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**JOURNAL OF SCIENCE, TECHNOLOGY,
MATHEMATICS AND EDUCATION
(JOSTMED)**



ISSN: 0748 – 4710

VOLUME 13(2), JUNE, 2017

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ISSN 0748-4710

CHARACTERIZATION AND CLASSIFICATION OF SOILS OF KWARA STATE UNIVERSITY TEACHING AND RESEARCH FARM, MALETE, NIGERIA

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Abstract

Proper soil use is inched on understanding its physical and chemical properties. To this end, the soils of Kwara State University Teaching and Research farm, Malete, situated in the Southern Guinea Savannah zone of Nigeria were characterized and classified according to the United State Department of Agriculture (USDA, 2014) Soil Taxonomy and Food and Agriculture Organization- World Reference Base (FAO – WRB, 2006). Soil survey was done to establish mapping units. Three profiles (0-147 cm, 0-156 cm and 0-156 cm) were dug in each established mapping units along the toposquence of the area (upper, middle and lower slopes). Soil samples (0-19, 19-35, 35-86, 86-147 cm), (0-21, 21-41, 41-61, 61-156 cm), (0-40, 40-61, 61-91, 91-156 cm) were collected from the pedogenic horizons for soil characterization. The soils were deep (0-147 cm, 0-156 cm, depth) and well drained. The soil physical parameters like the textural classes identified ranged from sandy loam to sandy clay loam. The soils were moderately acidic to slightly acidic (pH 5.47 - 6.31). The macro nutrients (N, P), organic carbon (OC) and CEC of the soils were generally low with high base saturation (>50%). All the pedons had varying quantities of mottles and iron- manganese concretions. All pedons were classified as Alfisol, having ustic moisture regime and plinthite occupied more than half volume of soils within 150 cm depth. Therefore, they were classified as Typic Plinthustalfs (USDA) and as Plinthosol (FAO). At the soil series level, they were classified as Gambai series (Local classification by Smyth and Montgomery, 1962).

Keywords: Pedogenic horizons, Soil physical parameter, Plinthite, Toposequence

Introduction

Soil characterization provides useful information for assessment and monitoring of the behaviour of soils. It also provides an introduction to the management requirements of the major soils both in the present and future (Abdulkadir, 2008; Behzad, 2012). On that basis, soil is often regarded as the basic natural resource which determines the ultimate suitability and sustainability of any agricultural system. Raju et al. (2005), described the inherent ability of soils as virtual that determines the productivity of agricultural systems by supplying nutrients for crop growth and sustain soil physical conditions to optimize crop yields.

Again, it is through precise measurement and full understanding of the nature and properties of soils as well as proper management of the nutrient and moisture requirements that one can maximize crop production to the allowable potential limits (Esayas & Debele, 2014). In order to evaluate the quality of our natural resources and their potential to produce food, fodder, fiber, and fuel for the present and future generations, detailed information on soil properties is required.

This further pinpoints the need for good soil management as essential option for sustainable agriculture. In the development of sustainable agricultural systems the focus is to reduce degradation of natural resources and promote environmentally compatible ways to increase production and promoting broad-scale development (Ajboye *et al.*, 2011).

Therefore, Intensification of agriculture on land currently requires a thorough knowledge of the soil as a resource, material and according to intended uses. Thus, a good knowledge of the soil resources of any given territory is indispensable for planning its agricultural development (Eswaram *et al.*, 2003). Soil surveys provide a scientific inventory of the soils occurring within a specified land area and involve the systematic examination, description, classification and mapping of such soils. According to Esu (2010), during a soil survey, sufficient information is gathered in order to help the surveyor to correlate and to predict the adaptability of soils to various crops, behaviour and productivity under different management systems.

Soils of Kwara State University Teaching and Research Farm, Malete have been used for several purposes with little or no information on the physical and chemical properties of the soil. According to Esu (2004), the lack of information on the soil resources of any region contributes to the problem of soil degradation and that of world food crises among others, due to wrong uses and poor management practices.

The information on the characteristics of the soils of University Teaching and Research Farm needs to be documented and it is on this premise that the study was carried out to obtain detailed characterization of the physical, chemical properties of the soil mapping units of Malete soils and give out a taxonomic classification of the soils based on the criteria of the USDA soil Taxonomy (Soil survey Staff, 2014) and the FAO/UNESCO (2006).

Materials and Methods

The Study Area

The experimental site used for this research was located at the Teaching and Research farm of Kwara State University, Malete, Nigeria. The farm has latitude 8°7'1" N and longitude 4°44' E at 365 above sea level. The Kwara State University Teaching and Research Farms, Malete consists of approximately 1,400 hectares. The climate is characterized by distinct wet and dry seasons with a mean annual temperature that ranges from 25 - 28.9 °C; the annual mean rainfall is about 1,150 mm, exhibiting a double maximal pattern between April and October of every year. The wet season is between April and October while dry season starts November and ends in March (Olanlyan, 2013).

Farming activities has destroyed the natural vegetation of the site. The area can presently be regarded as anthropogenic because it has suffered various degrees of human interference (ploughing, harrowing, ridging etc). The present vegetative cover of the site can now be regarded as savannah woodlands.

The Vegetation of site consists of arable crops like soyabeans, bean/seed ,cowpea etc. The dominant woody species include Baobab trees, acacia trees and (Drupa) trees. Grasses dominated the site include among others Spear grass (*Imperata cylindrica*), Andropogon gayanus, Elephant grass, Guinea gamba grass , while the dominant broadleaf is Slam weed, *Chromolaena odoratum*.

Field Studies

The experimental sites were selected to cut across major soil series of Smyth and Montgomery (1962) along a toposequence in farmer's plots, using soil and site descriptions from 0-100cm auger samples to establish the mapping unit. Three mapping units were established and three soil profiles were dug to represent the three mapping units. The profiles were described using the guidelines of FAO (2006) and Soil Survey Staff, 2014. Sampling of each profile was carried out according to the pedogenic horizons.

Soil Analysis

The 1 Kg of soil samples were collected from pedogenic horizons (0-19, 19-35, 35-86, 86-147 cm), (0-21, 21-41,41-61,61-156 cm), (0-40, 40-61, 61-91, 91-156 cm) on September, 2015 and air-dried at room temperature for 48 hours and passed through a 2 mm sieve to remove large particles, debris and stones. The soil samples were analyzed for soil texture, pH, organic carbon, total N, extractable P, exchangeable bases and exchangeable acidity and micro-nutrients. Soil texture was determined by the Bouyoucos hydrometer method (Gee & Bauder, 1986). Soil pH was measured electrometrically in a 1:1 in H₂O. Organic carbon was determined by Walkley-Black method (Olowooko & Ojo, 2015). Total nitrogen was determined by the Micro- Kjeldahl method (Foth, 2014; Ojanuga, 1975) and extractable P was determined by Bray 1 method (Bray). Exchangeable bases were determined by the atomic absorption spectrophotometer following the standard procedures. Micronutrients were extracted with 0.1 Ethylenediaminetetraacetic acids (EDTA) and determined using atomic absorption spectrophotometer.

Results and Discussion

Soil physical and morphological properties

The physical and morphological properties of soils of the study area are shown in Table 1. The first profile was located in the upper slope of the toposequence on a gentle slope. Pedon UFP had colour variations between reddish brown (5 YR 4/3) in the surface soil to a range of red (10 YR 4/6) and Yellowish red (5 YR 5/8) in the subsurface soils. This profile had a loamy sand epipedon overlying a sandy loam to sandy clay loam subsoil. This pedon had high sand, moderate silt and clay contents with clay content increased with depth indicating the evidence of argilluviation in the second, third and fourth horizons of this pedon. The iron- manganese concretions were identified in the subsurface horizon between depths 35 and 86cm and 86 to 147 cm. Generally, the soil was well drained at the time of sampling, but few, distinct dark reddish grey mottles (10 R 4%) were observed at a depth of 35 -86 cm. With increase in depth, the mottles became many, coarse and prominent with a colour change from dark reddish grey to black (5 YR 2/1) at a depth 86 -147 cm. The mottling observed in the soils may be attributed to the reducing condition of iron in the soil due to alternating wetting and drying conditions over a long period of time (Eswaram *et al.*, 2003).

The pedon had medium sub angular blocky structure in both surface and sub surface soils. The profile had a consistency that ranged from friable, loose, slightly- sticky, to slightly- plastic (wet). The boundaries between the horizons were gradual and smooth throughout the pedon.

The second profile was located on the middle slope of the toposequence. The colour of the pedon also ranged from Dark brown (7.5 YR 4/2) on the surface to dark brown (7.5 YR4/4) to Yellowish red (5YR 4/6 and 5 YR 5/8) in the sub soils. The Pedon had loamy sand texture on the surface horizon and loamy sand, sandy loam in the sub surface soils. The epipedon were fairly stony and free of concretion while iron- manganese concretions were encountered at depth 41-61 cm and 61-156 cm. The soil was deep and well drained at the time of sampling. However, dark gray (5 YR 4/1), fine, medium and distinct to dark reddish brown (5 YR 3/2), many, common, coarse and prominent mottles were encountered between 41 and 156 cm depth, respectively which may be attributed to the oxidation-reduction processes in the soil.

Table 1: Physical and Morphological Characteristics of the soils of the study area

Soil Profile	Horizon	Soil Depth (cm)	Soil Colour	Soil Moisture (%)	Soil Temperature (°C)	Soil pH	Soil Structure	Consistency	Soil Colour (Munsell)	Soil Texture	Soil Consistency	Soil Colour (Munsell)	Soil Texture	Soil Consistency
UPP	0-10	10	10	10	10	10	10	10	10	10	10	10	10	10
	10-20	20	20	20	20	20	20	20	20	20	20	20	20	20
	20-30	30	30	30	30	30	30	30	30	30	30	30	30	30
	30-40	40	40	40	40	40	40	40	40	40	40	40	40	40
	40-50	50	50	50	50	50	50	50	50	50	50	50	50	50
MDD	0-10	10	10	10	10	10	10	10	10	10	10	10	10	10
	10-20	20	20	20	20	20	20	20	20	20	20	20	20	20
	20-30	30	30	30	30	30	30	30	30	30	30	30	30	30
	30-40	40	40	40	40	40	40	40	40	40	40	40	40	40
	40-50	50	50	50	50	50	50	50	50	50	50	50	50	50
LS	0-10	10	10	10	10	10	10	10	10	10	10	10	10	10
	10-20	20	20	20	20	20	20	20	20	20	20	20	20	20
	20-30	30	30	30	30	30	30	30	30	30	30	30	30	30
	30-40	40	40	40	40	40	40	40	40	40	40	40	40	40
	40-50	50	50	50	50	50	50	50	50	50	50	50	50	50

Keys: SL= Sandy loam; SC= Sandy clay; SCL= Sandy clay loam, LS= Loamy sand, SG= Single grained, UPP= Upper, MDD= Middle, LS= Lower slopes.
 FBAB = Fine sub angular blocky; MBAB = Medium sub angular blocky; CSAB= coarse sub angular blocky; Fr = friable; Fm = Firm; L = loose; hd = Hard; shd = Slightly hard, s = soft, c=common, f=fine, d=distinct, s=sharp, m=many, cr=coarse, p=prominent, gw= gradual wavy, gs= gradual smooth, cs= clear smooth, Fe-Mn= Iron-Manganese concretions, ss/Topo=slope or Toposequence,UPP= upper slope, MDD= Middle slope, LS= lower slope,

The structure of the pedon ranged from fine sub angular blocky to single grained on the surface and coarse subangular blocky to subangular blocky in the subsurface soils. Profile consistency ranged from friable, loose, non-sticky, non-plastic (wet) on the surface to firm, hard, very sticky, very plastic in the subsoil. The boundaries between horizons were gradual and smooth (Boundary is 6 – 12.5 cm wide in distinctness and nearly a plane in form).

The third profile (LS) was located on the lower slope of the toposequence. The surface and second horizon of this pedon were dark brown (7.5 YR 4/2) and reddish brown (5YR 5/4) respectively, while the subsurface horizons were red (2.5 YR 5/6) and yellowish red (5 YR 5/8). The pedon had loamy sand in the first and second horizons and sandy clay loam to sandy loam in the third and fourth horizons. There was evidence of argilluviation in the subsoils due to increase in clay content (Ojanuga, 1975). The profile was well drained. However, black (5 YR 2/1) fine, coarse distinct, prominent mottles were noticed between 61 to 156 cm depth. The profile had medium subangular blocky structure in the surface soils to single grained in the subsurface soils. The characteristics of the horizons ranged from firm, slightly-sticky, slightly-plastic in the surface to friable, loose, non-sticky, non-plastic in the subsurface soils. The horizon boundaries were gradual smooth in the surface horizon but gradual wavy in the sub-surface horizon (boundary is 6 – 12.5 cm wide in distinctness and nearly a plane in form at the surface while it's shallow pockets are wider than they are deep in form at the subsurface).

Chemical characteristics of the soil

The soils had reactions ranging from moderately acidic to slightly acidic (5.47 -6.31) in distilled water (Table 2). However, the upper slope had a range between 5.80 and 6.01, the lower slope had the highest pH value in the second horizon (6.31) and the first horizon (6.16) while other horizons exhibited moderately acid condition. A similar pattern of pH variation was noticed in the middle pedon with the highest value in the first horizon and second horizons. The acidic nature of the soils indicated basement complex rocks as the parent material.

The total exchangeable acidity was moderate for all the pedons ranging from 0.15 - 0.35cmol/Kg. The total Nitrogen of all the pedons were generally low (0.09-0.24 %), but the middle pedon fell into medium class, having a range between 0.14 -0.24 %. This could be attributed to loss of organic nitrogen through leaching and crop removal due to cultivation. The first horizon of the middle pedon and third pedon had a very high organic carbon, while other horizons of the pedons had moderate to high content of organic carbon with the exception of third horizon of the upper slope pedon which was low (0.82 %). The high content of organic carbon exhibited by middle slope pedon was probably due to the presence of Baobab tree (*Adansonia digitata*) around the site; which shed leaves that formed litters on the ground. The available Phosphorus were generally low for all pedons (ranging between 0.77 and 2.96 ppm).

The extractable Zinc (Zn), copper (Cu), Manganese (Mn), Iron (Fe), (Micro nutrients) contents of the soils were moderate to high. The highest value of Fe and Mn was probably due to the presence of Iron- Manganese concretions found in all profiles and which increased with increasing soil depth. The value of Fe ranged from 22.7and 104.0 mg/Kg while value of Mn ranged from 95 – 202 mg/Kg. The content of Cu and Zn also followed the same trend.

The percentage base saturation of the soils was consistently higher than 90%. It ranged from 92.0 -97.9%.

The low CEC of these soils coupled with low organic matter, low total Nitrogen and available Phosphorus were indications of low inherent soil fertility status, which under- scored the need for improved soil management techniques. All deficient nutrients are macro nutrients which are needed in large quantities by plants. Therefore, there is the need to practice appropriate fertilizer use on the farm. Combination of organic manure and inorganic fertilizer is suggested.

Table 2: Chemical Characteristics of the Soils of the study area

Pedon	Location	Depth (cm)	pH	EC (dS/m)	CEC (cmol/kg)	Na ⁺ (mg/kg)	Ca ²⁺ (mg/kg)	Mg ²⁺ (mg/kg)	K ⁺ (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	P (ppm)	OC (%)	TEA (cmol/kg)	TSN (%)
Upper slope	SL	0-15	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	15-30	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	30-45	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	45-60	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
Middle slope	SL	0-15	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	15-30	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	30-45	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	45-60	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
Lower slope	SL	0-15	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	15-30	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	30-45	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15
	SL	45-60	5.80	1.00	1.0	0.15	1.70	1.30	1.90	0.19	1.70	0.11	0.11	0.41	0.41	0.15	0.15

Keys:

SL= Sandy loam; SC= Sandy clay; SCL= Sandy clay loam, LS= Loamy sand, SG= Single grained, UPP= Upper, MDD= Middle, LS= Lower slopes.

FSAB = Fine sub angular blocky; MSAB = Medium sub angular blocky; CSAB= coarse sub angular blocky

Fr = friable; Fm = Firm; l = loose; hd = Hard; shd = Slightly hard, s = soft, c=common, f=fine, d=distinct, s=sharp, m=many, cr=coarse, p=prominent; gw= gradual wavy, gs= gradual smooth, cs= clear smooth, Fe-Mn= Iron-Manganese concretions, ss/Topo=slope or Toposequence, UPP= upper slope, MDD= Middle slope, LS= lower slope,

Soil Classification

Pedon 1(upper slope) had Argillic B horizon (Bt₁, Bt₂). Pedon 2 and pedon 3 (middle and lower slopes) had no either an Argillic or Kandic horizon.

All the Pedons (Upper, middle, lower slopes) had CEC of clay < 16 cmol kg⁻¹ clay; base saturation > 30% by NH₄OAc at pH 7.0, this was in agreement with the requirements of soil order Alfisols. The moisture regime was Ustic moisture regime and this qualified these pedons into the sub-order Ustalfs. All pedons had 65% or more plinthite by volume on a horizon which was at least 15 cm thick within 30 cm of the surface that is, Plinthic subsurface horizons and mottling which occupied more than half volume of the soils.

Based on the above properties, with the predominance of plinthite in the sub-surface, all the pedons were classified as Typic Plinthustalf (According to USDA, 2014 and FAO/ UNESCO, 2006). The soils were classified as Plinthosol; Cutanic and Hypereutric. At the Soil Series level, all pedons belonged to Gambel series.

Classification at the family level could not be undertaken because the mineralogy was not determined. This gives direction for further studies.

Conclusion and Recommendation

Due to low cation exchange capacity, organic carbon contents and plinthic sub-surface horizons of the soils, the arable crop yield will be low and tree crops cannot be planted. Therefore, the surface soils should be protected from erosion and practices that improve organic matter content of the soils should be adopted.

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