

## TAXONOMIC CLASSIFICATION AND SUITABILITY EVALUATION OF SELECTED SOILS OF GBOKO FOR YAM AND CASSAVA PRODUCTION.

## CLASIFICACIÓN TAXONÓMICA, EVALUACIÓN E IDONEIDAD DE SUELOS SELECCIONADOS DE GBOKO-SOUTH PARA LA PRODUCCIÓN DE ÑAME Y MANDIOCA.

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### ABSTRACT

This study evaluated soil fertility status of Gboko-South in Gboko Local Government Area and their suitability for cassava and yam production. Auger point investigations were carried out at 100 m intervals along traverses spaced at 100 m apart. Three soil units were identified on the field based on soil colour, structure, textures, surface characteristics and topography. The results showed that the soil units were deep (102 – 141 cm) and well drained except unit I that was poorly drained. The soils were coarse-textured and slightly to moderately acidic in reaction with pH values which ranges from 5.38 – 6.50. They had low organic matter contents ranging from 0.20 to 0.95 % and high base saturation which ranged from 76 to 86 %. The soils were classified as Typic Epiaqualfs/Epigleyic Stagnosols, Arenic Haplustalfs/Eutric Luvisols, and Eutric Haplustept/Eutric Haplic Luvisols. Soils of unit I (Pedon I and II), unit II (Pedon III and IV) and unit III (Pedon V and VI) were evaluated to be moderately suitable for cassava and yam production.

Keywords: Soil, Taxonomic classification, Suitability evaluation, Land suitability assessment, Yam and Cassava.

## RESUMEN

Este estudio evaluó el estado de fertilidad del suelo de Gboko-South en el área del gobierno local de Gboko y su idoneidad para la producción de yuca y ñame. Las investigaciones del punto de barrena se llevaron a cabo a intervalos de 100 m a lo largo de recorridos espaciados a 100 m de distancia. Se identificaron tres unidades de suelo en el campo en función del color del suelo, la estructura, las texturas, las características de la superficie y la topografía. Los resultados mostraron que las unidades de suelo eran profundas (102 - 141 cm) y bien drenados, excepto la unidad I que estaba mal drenada. Los suelos eran de textura gruesa y de reacción leve a moderadamente ácida con valores de pH que oscilaban entre 5,38 y 6,50. Tenían bajos contenidos de materia orgánica que oscilaban entre 0,20 y 0,95% y una alta saturación de bases que oscilaba entre 76 y 86%. Los suelos se clasificaron como Typic Epiaqualfs / Epigleyic Stagnosols, Arenic Haplustalfs / Eutric Luvisols y Eutric Haplustept / Eutric Haplic Luvisols. Los suelos de la unidad I (Pedon I y II), la unidad II (Pedon III y IV) y la unidad III (Pedon V y VI) se evaluaron como moderadamente adecuados para la producción de yuca y ñame.

Palabras clave: suelo, clasificación taxonómica, evaluación de idoneidad, evaluación de idoneidad de la tierra, ñame y mandioca.

## INTRODUCTION

Soils are important natural resource and foundational materials for crops, houses, roads and buildings. In order to ensure that the soil is put to the most appropriate and sustainable agricultural use, there is a need to know its fertility content/characteristics. Soil fertility refers to the ability of a soil to supply essential plant nutrients to sustain plant growth and production (Dabbert, 1994). The fertility status of any soil deteriorate with changes in land use (forest, fallow, grass and cultivated land) especially with conversion of the natural ecosystem to crop land under continuous cultivation for increased production of food and other materials needed by man and animal for the growing population (Ezeaku and Alaci, 2008). The people of Gboko Local Government Area are predominantly farmers, who specialized majorly in tuber and cereal crops: maize, sorghum, yams, cassava, tomatoes, pepper, rice and soybeans. Due to the growing population and shelter needs of Gboko Local Government Area, there has been serious competition on land ownership and their usage (Adamgbe and Ujoh, 2013). As a result of these, soils of this area have been under pressure; from agricultural use to human settlement, and from natural vegetation to continuous cultivation leading to decrease in agricultural productivity. The clearing of the natural vegetation and its conversion to arable farm land has resulted in decreased soil fertility (Cronon, 1983). Similarly,

continuous cultivation under different types of landuse has greatly affected soil organic matter (SOM), water and nutrient holding capacities of these soils (Lal, 1995).

Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide optimal ecological requirements of a certain crop variety. Thus evaluation needs a specification of the respective crop requirements and calibrating them with the terrain and soil parameters (Dent and Young, 1981). The identified limiting factors could be managed to suite various crop requirements and improve crop productivity. This is a pre-requisite to productivity maximization in agricultural sector. Land evaluation provides avenue for sustainable land use since land will be used according to its capability. This therefore, makes it mandatory to carry out land suitability in order to ensure that the selected site is suitable and capable of sustaining long term production of crops. Cassava (*Manihot esculenta*) and yam (*Dioscorea* spp) were the most common staple crop grown in Gboko, Benue State. There is dearth of information on soils of Gboko Local Government area in these regards. Therefore, the objective of this study is to characterize and classify some soils of the area at detailed level and evaluate the suitability of the soils for cassava and yam production.

#### MATERIALS AND METHODS

**Study area:** the study was conducted within Gboko Local Government Area of Benue State, located between latitudes 7<sup>o</sup>13' and 7<sup>o</sup>35'N and longitudes 8<sup>o</sup>30' and 9<sup>o</sup>03'E. Gboko L.G.A. is bordered to the north by Tarka and Buruku Local Government Areas, to the south by Konshisha Local Government Area, west by Gwer Local Government Area and southeast by Ushongo Local Government Area. It comprises of five districts which include: Mbatieriv, Mbayion, Mbativ, Yandev and Ipav.

The area experiences a tropical humid climate, characterized by distinct wet and dry seasons. The wet season which is the planting season starts from April to October while the dry season starts from November to April and is regarded as the harvesting period. Rainfall is convectional and varies between 1000 and 1500mm per annum. The rainiest months are July and September. The mean monthly temperatures in the area ranged between 28 and 32<sup>o</sup>C while relative humidity values ranged between 80 and 85%. The mean annual temperature is 30<sup>o</sup>C, while the mean relative humidity is 82.5% (Tyubee, 2006).

The area consists generally of rolling plains with isolated hills at Mkar and Gboko town. The area is drained by streams and rivers: Kontein, Ahungwa, Ambor, Ngo, Nguebi and the head stream of river Konshisha (Kowal and Knabe, 1972). The study area is situated within the guinea savannah vegetation zone characterized by varying proportion of scattered tall trees and grasses. The tree

species include *Vitellaria paradoxa*, *Gmelina arborea*, *Mangifera indica*, *Isobaelina doka* and *Daniella olivera*.

Field study: the grid method of soil survey was employed in the field with auger point investigations at 100 m intervals. Three soil units were identified on the basis of soil colour, structure, textures, surface characteristics and topography. Two pits in each soil unit were sunk and described according to the guidelines for soil profile description (USDA Soil Survey Staff, 2014). Soil samples were collected from identified soil horizons and carefully labeled for laboratory analysis.

Laboratory Analysis: all the laboratory determinations were carried out at the Department of Soil Science Laboratory, University of Agriculture, Makurdi. Appropriate laboratory procedures were employed to determine some physical and chemical characteristics of the soils (Udo and Ogunwale, 1986, IITA, 1979, Day, 1965, Hesse, 1971, Black, 1965). The soil characteristics analysed include; soil pH, particle size distribution (sand, silt and clay), organic matter (OM), organic carbon (OC), available phosphorus (P), exchangeable acidity (EA), exchangeable base (basic cations like Ca, Mg, Na and K), effective cation exchange capacity (ECEC) and total nitrogen (N) (Table 3).

Suitability Classes in the Study Area: the suitability of soils for production of cassava and yam was assessed using the principle of limiting condition (FAO, 1995). The soils were placed in suitability classes by matching their characteristics with requirements of the crops and overall suitability class of the soils was that indicated by its most limiting characteristics for conventional approach (FAO, 1995). Detailed land and soil requirements for cassava and yam according to Sys (1985) were adopted as presented in Table 1. The profile descriptions summarizing the soil characteristics were presented in Table 4 and 5 to give over view of the soil information alongside other land characteristics in order to arrive at aggregate suitability classes.

## RESULTS AND DISCUSSION

Soil morphological characteristics: the units were generally low-lying with slope gradient ranging from 0-4%. The morphological characteristics of the soils are presented in Table 3. The soils were deep ranging from 102 to 141cm. The soils were well developed, having strong to moderate coarse and medium sub angular blocky. The good structural development could have been influenced by the high clay content of the soils (Idoga, 1985). Surface soil textures were generally sandy loam, while the sub-surfaces varied from sandy loam to clay loam. The soils include Yellowish brown (10YR3/4) Sandy loam; Brown (10YR5/3) loamy sand; Light reddish brown (5YR6/3) loamy sand; Brown (7.5YR5/4) loamy sand; Brown (7.5YR5/4) loamy sand; to Dark brown (7.5YR4/4)

loamy sand. This colour differences may be due to the differences in organic matter which is the main colouring agent in especially the top soil (Ufot, 2012, Brady and Weil, 2014).

Table 1. Land and soil requirements for yam and cassava production

	Land Qualities classes/grades				
	100-85	85-60	60-40	40-25	<25
	S1	S2	S3	N1	N2
Theoretical requirements					
Climate (c)					
Mean annual rainfall (mm)	1000-1800/ 1800-240	750-600/ >2400	600-550	550-500	<500
Mean annual temperature (°C)	20-30/ 20-18	>30/ 18-16	16-14	14-12	<12
Soil texture	L, SCL, CL, SL, SiCL, SiC	Cs, LFs, LS, LCS, Fs	CS, S, Cs	SC, Cm	Cm, S
Fertility (f)					
CEC (Cmol/kg)	>16	<10	<10	<5	<5
Base saturation (%)	>35	35-15	15-10	<10	<10
Organic matter (g/kg OC) (0-15 cm)	>15	>8	>5	<3	<3

Source: Sys (1985)

Symbols used for soil texture and structures are defined as follows: Cs= structural clay; Cm = massive clay; SiC = silty clay; SiCL = silty clay loam; CL = clay loam; Si = silt; L = loam; SCL =sandy clay loam; SL = sandy loam; LFs = loam fine sand; LCS = loam coarse sand; Fs = fine sand; S = sand

Soil Physical Characteristics: table 3 shows the physical properties of soils of the study area. The clay content increased with depth in all the pedons and ranged from 7.6% in the A horizon to 25% in B horizon, which may be as a result of some pedogenic processes such as lessivage, eluviation and illuviation and moreso, differences in topography and the intensive of cultivation. The clay contents were higher in the surbsurface than the surface horizons. This is in agreement with the observations made by Idoga, (2002) and Ugwu *et al*, (2001) where they asserted that clay content generally increases with depth due to some pedogenic processes such as lessivage, eluviations, and illuviation as well as the contribution of the underlying geology through weathering.

The sand fraction decreased with depth in all the pedons except in the fourth horizon of pedon 2 and ranged from 55.7 to 81.2%. The silt content increased regularly with depth which agrees with observation made by Miura *et al.*, (1997). The irregular distribution pattern of the percentage silt may be attributed to the differences in relief and the rate of deposition of accumulated materials brought down from the upper slope by fluvial processes. The very low silt content of the soils may be due to excessive washing away of the soil particles by water erosion and runoff (Idoga and Ogbu, 2012).

Table 2. Morphological Description of the Pedons in the Study Area

Horizon	Depth (cm)	Munsell colour	Mottling	Mottling details	Texture	Structure	Boundary
Unit I: Pedon 1		Typic Epiaqualfs/Epigleyic Stagnosols					
A	0-8	10YR3/4	7.5Y4/2	F1F	SL	2MG	as
AB	8-32	10YR5/4	7.5YR5/6	F1F	"	2MSBK	cw
Bt <sub>1</sub>	32-77	10YR8/4	7.5YR5/4	C2F	"	2MSBK	gs
Bt <sub>2</sub>	77-109	10YR7/2	-	-	SCL	2MSBK	-
Unit I: Pedon 2		Typic Epiaqualfs/Epigleyic Stagnosols					
A	0-6	10YR5/3	7.5YR4/4	C1F	LS	1MCR	as
Bt <sub>1</sub>	6-27	5YR7/1	-	-	"	2MSBK	as
Bt <sub>2</sub>	27-69	5YR8/2	5YR5/8	M2F	SCL	3MSBK	gs
Bt <sub>3</sub>	69-133	5YR8/3	5YR5/6	F2F	"	3MSBK	cw
Bt <sub>4</sub>	133-141	7.5Y7/.	-	-	"	3MSBK	-
Unit III: Pedon 3		Arenic Haplustafs/Eutric Luvisols					
A	0-17	7.5YR5/4	-	-	LS	1FCR	cw
AB	17-60	5YR6/3	-	-	"	2MSBK	cw
Bt <sub>1</sub>	60-103	7.5YR6/4	-	-	SCL	3CSBK	-
Unit III: Pedon 4		Arenic Haplustafs/Eutric Luvisols					
Ap	0-13	7.5YR4/4	-	-	LS	1FG	cw
Bt <sub>1</sub>	13-56	5YR2/1	-	-	SL	2CSBK	cw
Bt <sub>2</sub>	56-97	7.5YR3/3	-	-	"	2MSBK	gs
Bt <sub>3</sub>	97-140	5YR4/2	-	-	"	3FSBK	-
Unit V: Pedon 5		Eutric Haplustept/Eutric Haplic Luvisols					
A	0-12	7.5YR2/5	-	-	SL	2FCR	as
B <sub>1</sub>	12-50	7.5YR2/1	-	-	"	2MSBK	cw
B <sub>2</sub>	50-102	7.5YR5/8	-	-	SCL	3MSBK	-
Unit V: Pedon 6		Eutric Haplustept/Eutric Haplic Luvisols					
A	0-19	5YR2/3	-	-	SL	1FG	cw
B <sub>1</sub>	19-70	7.5YR2/5	-	-	"	2CSBK	ds
B <sub>2</sub>	70-116	7.5YR5/6	-	-	SCL	3FSBK	-

Mottles detail: F1F = few fine faint, C2D = common medium distinct, F2F = few medium faint, C3D = common strong distinct, F1D = few fine distinct, M2D = moderate medium distinct,

Texture: SL = sandy loam, SCL = sandy clay loam, LS = loamy sand

Structure: 2MG = moderate medium granular, 2CG = moderate coarse granular, 2MSBK = moderate medium subangular blocky, 1MCR = weak medium crumbs, 3SBK = strong subangular blocky, 2CSBK = moderate coarse subangular blocky, 3CSBK = strong coarse subangular blocky, 3FSBK = strong fine subangular blocky, Ma = massive

Boundary: AS = abrupt smooth, CW = clear wavy, GS = gradual smooth, DS = diffuse smooth

The soil structures were commonly weak to moderate fine crumbs and weak to moderate fine, medium and coarse granular at the surface and moderate to strong, medium to coarse subangular blocky in the subsurface horizons. These may be attributed to the weight of overlying horizons and fine textures due to influence of the underground water in Bt1 and B4 horizons (Idoga, 1985). The weak surface structures could be due to low content of soil organic matter (Akinyemi and Vivian, 2001).

Soil Chemical Characteristics: soil chemical properties are presented in Table 3. The soils were slightly to moderately acid in reaction with pH values ranging from 5.38 to 6.55 in H<sub>2</sub>O which may be caused the high rainfall experienced in this areas. The pH values decreased with depth in all the pedons which may be attributed to the effect of nutrient biocycling (Ogunwale *et al.*, 2002). This is in agreement with the work of Idoga and Ogbu, (2012) who attributed decrease in soil pH with depth to frequent crop harvesting and leaching of bases. The organic carbon and the total nitrogen were low (9.5 and 1.05 gkg<sup>-1</sup>). The amount and distribution of total nitrogen correlated positively with that of organic carbon. This is because the two occur in relatively fixed ratios (Ayolagha and Opene, 2012). Based on the rating by Metson (1961), the soils were very low in nitrogen content. This implies that the crops grown in the soils are likely to respond to N-application (Asadu and Nweke, 1999). The low organic carbon content of the soils may be due to continue cropping, bush burning, high erosive rate, grazing and poor management of the soils. Ogbu *et al.* (2019) also attributed low organic carbon of the soils to continue cropping for long period, bush burning, high erosive rate, grazing, harvested crop residues without replacement and very poor management activities. Available P was rated low with values ranging from 2.50 to 4.20 mgkg<sup>-1</sup> according to the rating by Landon (1991) and Metson (1961). The low P in soils may be related to intensity of weathering or soil disturbance, low pH level which fixed the P and make it unavailable. It may also be attributed to the low amount of organic carbon, continue cropping, crop removal, erosion of P-carrying particles, P dissolved in surface runoff and leaching due to the coarse nature of the soils. Exchangeable bases (Ca, Mg, K and Na) were low in all the soil units. Calcium was the most prevalent cation on the exchange complex with values ranging from 3.10 to 4.60 cmolkg<sup>-1</sup>. This might be linked to the occurrence of exchange sites which have specific affinity to Calcium (Idoga, 1985) or might be attributed to the fact that Calcium is least easily lost from exchange site or has high displacement ability over other cations in exchange reaction. The low exchangeable bases of these soils may be due to the underlying materials, intensity of weathering, leaching, low activity clay, very low organic matter content and the lateral translocation of bases (Krasilnikoff *et al.*, 2002; Kang, 1993). The Mg values ranged between 1.44 and 2.50 cmolkg<sup>-1</sup> while that of K and Na ranged from 0.22 to 0.50 cmolkg<sup>-1</sup> and 0.46 and 0.77 cmolkg<sup>-1</sup> respectively. These values confirmed the predominance of Calcium follow by Mg over K and Na as observed by Idoga, (1985),

and Ogunkunle, (1989). Percentage base saturation values for all soils were generally high (79 to 88 %) which implies that the soils have high fertility potential (Landon, 1984). This could also be attributed to the presence of weathered minerals which release nutrients into the soil and also their alluvial nature. Generally, correlation exists between the base status and pH. As the base status decreased owing to the loss in calcium and other metallic constituents, the pH also decreased in a more or less definite proportion.

Land suitability evaluation: the result of matching the land qualities/characteristics (Table 2 and 3) with the land requirements (Table 1 and 2) as represented by characteristics of the profiles with the requirement of the crops produced various suitability classes for the various crops given in Table 4 and 5. Land suitability evaluation is the process of assessing the suitability of land for specific kinds of use (Ufot, 2012, Brady and Weil, 2014). Land suitability rating involves matching of crop requirements with the land qualities (FAO, 2016). It is the fitness of a given traits of soil for a specific kind of land use. It is the effects of individual land qualities on specific use. The suitability rating of Gboko soils were carried out by comparing the qualities of the soils with the requirements of yam and cassava. The chemical characteristics of the soils such as pH, organic carbon, total N, available P, exchangeable bases, exchange acidity and ECEC were found to be either conducive to yam and cassava production or can be amended by individual farmers and therefore could not be considered as permanent limitations. Pedons were placed in suitability classes by matching their characteristics (Tables 2 and 3) with the land requirements of yam and cassava production in the study area. Soil depth, drainage, slope, texture and structure are important physical characteristics that influence water retention. The relatively low content of soil organic carbon, total N, available P, exchangeable bases and ECEC gave an indication of low nutrient status of the soils of Gboko (Table 3). For soil of pedons I and II, the major limitations were drainage. Though, the high clay content and the good structural development of the soils positively influence water retention for plant use. They are therefore grouped as S2-d, which implies moderately suitable for cassava and yam cultivation. This implies that, the individual farmer who cultivates these soils needs little human manipulation to have maximum yield of yam and cassava. Soils of pedon III and IV were gravely and limited in nutrient and depth by lateritic ironstone. They are also moderately suitable for yam and cassava cultivation. The slightly to moderately acidic reaction (5.38 to 6.50) of these units and the high base status are also favourable for yam and cassava production. For soil of pedons V and VI, their major limitations were basically low nutrients and therefore grouped as S2-n. These soils were moderately suitable for yam and cassava cultivation.

Soil classification based on USDA soil taxonomy: the USDA Soil Taxonomy (Soil Survey Staff, 2014) was used to classify the soils according to their morphological, physical and chemical properties. The clay distribution pattern showed that there were argillic horizons in all the pedons

studied except pedons 4, 7 and 10. The clay distribution pattern together with the high base status of the soils qualified them as Alfisols. The presence of mottles and gleyic colour in pedon I and II further qualified the soils of as Aqualfs. The position of the mottles right at soil surface further qualified them as Epiaqualfs implying episaturation. These soils were classified as Typic Epiaqualfs which correspond with Epigleyic Stagnosols of the world reference base (WRB) for soil resources (FAO, 2006). Pedons III, IV, V VI had Ustic moisture regime because they remain dry for more than 90 consecutive days, and therefore qualified as Ustalf. Pedons III and IV were classified as Arenic Haplustafs because they had a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more. This corresponds with Epigleyic Stagnosols of WRB for soil resources (FAO, 2006). Soil pedons V and VI qualified as Haplustept because of their simple horizon designation, ustic moisture regime because they remain dry for more than 90 days. Due to the high base saturation they are therefore classified as Eutric Haplustept/Eutric Haplic Luvisols.



Bt <sub>1</sub>	60-03	65.7	14.3	20.0	SCL	6.00	4.2	0.70	3.5	4.50	2.30	0.45	0.78	8.03	1.56	9.13	82
Unit III: Pedon 4		Arenic Haplustalfs/Eutric Luvisols															
Ap	0-13	81.2	11.2	7.6	LS	6.35	8.8	0.96	3.1	3.58	1.80	0.25	0.61	6.24	1.23	7.25	86
Bt <sub>1</sub>	13-56	73.3	12.6	15.1	SL	6.12	6.4	0.81	2.7	3.79	1.93	0.42	0.65	6.79	1.34	7.96	85
Bt <sub>2</sub>	56-97	69.5	14.2	16.3	SL	5.86	4.8	0.77	2.9	3.99	1.99	0.44	0.68	7.10	1.47	8.40	85
Bt <sub>3</sub>	97-140	67.4	15.1	17.5	SL	5.71	3.9	0.66	3.8	4.17	2.10	0.46	0.73	7.46	1.51	9.50	84
Unit V: Pedon 5		Eutric Haplustept/Eutric Haplic Luvisols															
A	0-12	72.0	12.2	15.8	SL	6.20	7.9	0.88	3.0	3.38	1.76	0.27	0.60	6.01	1.65	7.20	83
Bt <sub>1</sub>	28-50	66.4	14.2	16.4	SL	5.80	6.2	0.71	3.3	3.90	1.95	0.36	0.69	6.90	1.73	8.40	82
Bt <sub>2</sub>	50-102	64.2	15.2	17.0	SCL	5.71	5.3	0.71	3.7	4.30	2.19	0.45	0.77	7.71	1.67	9.50	81
Unit V: Pedon 6		Eutric Haplustept/Eutric Haplic Luvisols															
A	0-19	70.2	13.1	16.7	SL	6.40	8.6	0.80	3.6	3.45	1.66	0.28	0.56	5.95	1.70	7.38	81
B <sub>1</sub>	19-70	66.0	14.5	17.0	SL	6.26	5.8	0.69	3.0	3.84	1.89	0.33	0.62	6.68	1.74	9.30	80
B <sub>2</sub>	70-116	62.3	16.3	17.2	SCL	5.98	5.0	0.56	2.5	4.42	2.3	0.50	0.77	7.99	1.80	9.78	80

Table 4. Suitability class scores and aggregate suitability classification of the soils for yam and cassava

Pedon	MAR	MAT	Texture	CEC (cmol/kg)	BS (%)	OM (g/kg)	ASC	SuC
I	S1	S1	S1	S3	S1	S2	S2	S2f
II	S1	S1	S1	S3	S1	S2	S2	S2f
III	S1	S1	S2	S3	S1	S3	S2	S2f
IV	S1	S1	S1	S3	S1	S3	S2	S2f
V	S1	S1	S1	S3	S1	S3	S2	S2f
VI	S1	S1	S1	S3	S1	S3	S2	S2f

MAR = Mean Annual Rainfall; MAT = Mean Annual Temperature; CEC = Cation Exchange Capacity; BS = Base Saturation; OM = Organic Matter; ASC = Aggregate Suitability Class; SuC = Suitability subclass with fertility (f) limitation; S1 = Highly Suitable; S2 = Moderately Suitable; S3 = Marginal Suitable.

As conclusion, three major soil units were identified in the area. The soils were deep, well drained except unit I that was poorly drained and had sandy loam to loamy sand and sandy clay loam texture. They were generally moderately acid in reaction with pH values ranging from 5.38 to 6.50. This pH range is safe for any sustainable crop production. Based on the above physical and chemical properties of the soils, they were classified as follows: Typic Epiaqualfs/Epigleyic Stagnosols, Arenic Haplustalfs/Eutric Luvisols, and Eutric Haplustept/Eutric Haplic Luvisols. From the study, it can be concluded that all the units were moderately suitable for cassava and yam production. The major constraints were drainage and unfavourable soil fertility. However, these can be ameliorated through a well-planned soil nutrient application.

#### REFERENCES

- Adamgbe E.M. and Ujoh F. (2012). Effect of rainfall variability on maize yield in Gboko, Nigeria. Peer Reviewed Journal of Environmental Protection (JEP). Publication of scientific research inc. Delaware, USA. September 2013, 4, 881887
- Asadu, C.L.A. and Nweke, F.I. (1999). The soils of cassava-growing areas in sub-Saharan Africa COSCA Working Paper No. 18. Collaborative Study of Cassava in Africa. RCMD, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 199pp
- Ayolagha, G.A. and Opene, G.A. (2012). Characterization and Classification of Selected Soils of Ndoni in the Meander Belt of Niger Delta. Nigerian Journal of Soil Science Vol. 22 (2) 54p
- Black, G.R. (1965). Bulk density In: Methods of Soil Analysis. Part 1 (Ed.): Black, C.A. American Society of Agronomy. Madison, Wisconsin, USA. Pp. 375-390

- Brady, N.C and Weil, R.R. (2014). *The Nature and Properties of Soils'* 14<sup>th</sup> ed. Prentice Hall. New Jersey, USA. 960pp
- Cronon, W. (1983) *Changes in the Land: Indians, Colonists, and the Ecology of New England*, NY: Hill & Wang, p. 145-152
- Dent, D. and Young, A. (1981). SOIL Survey and Land Evaluation. George Allen and Unwin Ltd., Derived Savanna Area of Southwestern Nigeria. *International Journal of Soil Science*, 6
- Ezeaku, P. I. an Alaci, D. (2008). Analytical situations of land degradation and sustainable management strategies in Africa. *Pakistan J. Agric. Soc. Sci.*, 4:42-45.
- Fagbami, A., and F.O.R. Akamigbo (1986). Soils of Benue State and their Capabilities. Proceedings of the 14<sup>th</sup> Annual Conference of soil Science Society of Nigeria Held in Makurdi pp6-23
- FAO (1995). GUIDELINES, Land Evaluation for Rainfall Agriculture. Soil Resources Managejent and Conservation Services, Land and Water Development Division Rome. FAO Soil Bulletin. 52m pp. 237
- Day. P.R. (1965). Particle fraction and particle size analysis. In: C.A. Black(ed), *Methods of Soil Analysis, Agron.9.ASA*, Madison, Wisconsin,USA, Pp547-577
- Hesse, R.P. (1971). A textbook of soil chemical analysis. John Murray Publishers Ltd., London. Pp8-184
- IITA, (1979). Method of Soil and Plant Analysis. *International Institute for Tropical Agriculture Publications*
- Idoga, S. (1985). The Relationship of Topography to Soils and Vegetation inn the Northern Guinea Ecosystem, Nigeria. MSc thesis Submitted to the Department of Soil Science, Ahmadu Bello University, Zaria, Nigeria. 182p
- Idoga, S. (2002). Characterization and Effects of Hamaterm Dust on the Soils of Lower Benue Valley, Nigeria. Unpublished Ph.D. Thesis, Dept. of Soil Science UAM, Benue State, Nigeria. 130pp.
- Idoga, S. and Ogbu, O.J. (2012). Agricultural Potentials of the Andibilla Plateau of Benue State, Nigeria. *Nigeria Journal of Soil Science*. 22(2): 124-228
- Kang, B.T. (1993). Changes in Soil Chemical Properties and Crop Performance with Continuous Cropping on an Entisol in the Humid Tropics. In Mulongoy, K. and R. Merckx (eds) *Soil Organic Matter and Sustainability of Tropical Agriculture*: John Willey and Sons (UK), KU Lenven (Belgium) and IITA (Nigeria) pp 297-305
- Kowal, J.M. and Knabe, D.I. (1972). An Agroclimatological atlas of Northern States of Nigeria, Ahmadu Bello University, Zaria. Pp 111
- Krasilini-Koff, G., Gahoonia, T.S. and Nielsen, N.E. (2002). Rice Products in the subtropical Africa Wet land Soils
- Lal, R. 1995. Erosion crop productivity relationships for soils of Africa. *Soil Sci. Soc. Am. J* 59:661-667.

- Landon, J.R. (1984). Booker Tropical Manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Booker Agricultural International Ltd. UK.
- Malgwi, W.B. (1979). A study of soils in the high plains of Hausa Land, Samaru, Zaria Nigeria. M.Sc Thesis, Department of Soil Science A.B.U. Zaria, Nigeria. 126p
- Metson, A.J. (1961). "Methods of Chemical Analysis for Survey Samples". Soil Bureau Bulletin No. 12, New Zealand Department of Scientific and Industrial Research. Pp. 168-175 (Government Printer: Wellington, New Zealand)
- Miura, K., Badayos, R.B. and Briones, A.M. (1997). Characteristics of Soils of Iowland areas in the Philippines with Special reference to Parent Materials and climatic conditions JIRCASJ, 5, 31-42
- Ogbu O. J<sup>1</sup>, S. Idoga<sup>2</sup> and J. Usman (2019). Land Suitability Evaluation of the Wetland Soils of Obukiyo, Oju LGA of Benue State, Nigeria for Rice (*Oryza sativa*) Production. Nigeria Journal of soil science. 29 (1) 2019 1-11
- Soil Survey Staff (1999). A Basic System of Soil Classification for making and Interpreting Soil Survey. Second Edition. Soil Survey Staff.
- Dabbert, S. (1994): Economics of soil fertility. Stuttgart: Ulmer
- Sys, C. (1985). Land evaluation. State University of Ghent, International Training Centre for post-raduate soil scientists; Algemeen Bestuur van de Ontwikkelingss. Ghent, Belgium
- Tyubee, B.T. (2006). An Analysis of Food Crop Yields and Climate Relations in Benue State, Nigeria. *Journal of the Nigreian Meteorological Society*. Vol. 6 No. 1
- Udoh E.J. and Ogunwale, J.A. (1986). Laboratory Manual for Analysis of Soils, Plants and Water Samples
- Ufot, U. O. (2012). Soils and the Environment for Colleges and Universities, Shadow Publishers Ltd, Owerri, Nigeria 1634p.
- Ugwu. T. O., Ibadan, I.J., Lekwa G. and Ucheagwu, H.M. (2001). The Soils of Basement Complex Toposequence of the Jos Plateau, *Nigeria Journal of Soil Science*, 27:5-25.

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