Effect of Land Use Systems on Selected Chemical Properties of Soils in Gidan Sule, Wamakko, Sokoto State, Nigeria

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Abstract: **- The study was carried out in Gidan Sule District Wamakko Local Government, Sokoto State, with the aim to study the effect of land use systems on selected chemical properties of the soils. A total area of 20 hectares was covered during the study. Three major land use systems namely rainfed, irrigated and orchard farming were identified, described and mapped on the basis of their soils and covariates. Three pedons, one on each land utilization types were dug. Samples were collected for chemical analysis in the laboratory. The data obtained were subjected to descriptive such as means, standard error etc. Orchard farming was the most expansive (49%) land utilization type in the study area. Chemical properties such as pH was rated neutral, organic carbon, organic matter, available phosphorus and base saturation were all rated low. Total nitrogen, potassium and cation exchange capacity, calcium and magnesium were all rated high. Also, sodium was rated moderate. The soils of the study area where generally rated to be low to moderately fertile. Proper management practices and the application of organic and inorganic fertilizer should be applied to correct the nutrient deficiency in the soils.**

Keywords: **land use systems, chemical properties, Gidan Sule, orchard, rainfed.**

I. INTRODUCTION

Many studies have identified soil nutrient availability to be an important factor controlling net primary productivity [1]. This fact makes it very important for the characterization of the spatial and temporal variabilities of soil nutrients in relation to site feature.

Such site features include climate, land use and landscape position and other variables which help in predicting the rate of ecosystem processes [2], how ecosystem works [3] and assessing the effects of future land use change on soil nutrients [4]. Land use and cultural practices act as dominant factors affecting soil chemical properties and crop production under the same agro ecological environment [5]. Reference [6] observed that at any given time land use is a resultant interplay of available land resources with cultural, social and economic conditions of the past and present development. Similarly, [7] reported significant differences between land use types in soil pH, extractable P, K, Ca, Mg, total nitrogen, organic matter and bulk density. In addition, soils form over the same parent materials and under the same climate and relief had dissimilar chemical, biological properties [8] and other properties due to variation in land use system put in place.

All of these make it very imperative to obtain information on land use which is vital in various decision-making purposes. Hence, understanding changes in soil quality due to land use practices has become very essential especially in the era food security has become global concern due to rapid population growth.

The different land use systems in and around Gidan Sule affect soil chemical properties differently. It therefore became a special and interesting area for the performance of an integrated study of soil nutrients in relation to different agricultural land use systems, owing to the depletion of nutrients as slightly lamented by the farmers during reconnaissance visit. This study however, helped in determining nutrient status and potential changes in nutrient contents due to land use activities.

II. MATERIALS AND METHODS

A. Description of the Study Area

The study was carried out in Gidan Sule village, Wamakko local government area, Sokoto state. The study area is located at the western part of Sokoto metropolis on latitude 13° 12’ 0’’ N and longitude 5° 20’ 0’’ E in the Sudan Savannah zone of Nigeria. The climate of the area is semi-arid with mean (20 years) annual rainfall of about 645 mm [9]. The administrative map showing Sokoto and study area was presented in Figure 1. The relative humidity ranges from 21-47 % in the dry season and 51-79 % during the rainy seasons with minimum and maximum temperature of 15 °C and 40 °C respectively [10].

The study area is divided into three land utilization types. The rainfed arable land which comprises of few trees like acacia trees, shrubs with scattered grasses and mainly cultivated with millet, sorghum and cowpea. The land has a gentle slope with structures like the anthill. The orchard land is densely populated with mango trees and few grasses. The land is relatively a flat land. The irrigated arable land is intensively cultivated all year round based on the information obtained from the farmers; it has a gentle slope with scattered mango trees and dark coloured soils. It is mainly cultivated with rice, maize, tomato and sweet potato. The soil fertility was managed by the application of both mineral (NPK) fertilizer and organic manure. Weed control was by the manual method of hoeing.

B. Geology

Two major geological formations characterized the area; Basement Complex and Sedimentary Rocks. The earlier comprises of Old Volcanic and Metamorphic Rocks which are mainly Granite and Meta sediments, while the latter is the Gwandu Formation overlying Basement Rocks in the illumenden Basin, extending from Sokoto, Niger to Mali. The Sedimentary Rocks comprise of sandstones and clays with a high potential for ground water. The soil is characterized by Sandy topsoil of Aeolian origin while the subsoil is Clayey, derived from Marine Deposit [11]. The Geological map, showing study area and Sokoto was presented in Figure 1.

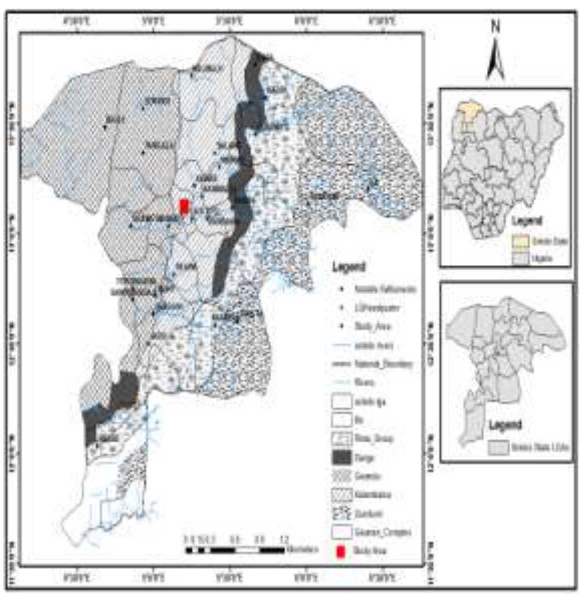

Fig. 1: Geological Map of Sokoto showing the study site and Wamako LGA

Source: Arc GIS Generated by GIS Lab. Department of Geography UDUS 2018

C. Field Work Procedure

Reconnaissance and familiarity visitation was paid to the community leader(s) and their people whose lands were used in the research to create awareness about the research conducted and also to seek for prior permission to enter their lands. During this forum, enlightenment was also made as regards to the significance of the research in their area. A reconnoiter was then conducted around Gidan Sule to identify and document different land use types and also to collect information on landforms, vegetation, cropping history, topography and slope of the area, drainage characteristics, erosion hazard and general soil conditions.

This enabled the identification as well as the selection of the area that represents the soils of the study area. SPOT-5 image of the study area was used as the base Map (Figure 2). The different land utilization types observed were documented. Three land utilization types namely, rainfed, irrigated and orchard were selected for soil examination using free survey procedure as guided by land use, soils and covariates (topography, parent material, vegetation, anthropogenic effects etc).

Single representative pedon was dug and described to characterize the soils in each land use system. Soil samples were collected from each pedogenic horizon in a well labeled plastic container for chemical analysis.

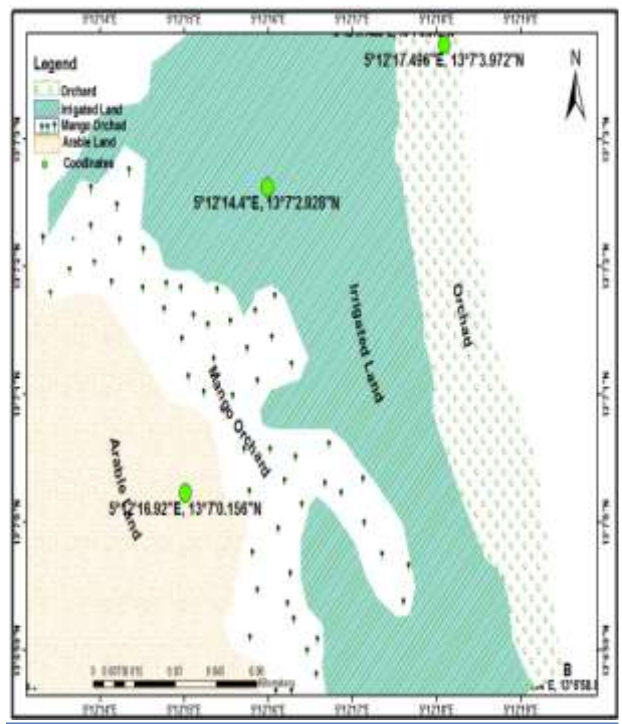

Fig. 2: A map showing the extent and distribution of LUTs as well as location of profile pits

Source: Arc GIS Generated by GIS Lab. Department of Geography UDUS 2018

D. Laboratory Analysis

The soil samples were taken to the laboratory, air dried, crushed gently and passed through a 2 mm sieve. Separates with particle sizes < 2 mm were used for the analysis.

1. *Soil pH*: Soil pH was determined using a 1:1 soil-water ratio using glass electrode pH meter [12].

2. *Total Nitrogen:* Total nitrogen was determined by Kjeldahl digestion method [13].
3. *Organic Carbon Content:* Organic carbon was determined using the Walkley-Black wet combustion method [14].
4. *Organic Matter Content:* Organic matter content was obtained by multiplying organic carbon content by 1.724.
5. *Available Phosphorus:* The available phosphorus content was determined using Bray-1 method [15].
6. *Exchangeable Bases:* Exchangeable bases [Ca, Mg, K and Na] were determined by extraction with neutral 1*N* NH_4OAC saturation method. Ca and Mg were read using atomic absorption spectrophotometer (AAS), whereas K and Na were read using Flame Photometer [16].
7. *Cation Exchange Capacity:* Cation exchange capacity was determined by the neutral ammonium acetate saturation method buffered at pH 7 [17].
8. *Percentage Base Saturation:* Percentage base saturation was calculated by dividing total exchangeable bases by CEC and multiplying by 100. Thus,

$$\text{PBS}= \frac{\Sigma(\text{Exchangeable Bases})}{\text{CEC}} \times 100$$

E. Data Analysis

The data collected were subjected to descriptive statistics such as means, ranges, percentages, standard error etc using SPSS statistical package version 16.0.

III. RESULTS AND DISCUSSIONS

A. Effect of land use on soil pH

The result on soil pH was presented in Table 3. In the surface horizon of the pedons under different land use systems, the pH value ranges from 6.7-7.3 (7.0 average) which was rated neutral. In the subsurface horizons the pH value varied between 6.6-7.5 (7.1 average) which was also rated neutral (Table 3). The neutral pH of the soils agreed with the explanation of [18] that arid and semi arid region soils occur in areas where the rainfall is seldom more than 50 cm per year; leading to lack of extensive leaching which leaves the base status of these soils high, which in turn influence and regulated the pH status of the soils. These values are within the pH requirement for most arable crops for nutrient up take [19]. This result is similar to the one reported by [20] and [21] who worked the soils of the north western part of Nigeria.

B. Effect of land use on SOC Content

The result on soil organic carbon content was presented in Table 3. In the surface horizon of the pedons under different land use systems, the SOC ranges from 1.3-2.0 gkg^{-1} (1.2 gkg^{-1} average) which was rated very low (Table 3). In the subsurface horizons, the SOC varied between 0.7-1.8 gkg^{-1} (1.3 gkg^{-1} average) which was also rated very low (Table 3). The low SOC may be partly due to effect of land use activities and high temperature which favours rapid mineralization of organic matter [22].

C. Effect of Land Use on TN

The result on total nitrogen was presented in Table 3. In the surface horizon of the pedons under different land use systems, the total nitrogen content ranges from 0.28-0.4 gkg^{-1} (0.35 gkg^{-1} average) which was rated very high (Table 3). In the subsurface horizons, the total nitrogen value varied between 0.03-0.39 gkg^{-1} (0.21 gkg^{-1} average) which was also rated high (Table 3). The high value of total nitrogen may be due to low volatilization of ammonia, leaching, fixation and denitrification of nitrates. This result contradicted the research findings by [23] [24] [25] who reported low nitrogen values while working on soils of Zaria and Sokoto State, Nigeria.

D. Effect of Land Use on AP

The result on available phosphorus was presented in Table 3. In the surface horizon of the pedons the available phosphorus content value ranges from 0.6-1.5 $mgkg^{-1}$ (1.05 $mgkg^{-1}$ average) which was rated low (Table 3). In the subsurface horizons, the available phosphorus value varied between 0.5-1.8 $mgkg^{-1}$ (1.15 $mgkg^{-1}$ average) which was also rated low (Table 3). Reference [26] reported that extensive shortage of available phosphorus is observed in most Nigeria soils like what is found in other tropical region of Africa. In addition, the values were lower than those reported by [27] for soils of the South-Eastern Nigeria, and might be due to enhanced recycling in the more luxurious forest vegetation

E. Effect of Land Use on Calcium

The result of exchangeable calcium was presented in Table 3. In the surface horizon of the pedons under different land use system, the value of the exchangeable calcium ranges from 0.9-1.3 $cmolkg^{-1}$ (1.1$cmolkg^{-1}$ average) which was rated low. In the subsurface horizons, the calcium content varied between 0.3-1.5 $cmolkg^{-1}$ (0.9 $cmolkg^{-1}$ average) which was also rated low (Table 3). The result obtained has contradicted the findings by [28] who reported that calcium and magnesium are the predominant basic cations in West Africa soils. The low calcium content could be attributed to the nature of the parent materials from which the soils were formed (i.e. basement complex).

F. Effect of Land Use on Magnesium

The result of exchangeable magnesium was presented in Table 3. In the surface horizon exchangeable magnesium ranges from 1.3-3.4 $cmolkg^{-1}$ (2.4 $cmolkg^{-1}$ average) which was rated high (Table 3). In the subsurface horizons, the magnesium varied between 1.1-1.8 $cmolkg^{-1}$ (1.5 $cmolkg^{-1}$ average) and was also rated high (Table 3). This result agrees with [28] who reported that calcium and magnesium are the predominant basic cations in West Africa soils.

G. *Effect of Land Use on Potassium*

The result on exchangeable potassium was presented in Table 3. In the surface horizons exchangeable potassium ranges from 0.21-0.60 $cmolkg^{-1}$ (0.405 $cmolkg^{-1}$ average) which was rated high. In the subsurface horizons, exchangeable potassium values varied between 0.18-1.28 $Cmolkg^{-1}$ (0.73 $cmolkg^{-1}$ average) which was also rated high (Table 3). This result is similar to the previous findings by [29].

H. *Effect of Land Use on Sodium*

The result of exchangeable sodium was presented in Table 3. In the surface horizons exchangeable sodium ranges from 0.35-0.43 $cmolkg^{-1}$ (0.39 $cmolkg^{-1}$ average) which was rated moderate. In the subsurface horizons, the sodium content varied between 0.09-0.61 $cmolkg^{-1}$ (0.35 $cmolkg^{-1}$average) which was also rated moderate (Table 3).The highest Sodium content was recorded at the subsurface soils of rainfed farming which could be attributed to leaching of basic cation down the profile. This result was similar to the report by [30] who reported higher sodium content and attributed it to the nature of parent material in the location.

I. *Effect of Land Use on CEC*

The result on cation exchange capacity was presented in Table 3. In the surface horizon of the pedons cation exchange capacity ranges from 7-13 $cmolkg^{-1}$ (10 $cmolkg^{-1}$ average) which was rated moderate. In the subsurface horizons, the cation exchange capacity content varied between 6.8-12 $cmolkg^{-1}$ (9.4 $cmolkg^{-1}$ average) which was also rated moderate (Table 3). Generally, the surface soils of irrigated land had the highest value of CEC (13 cmol/kg) which could be attributed to high clay content of the soils, which is in agreement with the findings by [31].

J. *Effect of Land Use on PBS*

The result of base saturation was presented in Table 3. In the surface horizon of the pedons under different land use systems, base saturation ranges from 32-52 % (42 % average) which was rated low. In the subsurface horizons, the base saturation varied between 17-71 % (44 % average) which was also rated low (Table 3). The rainfed subsoil (Table 1) had the highest base saturation value (71 %), which could be attributed to leaching of basic cation and higher clay content of the subsoils. This research finding confirmed the report by [32] who observed higher base saturation values in the subsoil as compared to topsoil.

IV. CONCLUSIONS

Generally, the soils were rated low to medium infertility. Similarly from the results obtained, it was established that, all the chemical properties of the soils were not significantly affected by land use systems.

V. RECOMMENDATION

As land quality or soil fertility is a major factor of food production as regards agriculture, a sustainable land use towards sustained food production is necessary. It is therefore recommended that, for optimum performance and upgrade of the fertility of the area to moderate/high level, farmers should adopt management practices such as incorporation of organic matter (residue), return of plants/crop residues into these soils and manure application etc.

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