

CHARACTERIZATION AND ERODIBILITY EVALUATION OF SOILS OF MINNA METROPOLIS IN SOUTHERN GUINEA SAVVANA ZONE OF NIGERIA

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ABSTRACT

The study was aimed to evaluate and characterize the erodibility of soils of Minna Township, Niger State Nigeria. Three profiles were sunked in the study area using free survey technique. Soil samples were collected from profile pits based on horizon differentiation and were subjected to routine laboratory analysis. Data generated were analyzed statistically using coefficient of variation. The result indicated that sand particle was predominant over other fine fractions as determined in both water and calgon in all the pedons. Soil pH ranged from 6.35 to 6.90 across the pedons. Organic matter (O.M) had mean value of 1.73%, 1.49% and 2.12% in pedons 1, 2 and 3. Cation exchange capacity (CEC) and available Zn were generally low while available Fe was high in all the studied pedons. The dispersion ratio (DR) ranged from 64.34% to 90.69% and clay flocculation index (CFI) ranged from 9.31% to 35.66% in pedons 1, 2 and 3. The soil pH, CEC, DR and CDI had low variation among horizons of each pedon soil pH and OM correlated positively ($\geq r = 0.190$, $\leq r = 0.44$) with available Fe and Zn. Organic matter correlated negatively with DR, CDI and CFI. Hence the soils were erodible therefore sustainable management practices must be adopted to ensure sustainable productivity and environmental protection in the studied area.

Keywords:-Characterization, Erodibility, Profile pits, Clay dispersion index

INTRODUCTION

The importance of any soil management system lies in the extent to which it can sustain agricultural production without adverse effect on soil water and environment. This soil management and conservation may not be effective unless the soil is reliably, characterized, classified, evaluated and interpreted with regard to land use (Ogunkunle, 2005).

Soil characterization pave way to soil survey and land use planning. It was well take into account the texture organic matter content,

cation exchange capacity, acidity and available phosphorus.

Soils are usually affected and sometimes destroyed by the forces of rainfall and wind causing a phenomenon known as Erosion. Rainfall is the real agent of soil erosion by water in the tropics, by virtue of its role as the source of water or the only form of precipitation contributing to hydrologic cycle. Soil changes soil properties especially physical properties mainly because it removes surface soil rich in organic materials and exposes lower soil layers. Soil are degraded because of erosion but

already degraded soils have a higher erosion risk. It is therefore difficult to separate which is the initial cause. Erosion causes the reduction in infiltration and water storage capacity, nutrient and organic matter content, soil depth, production, vegetation growth and biodiversity (Ogunkunle, 2005).

Soil erosion is one of the most severe forms of land degraded in the world (Nanna, 2016; Solan and Lal, 2011). More than 56% of land degradation is caused by erosion raising a global concern on land productivity (Elirehema, 2011). The problems associated with erosion include economic, political, social and environmental which result due to on site and off site damages. Soil erodibility can be determined using various soil erodibility indices based on soil characteristics. Different workers have employed erodibility indices like clay flocculation index (Igwe and Udegbuma, 2008; Oguike and Mbagwu, 2009; Chris Ementonu and Owerenmadu, 2011) to assess the soil erodibility. Erodibility varies with soil texture aggregates stability, shear strength, soil structures, infiltration capacity, soil depth, bulk density, soil organic matter and chemical composition (Agassi and Badford, 2009).

Therefore there is need to provide the erodibility data which will enable land users such as Agriculturist, Engineers, Town planners to know the areas that are prone to erosion. This will enable them to provide control measures and embrace sustainable land use practices that will help to check the menace of erosion in future.

Soil erosion causes great havoc to our immediate environment to the destruction of likes and valuable properties worth a reasonable amount of money; hence leaving people as victims of its operation. Minna township is not an exception of the menace of this commotion causing losses. Hence, soil characterization and erodibility evaluation of soils in Minna are

considered necessary.

MATERIALS AND METHODS

Description of the study Area.

The study was carried out on Minna in Chanchaga Local Government Area of Niger state, North Central Nigeria. It lies between latitude $9^{\circ} 32' 14.356''$ N and longitude $6^{\circ} 27' 53.418''$ E on elevation of 199-205 m above sea level. The geology of the study area is 15 undifferentiated basement Complex rocks. Ojanuga, 2006. The vegetation is Southern Guinea Savanna Zone of Nigeria, characterized with distinct wet and dry seasons. Mean annual rainfall for Minna is 1,200 mm with 90% of the rains usually falls between the Months of June and August. Mean daily temperature rarely falls below 22°C with Peaks of 40°C and 36°C in Months of February- March and November - December respectively Adeboye *et al*, 2009. Dominant soil type is Typicplinthustal/ HapicPlinthosols (Lawal *et al*, 2012) cultivation of rice, maize, Cowpea and tam of Subsistence level is a common practice in the community.

Site Selection

The first site was located behind college of Education Minna-(profile A) The coordinates of this site was N $06^{\circ} 50.446'$ and E $09^{\circ} 33.345'$, with an elevation of 195m. Minna Murtala Park was designated tube the second site (profile B): 11 has the coordinate of N $6^{\circ} 325'$ and E $09^{\circ} 46.169'$ with an elevation of 1.99m. The third profile pit was located at Army barracks Minna. The coordinate was N $06^{\circ} 52.76'$ and E $09^{\circ} 41.192'$ with an elevation of 201m.

Soil Sampling

A Profile pit was dug on each of the selected sites. Soil Samples were collected based on horizon differentiation according to Schoeneberger *et al* (2012) guidelines. A total of

15 Soil Samples were collected from the three Profile pits. The soil Samples were subjected to routine and Special laboratory analyses.

Laboratory Analyses

Particle size distribution was determined by Bouyoucous hydrometer method (Gee and Or, 2002). Soil pH was measured electrometrically using glass electrode pH meter in a solid water ratio of 1:2.5 (Thomas, 1996). Total nitrogen was determined by the micro-KJeldahl digestion technique Method (Bremner, 1996). Exchangeable bases were determined by the neutral ammonium acetate procedure buffer at pH 7.0 (Thomas, 1982). Exchangeable acidity was got by a method described by Mclean, 1982). Total Carbon was analyzed by wet digestion (Nelson and Sommers, 1996). Phosphorus was determined by Bray 1 Method according to the procedure of (Olsen and Summers 1996) Phosphorus was determined by Bray Method according to the procedure of (Olsen and Sommers 1982). Cation exchange capacity was determined using neutral ammonium acetate leachate method (Summer and miller, 1996) Available micronutrients (Fe and (Zn) were extracted by Diethylene Triamine Penta Acetic acid (DTPA) as described by Sablemedhin and Tage (2000) and all these Micronutrients were determined using atomic absorption Spectrophotometer.

The day-dispersion indices were calculated as follows:-

clay dispersion ratio (DR) = $\{ (\% \text{ silt} + \text{clay}) / (\text{H}_2\text{O}) \} \%$

$\text{Silt} + \text{clay} (\text{calgon}) \times 100$

Clay dispersion Index (CDI) = $15 \text{ clay} (\text{H}_2\text{O}) / (1. \text{clay} (\text{calgon}) \times 100$.

Clay flocculation index (CFI) = $[1. \text{clay} (\text{H}_2\text{O}) / \text{clay} (\text{H}_2) \text{ clay} (\text{Calgon}) \times 100$

The higher the CDR and CDI the more the ability of the soil to disperse while the higher the CFI, the better aggregated the soil. Clay dispersion ratio was used to determine the erodibility of the soils in which greater than 15% are erodible and less than 15% are not credible (middleton-2011).

Statistical Analyses.

The data generated were analyzed statistically using the coefficient of variations as described by Wilding *et al* (1994) to determine degree of variations among horizons of each pedon. However, the correlation matrix was used to determine the relationship among the selected properties of the Soil. Genstat Statistical Software version 811 were used to run the statistical analysis.

3.0 Result and Discussion

3.1 Soil Particle Distribution

The result (Table 1) of the particle size distribution showed that sand particles as determined in both water and calgon dominated over other fractions of soil in all the pedons. The sand particles as determined in water and calgon had low variation ($\geq 4.48 \% \geq 11.33 \%$) in pedons 1 and 3 while it had moderate variation ($\geq 16.22 \% \geq 17.73 \%$) in pedon 2. The sandiness of the study sites is not unconnected with the parent material. This conforms to the findings of (Weil and Brady, 2016) that parent material is a major determinant of soil textural composition. Sand particle increased down the pedon in no specific trend. This is contrary to the assertions of (Osujieke *et al.*, 2017). The high sand particle in some subsurface could be associated to buried horizons as a result of runoff deposit over time. The silt and clay particles as determined in calgon was higher than those determined in water. This resulted due to the ability of calgon to disperse particles efficiently more than water.

The silt particle as determined in water had a mean of 11.03 % , 20.57 % and 19.49 % in pedons 1 , 2 and 3 , respectively . Silt fraction as determined in water and Calgon had low variation (11.03 %) in pedon 1 and moderate to high variation ($\geq 19.49\% \geq 40.80\%$) in pedons 2 and 3. The silt fraction decreased down the pedons in no specific trend . According to the rating (10-25 %) of Hazelton and Murphy (2007), silt content of the pedons was low .

However, silt particles are highly susceptible to erosion. Clay had moderate variation ($\geq 16.37\% \geq 24.70\%$) in all pedons except the pedon 2 of Calgon determined which had low variation (4.23 %). However, clay had no specific trend of increase in all the pedons. The pattern of clay distribution down the pedons indicates that the soils of pedons 1 and 2 are young. This is in line with the findings of Soil Survey Staff (2014).

Table 1: Particle Size Distribution of the Studied Pedons

Horizon	Depth	PSD in H ₂ O			TC	PSD in Calgon			TC
	(cm)	Sand→	Silt %	←Clay		Sand→	Silt %	←Clay	
PEDON 1 (07°51.269' and E09° 46.693', elevation= 157.3m)									
A	0-35	66.4	17.28	16.32	SL	56.8	19.28	23.92	SCL
B1	35-59	68.4	11.28	20.32	SL	59.8	13.28	27.92	SCL
B2	59-117	80.4	7.28	12.32	LS	72.8	9.28	17.92	SCL
B3	117-200	74.4	8.28	17.32	SL	62.8	10.28	26.92	SCL
Mean		72.40	11.03	16.57		62.80	13.03	24.17	
CV		8.74	40.80	19.94		11.33	34.54	18.62	
PEDON 2 (07°51.269' and E09° 46.693', elevation= 157.3m)									
A	0-35	57.4	24.28	18.32	SL	45.8	27.28	26.92	CL
AB	35-46	71.4	14.28	14.32	SL	68.8	18.28	18.92	SCL
BA	46-56	65.4	19.28	15.32	SL	58.8	21.28	19.92	SCL
Bt1	56-62	51.4	24.28	24.32	SCL	42.8	29.28	27.92	CL
Bt2	62-112	51.4	20.28	25.32	SCL	46.8	25.28	27.92	SCL
Bt3	112-150	54.4	26.28	19.32	SCL	46.8	28.28	24.92	SCL
Bct	150-200	44.4	15.28	27.32	SCL	52.8	17.28	29.92	SCL
Mean		56.54	20.57	20.21		51.80	23.85	25.21	

CV		16.22	22.58	24.70		17.73	20.52	4.23	
PEDON 3 (07 °52.076' and E09 °47.192', elevation=171.3m									
A	0-23	63.4	24.28	12.32	SL	55.8	27.28	16.92	SCL
B1	23-57	60.4	22.28	17.32	SL	50.8	24.28	24.92	SCL
B2	57-117	66.4	17.28	16.32	SL	58.8	19.28	21.92	SCL
B3	117-200	66.4	14.28	18.32	SL	56.8	15.28	27.92	SCL
Mean		64.15	19.49	16.07		55.55	21.53	22.92	
CV		4.48	23.31	16.37		6.13	24.69	20.46	

PSD - particle size distribution , TC = textural class , SCL sandy clay loam , CL - clayey loam , CV- coefficient of variation , < 15 - low variability , =15-35 moderate variability , > 35 - high variability

3.2 Soil Chemical Properties and Micronutrients

The pedons (Table 2) were neutral to slightly acidic according to the ratings of Chude *et al.* (2011) . The soil pH had a mean of 6.90, 6.48 and 6.66 in pedons of 1, 2 and 3 , respectively . However, pH had low variation ($\geq 0.98\% \geq 2.08\%$) in all the pedons . The low variation could be associated with homogeneity in parent material and similarity in climatic condition. Soil pH of the study sites could be associated to quantities of variable charge minerals, organic matter and amount and type of clay. However, the pedons were less acidic compared to the finding of Musa and Gililanbe (2017) in soils of Northeast Nigeria . Organic matter was moderate in pedons 1 and 2 and high in pedon 3 according to the ratings of Esu (1991) and Landon (1991) . Organic matter had high variation ($\geq 40.08\% \geq 83.14\%$) in pedons 2 and 3 and low variation (13.70 %) in pedon 1. However, organic matter content was high compared to the finding of Tekwa *et al.* (2011) in soils of Northern, Nigeria.

Organic matter improves the soil structure thereby reducing the erodibility rate of the soil. Total nitrogen was very high while available phosphorus was very low in all the pedons according to the ratings of Landon (1991). However, phosphorus fertilizer should be added into the soil to enhance availability of phosphorus. Total nitrogen and available phosphorus had high variation ($\geq 40.08\% \leq 83.14\%$) in all the pedons except in pedon 3 where total nitrogen had low variation (5.89 %) . The total nitrogen was high while the available phosphorus was low compared to the finding of Tekwa *et al.* (2011) and Musa and Gililanbe (2017) in soils of Northeast Nigeria . The Table 2 showed that potassium was pre dominant over other cations in pedons 1 and 2 while Magnesium was predominant in pedon 3. However, Ca was low; Mg was low while Na and K were high according to the ratings of Landon (1991). This indicates that Ca and Mg are below the critical limit hence there are need to improve their status. The distribution of the

basic cation across the pedons was similar to the work of Gaillyson and David (2013). Cation exchange capacity (CEC) ranged from 3.55 - 3.60 cmol/kg in pedon 1, 3.09 - 4.30 cmol / kg in pedon 2 and 3.86 3.96 cmol / kg in pedon 3. The CEC was found to be below the critical limit according to the rating of Esu (1991). Cation exchange capacity was low and had no specific trend of decrease down the pedons . This agreed to the findings of Gaillyson and David (2013)

.Mulima *et al.* (2015) , also reported of low CEC in soils of Northeast Nigeria . However, the CEC of the pedons were < 24 cmol / kg, this indicated that the pedons have low activity clays and highly weathered according to the finding of Soil Survey Staff (2014). The highly weathered soils are more susceptible to erosion due to the formation of coarse particle which encourages poor aggregation.

Table 2: Selected Chemical Properties and Micronutrient Content of the Pedons

Horiz on	Depth (cm)	pH (H ₂ O)	OM	TN	Av.P	Ca	Mg	Na	K	TEA	CEC	Fe	Zn
PEDON 1 (07°51.269' and E09° 46.693', elevation= 157.3m)													
A	0-35	6.98	2.05	0.11	1.29	0.50	0.88	0.97	0.96	2.09	3.58	20.08	1.90
B1	35-59	6.94	1.69	0.90	0.47	0.39	0.77	0.90	0.94	2.28	3.60	29.05	1.43
B2	59-117	6.81	1.69	0.76	0.93	0.41	1.06	0.99	0.99	2.17	3.60	16.23	1.08
B3	117-200	6.85	1.48	0.70	0.36	0.37	1.03	0.90	1.02	2.13	3.55	59.38	1.20
Mean		6.90	1.73	0.62	0.76	0.42	0.94	0.94	0.98	2.17	3.58	31.18	1.40
CV		1.14	13.70	56.45	56.35	13.74	14.47	4.99	3.58	3.77	0.66	62.69	25.82
PEDON 1 (07°51.269' and E09° 46.693', elevation= 157.3m)													
A	0-35	6.43	2.42	0.10	1.19	0.90	0.40	0.88	0.77	2.00	3.51	6.83	18.78
AB	35-46	6.42	2.12	0.99	0.75	0.82	0.66	0.76	0.79	2.07	3.50	23.93	3.03
BA	46-56	6.61	1.00	0.85	0.72	0.82	0.70	0.66	0.76	2.03	4.30	13.68	2.75
Bt1	56-62	6.40	1.00	0.88	0.53	0.72	0.64	0.60	0.70	2.01	3.68	26.05	0.25
Bt2	62-112	6.45	1.33	0.81	0.43	0.66	0.69	0.70	0.75	2.01	3.75	2.13	1.03
Bt3	112-150	6.35	1.28	0.76	0.43	0.61	0.70	0.63	0.69	2.04	3.88	18.80	2.13
Bct	150-200	6.73	1.28	0.70	0.58	0.61	0.97	0.68	0.79	1.99	3.09	35.45	0.40
Mean		6.48	1.49	0.73	0.66	0.73	0.68	0.70	0.75	2.02	3.67	18.12	4.05

CV		2.08	37.33	40.08	40.08	15.60	24.42	13.39	5.39	1.35	10.18	63.72	162.51
PEDON 3 (07°52.076' and E09° 47.192', elevation= 171.3m													
A	0-23	6.65	2.59	0.99	0.45	0.77	1.02	0.99	0.88	2.21	3.86	26.93	1.03
B1	23-57	6.69	3.12	0.95	0.97	0.68	0.99	0.85	0.53	2.14	3.96	41.00	0.28
B2	57-117	6.72	1.39	0.88	0.24	0.64	0.85	0.87	0.44	2.07	3.86	21.35	0.15
B3	117-200	6.57	1.36	0.88	1.90	0.59	1.01	0.08	0.77	2.14	3.99	4.28	0.63
Mean		6.66	2.12	0.93	0.89	0.67	0.97	0.70	0.66	2.14	3.92	23.39	0.52
CV		0.98	41.68	5.89	83.14	11.37	8.19	59.68	31.25	2.67	1.72	64.93	75.48

OM = Organic matter, TN = total nitrogen, Av P = available phosphorus, TEA = total exchangeable acidity, CEC = cation exchangeable capacity, CV = coefficient of variation , < 15 = low variability, =15 =35 = moderate variability, > 35 = high variability.

Available Fe had a mean of 31.18 mg/ kg in pedon 1, 18.12 mg/ kg in pedon 2 and 23.39 mg/ kg in pedon 3. However, Fe content had a high variation ($\geq 62.69\%$ $\leq 64.93\%$) in all the pedons. The available Fe was high according to the ratings (> 10 mg / kg) of Esu (1991) , and also, it was above the critical level 2.5 - 5.8 recommended by Deb and Sakal (2002) . The available Fe was high compared to the findings of Mulina *et al.* (2015) but similar to the finding of Mustapha *et al.* (2010) in soils of North - east Nigeria. The level of available Fe could be associated with its availability in the parent material. Available Fe increased down in an irregular trend in pedons 1 and 2 while it decreased down in an irregular trend in pedon 3. The available Zn ranged from 1.08 - 1.90 mg/ kg (mean = 1.40mg/kg) in pedon 1, 0.28 - 18.78 mg/kg (mean = 4.05mg/kg) in pedon 2 and 0.15 - 1.03 mg/kg (mean 0.52 mg/kg) in pedon 3. The available Zn had a high variation ($\geq 75.48\%$ $\leq 162.51\%$) in pedons 1 and 2 while it had moderate variation (25.82 %) in pedon 1. However, available Zn was below the critical

limit recommended by Esu , (1991) in pedon 1 , moderate in pedon 2 and high in pedon 3. Generally, with the exception of Ap horizon of pedon2 , the available Zn obtained from other horizons fell below the critical available level of 3.3 mg/ kg as reported by Pam (1990) . Available Zn of the pedons was low compared to the finding of Shehu and Jamala (2010) in soils of Northern Nigeria. Zn decreased down the pedons following no specific trend which is in line with the findings of Ahukaemere *et al.* (2017) . However, researchers (Bassirani *et al.*, 2011 ; Mustapha *et al.*, 2011) have reported on the irregular pattern of distribution of Fe and Zn in pedons in Northeast , Nigeria . Variation of Zn and Fe among the horizons could be associated to soil pH level, organic matter level and phosphate level of the pedons .

Erodibility Indices

The dispersion ratio (DR) had a mean of 68.53 % in pedon 1, 81.04 % in pedon 2 and 70.59 % in pedon 3. However, the DR had low variation (5.55 % 8.45 %) in all the pedons . The DR is

greater than 15 % indicating that the horizons of the pedons are erodible. The DR decreased down the pedons 1 and 3 while it increased down in pedon 2. Soils with high DR are known to be weak structurally and can easily erode. Many researchers have used this index in predicting soil erosion by water (Bajracharya *et al.*, 1992; Igwe , 2005). Clay dispersion index (CDI) had means of 68.53 %, 81.04 % and 70.55 % in pedons 1 , 2 and 3 , respectively . The CDI had low variation (5.04 % 10.83 %) in all the pedons . The CDI followed the similar trend like DR in dis tribution down the pedons. Clay flocculation index (CFI) ranged from 27.22-35.66 % in pedon1 , 8.69-31.95 % in pedon 2 and 25.55 - 30.50 % in pedon 3. However, CFI had low

variation (8.60 % 10.97 %) in pedons 1 and 3 while it had high variation (946.29 %) in pedon 1. The CFI increased down the pedons 1 and 3 in no specific trend while it decreased down the pedon 2 in no specific trend. The clay - flocculation index (CFI) is also another index that shows the ability of the soils to resist dispersion in water . The CFI of the soils are low and a direct inverse of CDR. The result of the research, when compared to the finding of Oguike and Mbagwu (2009) in soils of Southern Nigeria shows that DR and CDI were high while CFI was low. Igwe and Udegbumam (2008), also reported that the DR , CDI , and CFI were high when compared to the soils of Southern Nigeria .

Table 3: Erodibility Indices used for the Pedons

Horizon	Depth (cm)	DR	CDI	CFI
PEDON 1 (07°51.269' and E09° 46.693', elevation= 157.3m)				
A	0-35	77.78	68.23	31.77
B1	35-59	76.70	72.78	27.22
B2	59-117	72.06	68.75	31.25
B3	117-200	68.82	64.34	35.66
Mean		73.84	68.53	31.47
CV		5.64	5.04	10.97
PEDON 1 (07°51.269' and E09° 46.693', elevation= 157.3m)				
A	0-35	78.60	68.05	31.95
AB	35-46	76.88	75.69	24.31
BA	46-56	83.98	76.91	23.09
Bt1	56-62	84.97	87.11	12.89
Bt2	62-112	86.69	90.69	9.31
Bt3	112-150	85.71	77.53	22.47
Bct	150-200	90.25	91.30	8.69
Mean		83.87	81.04	18.96
CV		5.55	10.83	46.29

PEDON 3 (07°52.076' and E09° 47.192', elevation=

171.3m

A	0-23	82.81	72.81	27.19
B1	23-57	80.49	69.50	30.50
B2	57-117	81.57	74.45	25.55
B3	117-200	68.52	65.62	30.38
Mean		78.35	70.59	28.41
CV		8.45	5.53	8.60

DR= dispersion ratio, CDI= clay dispersion index, CFI= clay flocculation index, CV = coefficient of variation, < 15 = low variability, =15 =35 = moderate variability, > 35 = high variability.

3.4 Correlation Matrix between Selected Soil Properties and Erodibility Indices

Table 4 shows the result of the correlation matrix between selected soil properties and erodibility indices. Sand particle had highly significant negative relationship ($r = -0.674$, $r = -0.817$, $r = -0.759$, $r = -0.769$, $p = 0.01$) with silt, clay, DR, CDI, and CFI . Clay particle had positive relationship ($r = 0.526$) with DR ; highly significant positive relationship ($r = 0.743$, $p = 0.01$) with CDI and highly significant

negative relationship ($r = -0.765$, $p = 0.01$) with CFI . However, DR had a positive relationship ($r = 0.836$) with CDI but a highly significant negative relationship ($r = -0.802$, $p = 0.01$) with CFI . CDI had a highly significant negative relationship ($r = -0.993$, $p = 0.01$) with CFI . Organic matter had a negative relationship ($r = -0.166$, $r = -0.462$, $r = . 0.462$) with DR , CDI , and CFI . Igwe and Udegbonam (2008), also reported on the highly significant relationship between CFI and clay .

Table 4: Relationship between Selected Soil Properties and Erodility Indices

	Sand	Silt	Clay		DR	CDI	CFI	OM
								
	%							
Sand	1							
Silt	-0.674**	1						
Clay	-0.809**	0.188	1					
DR	-0.817**	0.653**	0.526		1			
CDI	-0.759**	0.323	0.743**		0.836	1		
CFI	-0.769**	-0.313	-0.765**		-0.802**	-0.993**	1	
OM	0.175	0.185	-0.445		-0.166	-0.462	-0.462	1

OM= organic matter, DR= dispersion ratio, CDI= clay dispersion index, CFI= clay flocculation index

3.5 Correlation Matrix between Selected Soil Properties and micronutrients

Table 5 shows the correlation matrix between selected soil properties and micronutrients. Available Fe had a positive relationship ($r = 0.441$, $r = 0.190$, $r = 0.192$) with pH (H_2O) , OM and total nitrogen . Available Fe also had a negative relationship ($r = -0.013$, $r = -0.415$, $r = -0.302$) with clay , available phosphorus and cation exchange capacity . Available Zn correlated negatively ($r = -0.074$, $r = -0.169$, r

$= -0.329$) with clay , CEC and Fe while it had a highly significant negative correlation ($r = -0.656$, $p = 0.01$) with total nitrogen . However, available Zn correlated positively ($r = 0.308$, $r = 0.299$, $r = 0.273$) with pH (H_2O) , OM and available phosphorus . Iyaka and Kakulu(2009) , have reported that Zn correlated positively with pH and organic matter . The negative correlation between Fe and Zn was contrary to the findings of Oyinlola and Chude (2010).

Table 4: Relationship between Selected Soil Properties and Micronutrient

	Clay (%)	pH (H_2O)	OM → %	TN ← %	Av.P (mg/kg)	CEC (cmol/kg)	Fe →	Zn ←
Clay	1							
pH (H_2O)	-0.227	1						
OM	-0.445	0.141	1					
TN	-0.048	-0.174	-0.140	1				
Av.P	-0.183	0.028	0.236	-0.373	1			
CEC	-0.391	-0.199	-0.046	0.354	0.114	1		
Fe	-0.013	0.441	0.190	0.192	-0.415	-0.302	1	
Zn	-0.074	0.308	0.299	-	0.273	-0.169	-0.329	1

0.656**

OM = Organic matter, TN = total nitrogen, Av P = available phosphorus, TEA = total exchangeable acidity, CEC = cation exchangeable capacity.

4. Conclusion

The result obtained showed that the study sites were generally sandy and neutral to slightly acidic. The organic matter was moderate, total nitrogen was high, available phosphorus was very low, and CEC was low in all the sites. Available Fe was above recommended critical limit while Zn was below the recommended critical limit. However, the result as indicated by the dispersion ratio, clay dispersion index and clay flocculation index showed that the soils

of the study area are erodible.

The detrimental effects of erosion on agriculture and infra structural development in any place cannot be over emphasized. However, sustainable soil management practices such as cover cropping, conservation tillage, terracing of slopes, grassing of bare areas, windbreak and construction of conveyance have to be adapted to control the established gullies, as well as to prevent further deterioration.

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