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Classification of Some Selected Soils of Challawa – Gorge Microwatershed in Kano, Nigeria

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Abstract

A semi-detailed survey was conducted to evaluate the soils of an agricultural landscape in Challawa – Gorge micro watershed in Karaye Local Government Area of Kano State. Three soil mapping units A, B and C were identified on the basis of land forms and surface texture. The soils were classified into Typic Endoaqualfs and Plinthic Kanhaplustalfs (USDA) and Stagnic Gleysols and Plinthic Acrisols (Eutric) world reference base soil resource. The upper slope was classified into soil unit C, middle slope as soil unit B and lower slope as soil unit A.

Keywords: *Land, Suitability, Capability; Fertility, Classification, Evaluation.*

Introduction

There is an increasing demand for information on soils as a means to produce food (Fasina et al 2007). Agriculture is the predominant economic activity in Nigeria and because of agricultural development and increasing demand for experimental data in Nigeria, much work is carried out on soil characterization. This provides the basic information necessary to create functional soil classification schemes, and assess soil fertility in order to unravel some unique soil problems in an ecosystem (Lekwa et al., 2004). Soil classification deals with the systematic categorization based on distinguishing characteristics as well as criteria that dictate choices in use. Soil classification can be approached from the perspective of soil, as a material and resource considered critical to study, depending upon the fertility class of the soil. The domain knowledge experts determine which crops should be taken on that particular soil and fertilizers be used for the same (SWALIM, 2007).

Soil has been called "the skin of the earth" it is dynamic natural body capable of supporting vegetative cover. It contains chemical solution, gases, organic refuse, flora and fauna (Gabler et al 2009). According to Yusuf (2010) soil is the loose material that covers the land, surfaces of the earth and supports the growth of plants. The most widely accepted scientific definition of soil is that by Waugh (1995) who stated that Soil responds to climatic condition (especially temperature and moisture), to the land surface configuration, to vegetative cover and composition and to animal activity. Being dynamic entity, soil possesses physical, chemical and biological properties. Physical properties such as available water holding capacity is controlled by texture of the soil, amount of organic matter content and structure of the soil. Available water holding capacity can be defined as the amount of water (moisture) the soil can hold for the use of plants root for certain period of time (Yusuf, 2010).

Soil is so universal that all people know of its existence, and therefore have individual concepts of what soil is and what soil does. The universality of soil, the individuality of people, and the limited geographic exposure to soil each person has experienced ensure an infinite array of philosophies about how to classify soils. To some people, soil is a singular entity, but many have some appreciation for mor e than one kind of soil, abstractly referring to simplistic classifications of fertile, wet, black, red, sandy, clayey, etc. Others classify soil by association with geology, geography, climate, and vegetation. Philosophies of soil classification are fascinating.

Modern soil classification was pioneered by Vasily Dokuchaev founder of Russian Soil Science in 1870 (Glinka, 1927). He stated that soil was an independent entity, a product of several soil forming factors such as parent material, climate, living organisms, vegetation, topography and time. These ideas were adopted in the United States and gave rise to the systematic methodologies currently employed in the field and laboratory, where soils are classified as natural bodies, on the basis of their profile characteristics, morphological, physical and chemical properties (Brady and Weil, 1999). The soils of the Nigerian savannah regions are physically fragile because the topsoil contains large proportion of sand and low level of organic matter, resulting in weak aggr egation (Salako, 2003). Kano State is located in the semi-arid savannah; that is Sudan Savannah sandwiched by the Sahel Savannah in the north and the Guinea Savannah in the south. The savannah has been described as the zone that provides opportunity for optimal human attainment. The major soil types in Nigeria, according to FAO Soil Legends are Fluvisols, Regosols, Gleysols, Acrisols, Ferrasols, Luvisols, Lithosols, Cambisols, Nitosols, Arenosols and Vertisols. This is presented in Figure 1 indicating the soil map of Kano state. These soil types vary in their potential for agricultural use. However none of these soils is rated as class 1, with high productivity by the FAO, (2006). Over 48% of the Nigerian soils fall into classes 4 and 5, which are mainly Vertisols, Alfisols, Ultisols, Oxisols and Psamments.

OBJECTIVES OF THE STUDY

The objectives of the study were;

1. To map out soils into mapping units in the study area.
2. To determine the morphological properties of the soils in the study area.
3. To classify the soils according to USDA Soil Taxonomy and FAO World reference base soil resource.

MATERIALS AND METHODS

Location of study area

The Challawa - Gorge Dam is located in Karaye Local Government Area of Kano State in Northern Nigeria; about 90km south west of Kano city with a catchment area of 3,860km Challawa - Gorge Dam is located at Lat 11^0 ’”’52 41 N, and Long 08 o 28’ 09 E with an elevation of about 515 meters above sea level, It originated from Challawa River in Challawa village a tributary of the Kano river, which is the tributary of Hadeja river in the Sudan savannah ecological zone of Kano state (FAO/NSPFS, 2005). The landscape is a gentle undulating terrain selected as an arable farm land located at the Northern edge of the Challawa – Gor ge Dam between two streams that feeds the dam during the rainy season. The land use is a mixture of irrigated and arable crops, which has been under cultivation for more than ten years. The upper slope was cultivated to sorghum, while middle - slope section was cultivated to maize. Along the river course (Lower slope) crops such as rice, Tomato, pepper, Onion, Okro and Sweet potato were cultivated. The study area is located along Challawa - Gorge Dam situated between latitudes 11^{0} 46 03.40'' N and 1146' 29.90'' N and longitudes o08 ' 26.90'' E and 0800'00 48.10'' E and 515m above sea level. The location of the study area is presented in Figure1.

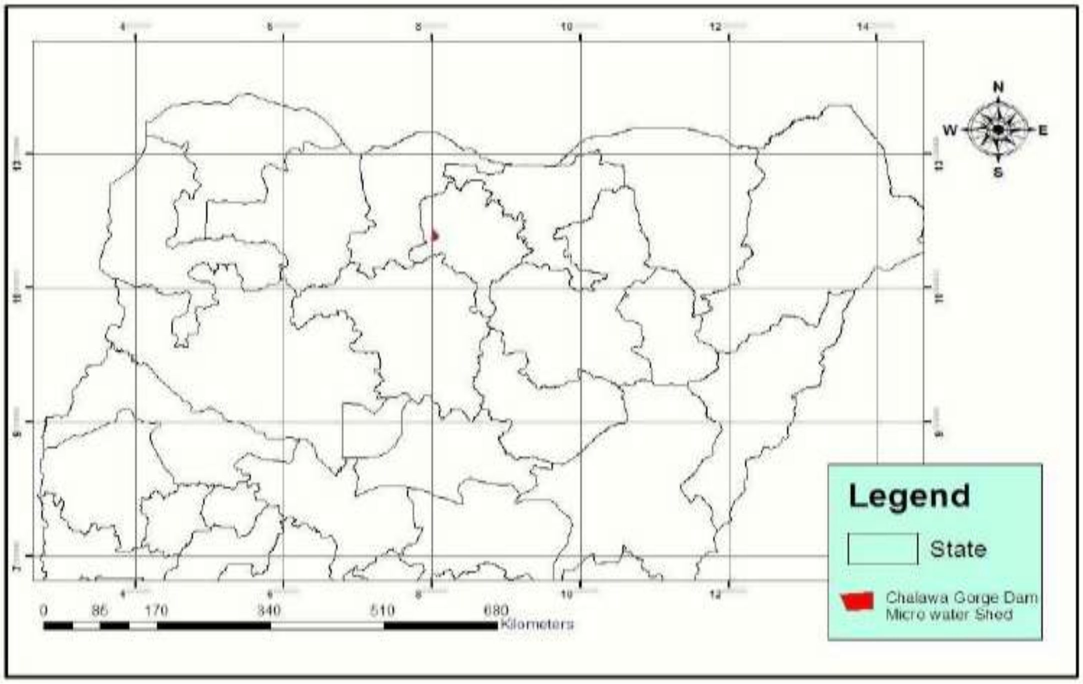

Figure 1: Map of Nigeria showing Challawa – Gorge Da m location in Karaye L. G. A. in Kano, Nigeria
Source: Geo. Dept. BUK.

Climate:

The climate of Kano State (Dambatta inclusive) is the tropical wet and dry type denoted as Aw by Koppen. The temperature is averagely warm to hot throughout the year at about 25°C+/-7°C (Olofin and Tanko, 2002). The monthly rainfall distribution over the Kano region is characterized by one peak (single maximum) which is usually attained in August (Buba, 2009).

Rainfall

The climate of the area is tropical wet and dr y, with a mean annual rainfall of 600 to 1000mm (Olofin, 2002). The mean annual rainfall attains it highest value (273.85mm) in August and drops rapidly to its lowest (24.85mm) in October. The study area had an average rainfall value of 763.33mm in the past 25 years.

Results and Discussion

General Description of Soil Pattern and Classification

The description of the soil of the study area considered as soil mapping units are group of soil closely interrelated soils (Soil Associations). The soil mapping units were not completely homogenous and show some variation with r espect to extent, depth, texture, and horizon arrangement. Each mapping unit was classified according to the USDA Soil Taxonomy (Soil Survey Staff, 2010) correlated to the FAO/UNESCO World Reference Base for Soil Resources (2006).

The distribution of the three soil mapping units denoted by soil unit A (CHGD1), soil unit B (B1 (CHGD2) and B2 (CHGD2) and soil unit C (CHGD3 and L.G.A. Secretariat) were identified; their distribution in the study area is given in the accompanying soil map produced at a scale of 1: 2,500. The area and proportion covered by each mapping unit is presented in Table 1.

Table 1 Extent of soil mapping units in Challawa – Gorge Dam micro water shed soils

Soil Mapping	Unit Symbol	Area (ha)	Area (%)
Soil unit A	(CHGD1)	19.324	33.123
Soil unit B1	(CHGD2)	4.959	8.500
Soil unit B2	(CHGD2)	10.511	18.017
Soil unit C	(CHGD3)	22.249	38.136
L.G.A. Secretariat		1.298	2.224
Total		58.341	100.00

CHGD =Challawa – Gorge Dam and L.G.A. = Local Government Area

SOIL CLASSIFICATION

Classification according to USDA Soil Taxonomy

Although soil-forming processes are no longer taxonomically differentiated as such, it appears that Concepts of soil formation still influence the ranking of the hierarchical categories.

The genetic Significance and the importance to use ascribed to the argillic horizon have led to the distinction of two orders in the USDA Soil Taxonomy (Soil Survey Staff, 1999). Soil classification has traditionally been considered a means to optimize land use and to transfer technology between comparable soils in different areas. This approach is based on the assumption that soil classification stratifies the environment in sufficient detail that transfer by analogy can take place. This assumption may be valid when the emphasis is on broad assessments, but it should be fully realized that technology transfer should rely not only on soil attributes, but on other factors as well, such as climate, relief, hydrology, level of inputs, and socioeconomic conditions. If any of these factors vary between locations, similarity of soil classes will not result in successful transfers. Hence soil survey interpretation has progressively evolved into land evaluation (FAO, 2007).

The study area experiences about seven months of dry season, which may translate to dry conditions in the moisture control section of the soil (upper 50 cm of the soils) for more than 90 consecutive days in most years. This suggests that the soils have ustic soil moisture regime. The mean annual soil temperature is more than ^{0}C with mean hot season and cool season soil22 temperature differing by less than 5^{0}C at more than 50 cm depth. The soils have isohyperthermic temperature regime. The classification of the soils in the mapping units of the study area indicated that, at the order level, all pedons in soil units A, B, and C had argillic horizons, with base saturation greater than 50% (by 4 OAc and ECEC) and therefore classified as NHAlfisols (Soil Survey Staff, 2010).

Although the three purposes of soil classification, taxonomy, soil survey, and interpretation, would benefit from being handled more independently, it is imperative that the experience gained with the relationship among soils, landform, and climate be blended with the new methods of data processing. Blind mathematical approaches could lead to stratifications of doubtful significance. A geographic dimension of the soil cover is essential for ensuring sound applications of soil science. Our soil classification has served us well, it has enabled us to explain and characterize soil diversity in function of different sets of soil-forming factors. However, with increasing demands for targeted soil information and with the advent of modern tools for data storage and processing, soil classification now needs to be addressed more specifically to the purposes that it is meant to serve. The rationale of its hierarchy and of the selection and weighing of its difference has to be clearly spelled out. Additional research is required on the relationships among soil characteristics, their effects on plant growth, and their use for different purposes FAO (1998).

At the suborder level, pedon 1 was classified as Aqualfs , because the soils were satur ated with water long enough to exhibit gray colours of chroma 2 or less; there was the presence of reddish or brownish Fe - mottles. Pedons 2 – 6 were classified as Ustalfs , because they had ustic soil moisture regime. At the great group level, pedon1 was classified asEndoaqualfs, while pedon 2 - 6 were further classified as Haplustalf . At the subgroup level, pedon 1 was classified as Typic Endoaqualfs , because they had redox depletions with chroma of 2 or less in layers that have aquic conditions in normal years. Pedons 2 -6 had a clay distribution, in which the percentage of clay did not decrease from its maximum amount by as much as 20% and plinthite within a depth of 125 cm from the mineral soil surface and were therefore classified as Plinthic Kanh aplustalfs.

Classification According to FAO World Reference Base for Soil Resources (WRBS)

The purpose of this mapping/classification (Soil Survey Staff, 2010) is to establish hierarchies of classes that permit soil scientists to understand, as fully as possible, the relationship among the surface soil groups and between the surfaces soil groups as well. Therefore, surface soils must be classified by their own physical appearance as they can be seen in the field; given names and descriptions that are strictly belonging to each soil. According to FAO-USDA classification systems (FAO, 2006; Soil Survey Staff, 2010), the surface soils of the study area fall into ten broad soil groups as physically assessed during the preliminary field survey in the field. Six of these soil groups belong to dry land: Alfisols, Anthrosols, Aridisols, Calsisols, Histosols and Oxisol; whereas four of them belong to fadama: Entisols, Inceptisols, Molisols, and Vertisols. The Visual Soil Assessment by naked eye according to FAO guidelines (FAO, 2006) revealed that there are varieties of colluvial, alluvial, transported, deposited, residual, and sand dunes parent materials, which might have been changed as a result of agricultural intensification system, climate change, and other environmental factors. The topographical surface soil condition on which these soil parent materials have been changed are back-slope, bendy, concave, contour, convex, deeply, flatly, linear-flats, shallow, and straight under aquic (high moisture), aridic (dryness), perudic (wetted condition), torric (hot and dry), ustic (moderate moisture), udic (sufficient moisture), and moisture surface characteristics (Atkinson, 1993).

According to FAO World Reference Base for Soil Resources FAO, (2006), pedon 1 in soil unit A was classified as Gleysols (Stagnic), because the soils were saturated with water long enough to develop a gleyic, colouration. Pedons 2 – 6 of soil units A, B and C were classified as Plinthic Acrisols (Eutric) because they had plinthic layer within 125 cm of the soil surface. These; -1 andwere soils with argillic B horizons, cation exchange capacity of less than 24cmolkg percentage base saturation of greater than 50%. The summary of the two (2) classification systems were presented in Table 2.

Table 2: Summary of soil classification of Challawa – Gorge Micro watershed

Soil Unit	Pedon	USDA System	WRBS
CHGD1	P1	Typic Endoaqualfs	Gleysols (Stagnic)
CHGD1	P2	Plinthic Kanhaplustalfs	Plinthic Acrisols (Eutric)
CHGD2	P1	Plinthic Kanhaplustalfs	Plinthic Acrisols (Eutric)
CHGD2	P2	Plinthic Kanhaplustalfs	Plinthic Acrisols (Eutric)
CHGD3	P1	Plinthic Kanhaplustalfs	Plinthic Acrisols (Eutric)
CHGD3	P2	Plinthic Kanhaplustalfs	Plinthic Acrisols (Eutric)

Conclusion

A study was carried out on the Challawa – Gorge Dam micro watershed soils in Karaye Local Government Area of Kano State, Nigeria, to map, characterize and classify the soils. The soils were classified using the USDA Soil Taxonomy (Soil Survey Staff, 1999) and correlated to FAO World Reference Base for soil Resources (FAO – ISRIC – ISSS, 1998). According to the USDA system of soil classification at the great group levels, pedon 1 was classified as Typic Endoaqualfs, pedons 2 – 6 were classified as Plinthic Kanhaplustalfs because the percentage of clay (in clay distribution) does not decrease from its maximum amount by as much as 20 % as well as the presence of Plinthite within the depth 125 cm from the mineral soil surface. In the FAO/UNESCO system, all the soils (pedon 2 – 6) were classified as plinthic Acrisols (Eutric) except pedon 1 which was classified as Stagnic Gleysols.

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