatt et al., (1996) is hard, cracks easily and does not permit root penetration, while the low bulk densities of Okigwe and lhiagwa indicated that the soils are not probably compacted and have more porosity (Attah, 2010). This is beneficial to root activity, water infiltration and overall growth of crops. Higher bulk density values could as well be attributed to the activities of oil pollution in the area, such as oil spillage which might cause compaction of soil pores and clogging effects.

Results of the chemical properties of the studied soils arc shown in Table 2. The result of the study indicated that soils were generally acidic with Okigwe and Egbema having mean values of 3.85 and 3.83 respectively while Ihiagwa recorded a mean of 5.12. According to Landon (1991), soil pH range of 3.5 is ultra acidic while 5.1 – 5.5 is strongly acidic. The low pH could be as a result of high rainfall pattern of the area. High rainfall tends to leach out the basic cations from the soil and could also be as a result of geological materials. Organic matter (OM) content of the soils of the studied area were generally low according to the rating of landon (1991). However, Okigwe and Egbema both have mean value of 1.69% each more than lhiagwa with a mean value of 0.97%. The low OM in the study area may be attributed to low decomposition rate of organic matter due to the agricultural activities (Adjiaet al., 2008) and could also be as a result of their varying parent materials especially, the coastal plain sands (Ihiagwa soils) having a low inherent organic matter content (Obi et al., 2012).

The total nitrogen percentage of all the soils of the area were Low and similar with the mean values of 0.08% for (Okigwe and Egbema) and 0.18% for Ihiagwa soils. The low total nitrogen is typical of the highly weathered soils of the sub-humid tropics, attributed to high nitrogen losses resulting from high rainfall that causes leaching of soil nitrates as well as low organic matter content (Eshctt *et al*., 1989; Brady and Weil, 1999; Opukiriet al., 1991). The low exchangeable bases (Ca, Mg, K, Na) in the studied soils could he attributed to high rainfall. Their mean values were similar with Okigwe having 3.9 Cmol/kg, Egbemawith3.23 Cmol/kg and Ihiagwa 3.32 Cmol/kg.

According to FAO (2006) these values were low. The result showed no significant difference in the Total Exchangeable acidity of the soils of the area. The soils are acidic due to high concentration of H+ and A13+asa result of leaching (Alekseeva *et al.*, 2009; Barthes et at., 2008).

The effective Cation Exchange Capacity of the soils were low but showed no significant difference. The mean values were low according to the rating of Esu (1991).

Table1. *Average values of Physical Properties of the Locations*

Location	Horizons	Sand g/kg	Silt g/kg	Clay g/kg	TC	BDg/cm^3	TP%	MCg/kg
Okigwe	AP1	774	98	128	SL	1.16	37.5	128.2
Okigwe	Bt1	654	98	248	SCL	1.16	54.68	174
Okigwe	Bt 2	554	98	348	SCL	1	60.94	207.2
Okigwe	Bt 3	534	58	408	SCL	1.12	56.25	222.2
	Mean	**629**	**8.8**	**283**		**1.11**	**52.3425**	**182.9**
Egbema	AP1	774	138	88	SL	1.78	30.47	86.1
Egbema	Bt1	674	118	208	SCL	1.74	32.19	102.2
Egbema	Bt 2	554	138	308	SCL	1.38	46.09	124.5
Egbema	Bt 3	554	98	348	SCL	1.25	48.83	182.9
	Mean	**639.00**	**123.0**	**238.0**		**1.54**	**39.40**	**123.9**
Ihiagwa	AP1	949.60	27.2	23.2	S	1.16	37.50	128.2
Ihiagwa	Bt1	889.60	47.2	63.2	S	1.16	54.68	174.0
Ihiagwa	Bt 2	909.60	27.2	63.2	S	1.00	60.94	207.2
Ihiagwa	Bt 3	889.60	7.2	103.2	S	1.12	56.25	222.2
	Mean	**909.60**	**27.2**	**63.2**		**1.11**	**52.34**	**182.9**
	LSD(0.05)	**89.5**	**1.73**	**9.03**		**0.224**	**7.3**	**2.175**

Table2. *Average Values of Chemical Properties of the Location*

Location	Horizon	pH(H_2O)	OC	OM	TN	Avail P Mg/kg	Ca	Mg	K	Na	AlcCmo/kg	H	TEB	TEA	ECEC	BS
Okigwe	AP1	5.5	4.4	1.33	0.108	37.7	2.4	1.8	0.115	0.246	0	0.72	4.561	0.72	5.28	86.38
Okigwe	Bt1	5	3.9	1.02	0.089	38.5	2.4	1.6	0.103	0.233	0.06	0.9	4.336	0.96	5.29	81.92
Okigwe	Bt 2	4.8	3.8	0.83	0.0073	35.3	2	1.6	0.096	0.272	0.12	0.92	3.968	0.04	5.01	79.2
Okigwe	Bt 3	4.4	3.3	0.76	0.06	33.4	2	0.8	0.086	0.272	0.28	0.28	3.058	1.28	4.44	71.13
	Mean	**4.925**	**3.85**	**0.985**	**0.0825**	**36.225**	**2.2**	**1.45**	**0.1**	**0.25558**	**0.115**	**0.705**	**3.9808**	**1**	**5.005**	**79.69**
Egbema	AP1	5.5	4.3	1.29	2.22	40.5	2.2	1.6	0.109	0.118	0	0.84	4.027	0.84	4.87	82.75
Egbema	Bt1	5.1	4	1.14	1.97	40	2	1.4	0.105	0.127	0	0.94	3.632	0.94	4.57	79.47
Egbema	Bt 2	4.8	3.5	0.8	1.38	39.3	1.6	0.8	0.093	0.129	0.04	0.96	2.622	1.	3.62	72.43
Egbema	Bt 3	4	3.5	0.68	1.17	38.5	1.6	0.8	0.084	0.171	0.13	1.01	2.655	1.14	3.79	70.1
	Mean	**4.80**	**3.83**	**0.98**	**1.69**	**39.58**	**1.85**	**1.15**	**0.10**	**0.14**	**0.04**	**0.94**	**3.23**	**0.98**	**4.21**	**76.19**
Ihiagwa	AP1	5.42	4.96	0.72	1.24	2.52	1.68	0.26	0.02	0.04	1.44	0.24	2.01	1.68	3.68	54.35
Ihiagwa	Bt1	5.82	5.21	0.68	1.17	1.05	2.32	1.06	0.01	0.04	0.88	0.44	3.43	1.32	4.76	72.25
Ihiagwa	Bt 2	2.85	5.30	0.52	0.89	1.68	1.68	1.02	0.00	0.00	0.00	0.96	2.73	0.96	3.66	73.77
Ihiagwa	Bt 3	5.53	5.02	0.34	0.59	1.92	1.92	3.19	0.00	0.00	0.60	0.92	5.12	1.52	6.65	77.13
	Mean	**5.66**	**5.12**	**0.57**	**0.97**	**1.90**	**1.90**	**1.38**	**0.02**	**0.02**	**0.73**	**0.64**	**3.32**	**1.37**	**4.69**	**69.38**
	LSD (0.05)		**0.519**	**0.146**	**0.249**	**0.359**	**0.395**	**1.66**	**0.044**	**0.044**	**0.65**	**0.489**	**1.916**	**0.406**	**1.75**	**15.83**

Table 3 shows the macro-aggregate stability of the studied soils. Okigwe had the highest mean values for both water stable aggregate (WSA>0.3) of 5.58% and dry aggregate (DSA>0.3) of 78.07% for Tables 3 and 5 respectively. Also Okigwe recorded the highest mean weight diameter (MWDw) of 0.31% and (MWDa) of 2.01% for Tables 5 and 6 respectively. Egbema recorded 3.71% on WSA>0.3 in table 3 and 48.4% DSA>0.3 with 0.37% and 1.07% MWD in Tables 5 and 6 respectively.

Ihiagwa recorded the least values of 1.77% WSA>0.3 and 14.63% DSA>0.3 in Tables 3 and 4 respectively with 0.44% and 0.16% MWD in Tables *5* and 6. Generally the soils recorded higher values in DSA>0.3 than in WSA>03 and this may be attributed to the low organic matter content of the soils due to leaching and high mineralization rate (Igwe and Nwokocha 2004). The mean weight diameter (dry) were smaller with percentage values between 0.25 – 0.45(Table 5). The difference between these two MWD indices explained the potential rate of structural deformation of the aggregate (Zobeck *et al.*, 2003).

These low values of MWDw could lead to quick dispersion of the soil during rainfall leading to severe rill erosion (Igwe and Nwokocha, 2004).Although Igwe *et al.*, (1995), Six *el al.*, (2003), Igwe (2003) demonstrated that MWD does not predict well the potential of the soil to erode yet, it is known *that* finer aggregates flow easily when submerged by water. The potential structural deformation index (PSDI) for the soils ranged from 016 to 0.85%. Mbagwu *et al.*, (1991) indicated that the higher the values of PSDI, the more the tendency of the aggregate to disintegrate upon wetting.

Table 7, shows the correlation matrix of some soil physicochemical properties. The WSA>0.3 indicated that it is influenced positively by Mg, TEB and ECEC. It has been stated earlier on that bases such as Ca^+ and Mg^+ aid aggregation. Also the higher the amount of TEB, the more acidity can be neutralized in short perspective (Turner and Clark, 1996). This also explained why MWDw correlated negatively with pH. When the MWDw increases it is more stable and reduces erosion. The PSDI is influenced by moisture content. In the tropical climate soils are subjected to frequent wetting and drying cycles, in the short term during the rainy seasons. In terms of climate, the aforementioned long term wetting and drying has implication on the aggregate stability of the soils (lgwe and Obalum, 2013).

Also, the characteristics rainstorms and the Associated heavy raindrop especially in the humid tropics can have considerable splash effect (Le Bissonais, 2006), Okigwe, Egbema and Ihiagwa as the case study may be and therefore are a force to reckon with in soil aggregate destabilization. It is thus clear that the studies soils are structurally fragile and susceptible to catastrophic erosion (Amezketa, 1999; Bajracharya *et al.*, 1992).

Table3. *Average Values of Water Aggregates of the Studied Soils*

Water stable aggregate under different (mm) sieve sizes %							
Location	**Horizon**	**Aggreg. 4.75**	**Aggreg. 2.0**	**Aggreg. 1.1**	**Aggreg. 0.825**	**Aggreg. 0.3**	**WSA>0.3**
Okigwe	AP1	1.045	3.893	0.121	1.949	13.16	7.008
Okigwe	Bt1	1.046	0.621	0.11	0.804	24.89	2.581
Okigwe	Bt 2	4.626	1.736	0.121	1.708	48.56	8.191
Okigwe	Bt 3	0.014	1.142	0.11	3.269	30.38	4.535
	Mean	**1.683**	**1.848**	**0.116**	**1.933**	**29.248**	**5.579**
Egbema	AP1	-	0.66	0.205	0.399	23.76	0.664
Egbema	Bt1	-	0.22	0.814	2.369	11.76	3.603
Egbema	Bt 2	-	0.05	0.162	0.723	19.77	1.385
Egbema	Bt 3	-	0.03	0.665	0.77	21.22	1.465
	Mean	**-**	**0.090**	**0.462**	**1.065**	**19.133**	**1.779**
Ihiagwa	AP1	-	2.04	0.161	0.327	13.43	0.528
Ihiagwa	Bt1	-	0.007	0.131	0.266	13	0.467
Ihiagwa	Bt 2	-	0.2	0.473	0.572	26.22	1.245
Ihiagwa	Bt 3	-	0.191	0.223	0.318	11.87	12.602
	Mean	**-**	**0.625**	**0.247**	**0.371**	**16.130**	**3.711**
	LSD (0.05)	**-**	**1.317**	**0.404**	**1.577**	**14.62**	**7.11**

Table4. *Average Values of Dry Aggregates of the Studied Soils*

Dry stable aggregate under different (mm) sieve sizes %							
Location	**Horizon**	**Aggreg. 4.75**	**Aggreg. 2.0**	**Aggreg.1.1**	**Aggreg. 0.825**	**Aggreg. 0.3**	**WSA>0.3**
Okigwe	AP1	25.46	17.26	5.83	5.96	30.57	54.51
Okigwe	Bt1	44.03	27.94	12.05	5.12	7.13	89.14
Okigwe	Bt 2	41.52	26.71	9.98	4.94	9.83	83.16
Okigwe	Bt 3	45.63	21.22	13.04	3.07	13.04	85.5
	Mean	**39.160**	**23.160**	**10.225**	**4.773**	**15.143**	**78.078**
Egbema	AP1	0	0.56	3	10.17	63.67	13.73
Egbema	Bt1	0	0.16	2.49	9.29	62.26	11.94
Egbema	Bt 2	0	0.15	2.71	98.5	61.43	11.36
Egbema	Bt 3	0	0.42	3.83	11.25	61.21	21.5
	Mean	**0.000**	**0.323**	**3.008**	**9.803**	**62.143**	**14.633**
Ihiagwa	AP1	1.77	12.48	8.75	6.9	44.49	29.9
Ihiagwa	Bt1	21.86	21.52	8.9	7.74	29.49	60.02
Ihiagwa	Bt 2	26.22	17.32	6.79	5.23	24.3	55.56
Ihiagwa	Bt 3	17.81	15.58	8.32	6.59	30.46	48.28
	Mean	**16.915**	**16.725**	**8.190**	**6.615**	**32.185**	**48.440**
	LSD(0.05)	**10.65**	**4.896**	**3.327**	**2.039**	**9.14**	**15.96**

Table5. *Averages Values of Wet Mean Weight Diameter Aggregates of the Studied Soils*

Wet MWD aggregate under different (mm) sieve sizes %							
Location	**Horizon**	**Aggreg. 4.75**	**Aggreg. 4.75-2.0**	**Aggreg. 2.0-1.1**	**Aggreg. 1.1-0.825**	**Aggreg. 0.8250.3**	**MWD**
Okigwe	AP1	0.015	0.009	0.015	0.005	0.003	0.047
Okigwe	Bt1	0.014	0.061	.0.18	0.018	0.109	0.21
Okigwe	Bt 2	0.033	0.012	0.006	0.016	0.078	0.145
Okigwe	Bt 3	0.779	0.16	0.009	0.015	0.031	0.84
	Mean	**0.210**	**0.036**	**0.010**	**0.014**	**0.055**	**0.311**
Egbema	AP1	-	0.005	0.038	0.096	0.326	0.467
Egbema	Bt1	-	0.01	0.038	0.115	0.286	0.402
Egbema	Bt 2	-	0.001	0.026	10.077	0.366	0.473
Egbema	Bt 3	-	0.007	0.046	0.096	0.299	0.443
	Mean	**-**	**0.006**	**0.037**	**0.096**	**0.319**	**0.446**
Ihiagwa	AP1	-	0.009	0.018	0.023	0.208	0.258
Ihiagwa	Bt1	-	0.008	0.018	0.026	0.214	0.266
Ihiagwa	Bt 2	-	0.007	0.017	0.025	0.245	0.244
Ihiagwa	Bt 3	-	0.019	0.026	0.028	0.166	0.239
	Mean	**-**	**0.011**	**0.020**	**0.026**	**0.252**	**0.252**
	LSD (0.05)	**0.379**	**0.026**	**0.0078**	**0.0158**	**0.368**	**0.368**

Table6. *Averages Values of Dry Mean Weight Diameter Aggregates of the Studied Soils*

Dry MWD aggregate under different (mm) sieve sizes %								
Location	**Horizon**	**Aggreg. 4.75**	**Aggreg. 4.75-2.0**	**Aggreg. 2.0-1.1**	**Aggreg. 1.1-0.825**	**Aggreg. 0.825-0.3**	**MWDw**	**PSDI**
Okigwe	AP1	0.6	0.583	0.092	0.057	0.077	1.409	0.967
Okigwe	Bt1	1.039	0.944	0.407	0.049	0.015	2.454	0.914
Okigwe	Bt 2	0.994	0.903	0.115	0.047	0.055	2.139	0.932
Okigwe	Bt 3	0.903	0.717	0.241	0.029	0.005	2.069	0.594
	Mean	**0.872**	**0.787**	**0.224**	**0.046**	**0.038**	**2.018**	**0.852**
Egbema	AP1	-	0.019	0.047	0.098	0.357	0.521	0.104
Egbema	Bt1	-	0.005	0.039	0.089	0.349	0.482	0.068
Egbema	Bt 2	-	0.005	0.042	0.082	0.344	0.472	0.001
Egbema	Bt 3	-	0.014	0.059	0.108	0.343	0.524	0.448
	Mean	**-**	**0.011**	**0.047**	**0.094**	**0.348**	**0.500**	**0.155**
Ihiagwa	AP1	-	0.059	0.193	0.066	0.427	0.745	0.999
Ihiagwa	Bt1	-	0.739	0.336	0.074	0.283	0.129	0.764
Ihiagwa	Bt 2	-	0.886	0.266	0.05	0.136	0.34	0.764
Ihiagwa	Bt 3	-	0.602	0.241	0.063	0.173	0.079	0.778
	Mean	**-**	**0.572**	**0.259**	**0.063**	**0.255**	**0.073**	**0.826**
	LSD(0.05)	**0.379**	**0.327**	**0.125**	**0.0196**	**0.123**	**0.425**	**0.333**

Table7. *Correlation Matric of Soil Physicochemical Properties*

	DSA>0.3	MWDw	PSDI	WSA>0.3	BD	BS	Clay	ECEC	MC	Mg	OM	pH(H_2O)	Sand	TEA	TEB	TP	TN
DSA>0.3	1																
MWDw	-0.15	1															
PSDI	0.72**	-0.58*	1														
WSA>0.3	0.34	-0.28	0.33	1													
BD	0.72**	0.32	-0.82**	-0.31	1												
BS	0.18	-0.25	-0.14	0.39	0.25	1											
Clay	0.15	0.50*	-0.24	0.14	-0.07	0.12	1										
ECEC	0.36	-0.34	0.29	0.79**	-0.07	0.58*	-0.15	1									
MC	0.70**	0.05	0.52*	0.45	-0.80**	-0.11	0.31	0.23	1								
Mg	0.17	0.37	0.13	0.81**	0.00	0.65*	0.15	0.93**	0.21	1							
OM	-0.16	-0.07	-0.26	-0.19	0.59*	0.55*	0.04	0.04	-0.74**	-0.04	1						
pH(H_2O)	0.02	-0.56	0.31	0.03	-0.08	0.09	-0.90**	0.26	-0.14	0.28	-0.05	1					
Sand	-0.11	-0.47	0.39	-0.04	-0.12	-0.24	-0.97**	0.16	-0.08	0.17	-0.24	0.88	1				
TEA	0.06	0.14	0.33	0.11	0.35	-0.79**	-0.19	0.03	0.37	-0.71**	-0.71**	0.06	0.37	1			
TEB	0.31	-0.39	0.18	0.72**	0.05	080**	-0.30	0.95**	0.10	-0.25	0.25	0.24	0.06	-0.29	1		
TP	0.72**	-0.05	0.47	0.29	-0.81**	-0.06	0.30	0.13	0.93***	-0.70	-0.70	-0.05	-0.11	0.24	0.05	1	
TN	0.13	-0.13	0.10	-0.30	-0.03	-0.02	-0.31	0.05	-0.04	-0.02	-0.02	0.40	0.30	0.12	0.02	0.09	1

CONCLUSION

The result of the study generally revealed that the soils arc structurally fragile and susceptible to erosion. However, soils of Okigwe and Egbema appeared to be more stable than those of Ihiagwa. The studied soils were sandy especially in Ihiagwa having a mean value of 909.6g kg^{-1} and least in Okigwe with 629g kg. Soils were generally acidic, ranging from a pH of 3.83 to 5.12. The soils recorded low organic matter content ranging from0.97 to 1.69% as a result of the parent materials. There were smaller percentage values between the MWDw and MWDd, indicating the potential rate of structures deformation of the aggregate. This leads to severe erosion. The soils of the area should be supported with enough organic manure to increase soil aggregation especially in the soils ofIhiagwa. This will help to improve the water holding capacity, infiltration rates and nutrients retention so as to enhance plant growth and optimum yield.

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