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Analysis of physico-chemical properties of soils in Guyuk Local Government Area, Adamawa State, Nigeria

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Abstract:
Land use is one of the main drivers of many processes of environmental changes as it influences basic resources within the landscape, including the soil resources and poor soil management which rapidly deteriorated the soil for farming and becomes threat for farmers. The study examines the physical and chemical characteristics of soil for farming in Guyuk Local Government area Adamawa State. Soil samples were collected from four (4) districts of Banjiram, Bobini, Chikila, and Dukul of different farmland. A GPS hand receiver was used to locate the sample points). The results revealed that the percentage of sandy, clay and silts accounts for 51.60%, 26.40%, 22% at a depth of 0-15cm and 55.60%, 24.40cm, 20cm at a depth of 15-30cm respectively in Banjiram. The highest content of soil is the sandy soil. In Banjiram, the analysis of chemical properties of soil at a depth of 0-15cm recorded a pH value of 6.6 thus it is neither too acidic nor alkaline and hence supports agricultural farming. Also, at depth of 15-30cm, the pH value increase by 0.1 hence the soil is still good for cultivation of crops. From this results, It is pertinent that some measures be applied in line with the studied carried out in the four district so as to maintain a balance in the physiochemical properties of soil. Some of this measures recommended include; stoppage of bush burning to avoid increase in alkalinity of the soil. Also, biological control of pest is a good measure as chemical is not used and hence the remains of the pest serve as manure for the soil which increases it fertility. Finally, it is essential that government impose strict measure in respect to the over use of soil.

Keywords: *Agricultural, Farming, Farmland, Physiochemical, Soil*

1. Introduction

Soil is a life supporting system upon which human beings have been dependent from the dawn of civilization. Hence, comprehensive information on soil resources, its potentials, limitations and capabilities, is required for a variety of purposes; such as project area development, soil conservation in catchment areas, sustainable agriculture, and reclamation of degraded lands [1]. In this context, characterization and mapping of different types of soils and developing rational criteria for land evaluation are important and very pertinent.

Successful agriculture requires the sustainable use of soil resource, because soils can easily lose their quality and quantity within a short period of time for many reasons. Agricultural practice therefore requires basic knowledge of sustainable use of the land. A success in soil management to maintain the soil quality depends on the understanding of how the soil responds to agricultural practices and it land uses over time. Recent interest in evaluating the quality of our soil resource has therefore been simulated by increasing awareness that soil is critically important component of the earth's biosphere, functioning not only in the production of food and fiber, but also in the maintenance of local, regional, and worldwide environmental quality [2].

In addition, the topography has also played a great impact on the soil quality and depth due to the interaction impact of cultivation practices and slope. Revising these trends lies in the enhancement of sustainable development of the agricultural sector. However, the basis of this sustainable agricultural development is good quality of soil, since maintenance of soil quality is an integral part of sustainable agriculture.

According to Wang, *et al.* [3] climate and geological history are importance factors affecting soil properties on regional and continental scales. However, Land-use may be the dominant factor of soil properties under small catchment scale. Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching [4]. As a result, it can modify the processes of transport and re-distribution of nutrients. In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content. Moreover, soils through land use change also produce considerable alterations [8], and usually soil quality diminishes after the cultivation of previously untilled soils [5]. Thus, land use and type of vegetation must be taken into account when relating soil nutrients with environmental conditions. The particular nature of the typical rugged relief with slopes subjected to cultivation for many years in the study area had led to decline in soil fertility. Therefore, there is special need for the analysis of soil nutrients in relation to land use in the study area. Such a local analysis is necessary to estimate nutrient storage in semi-natural and cultivated ecosystems [3].

Furthermore, feeding the ever -increasing human population is most challenging in developing countries due to alarming increase of oil degradation. For instance, in Sub-Saharan African countries, soil fertility depletion is the fundamental biophysical cause for declining per capita food production [6]. This challenge will continue as population pressure increases and degradation of soil resources also aggravated. Reversing this trend lies in the enhancement and Sustainable development of the agricultural land-use however; the basis of sustainable agricultural development is good soil quality. Hence maintenance of soil quality is an integral part of sustainable agriculture.

The rate of soil quality degradation depends on land-use effect in all systems, soil types, topography, and climatic conditions. Among these factors, inappropriate land use aggravates the degradation of soil physicochemical and biological properties [7, 8, 9]. In line with these Hoogsteen, *et al.* [10] reported that land use affects basic processes such as erosion, soil structure and aggregate stability, nutrient cycling, leaching, carbon sequestration, and other similar physical and biochemical processes. Land-use management practice changes such as cultivation of steep slopes, overgrazing, and no or limited fallow periods, and lack of institutions to enact regulations or laws that enhance sustainable land management practices have remarkable effects on the dynamics of soil properties. Land-use changes from forest cover to cultivated land may reduce input or organic residues that lead to a decline in soil fertility, increased rates of soil erosion, loss of soil organic matter, and nutrients.

Changes in physiochemical characteristics of soil and soil management cover density and intensification of agriculture aggravate the leaching rate of soil organic matter and nutrients, and an accelerated rate of land degradation [3]. The assessment of soil-topography relationships is an important tool used by pedologists in soil classification and mapping. Soil physicochemical properties are related to topographic heterogeneity, and changes in soil properties could affect soil water content, vegetation response, and the rate of land-use change. Physiochemical characteristics of soil and soil management changes influence the biogeochemistry, hydrology, and climate of the earth [2].

According to Hoogsteen, *et al.* [10] the impact of physiochemical characteristics of soil and soil management at the local to regional scales on soil quality status is not direct but rather complex to guarantee any generalizations cross sub-Saharan Africa, natural resources remain central to rural people’s livelihoods [11]. Nonetheless, natural (rainfall and temperature) as well as anthropogenic (farming, grazing, burning) forces can exert pressure on these resources, thereby influencing spatial and temporal scale changes on a landscape. Physiochemical characteristics of soil and soil management changes are indicators of forest resource dynamics within a landscape and that, the dynamics of physiochemical characteristics of soil and soil management change associated with the anthropogenic activities are occurring rapidly in tropical landscapes [11]. Recent international concerns place high attention on monitoring changes in tropical resources and reporting on those factors (such as agriculture) influencing these changes (such as deforestation), for consideration of novel and policy interventions (goal 15 of the 2030 Agenda for Sustainable Development). To understand the dynamics of ecological processes and the impacts related to these changes in physiochemical characteristics of soil and soil management, an assessment of the effects of these changes on soil quality is important [11].

Land use is one of the main drivers of many processes of environmental change, as it influences basic resources within the landscape, including the soil resources Physio-chemical characteristics and soil management in respect to agricultural practice among the people of Guyuk local government Area of Adamawa state. Poor soil management has rapidly deteriorated vast amounts of soil for farming, which frequently become a major threat in the study area. The impact of land use changes on soil can occur so unnoticed that land managers hardly contemplate initiating ameliorative measures. Knowledge and understanding of land use, the geographical change in soil properties and processes need to be looked into so as to ensure remediation or reclamation of disturbed or damaged soils properties in the study area. The aim of this study is to analyze changes in the physiochemical and physical properties of soil for agricultural farming in the study area.

2. Material and methods

2.1 Study Area

Guyuk is a town and Local Government Area in Adamawa State, Nigeria. Guyuk has many limestone deposits. Guyuk is located along Numan-Biu road. The town is located in the southern part of Adamawa state, about 115 miles northwest of Yola, the capital city of the state. It is situated between latitudes 9° 54' 20.0016'' N and longitude11° 55' 41.9988'' E as shown in Figure 1.

It comprises of seven districts which include Banjiram, Bobini, Chikila, Dukul, Dumna, Guyuk and Kola district [12]. The mean annual rainfall ranges from 700mm to 1600mm in the extreme Southern part. Rainfall distribution is unimodal, with much of the rain falling between May and October. The wettest months are August and September [13]. The rainy season is followed by a long dry season.

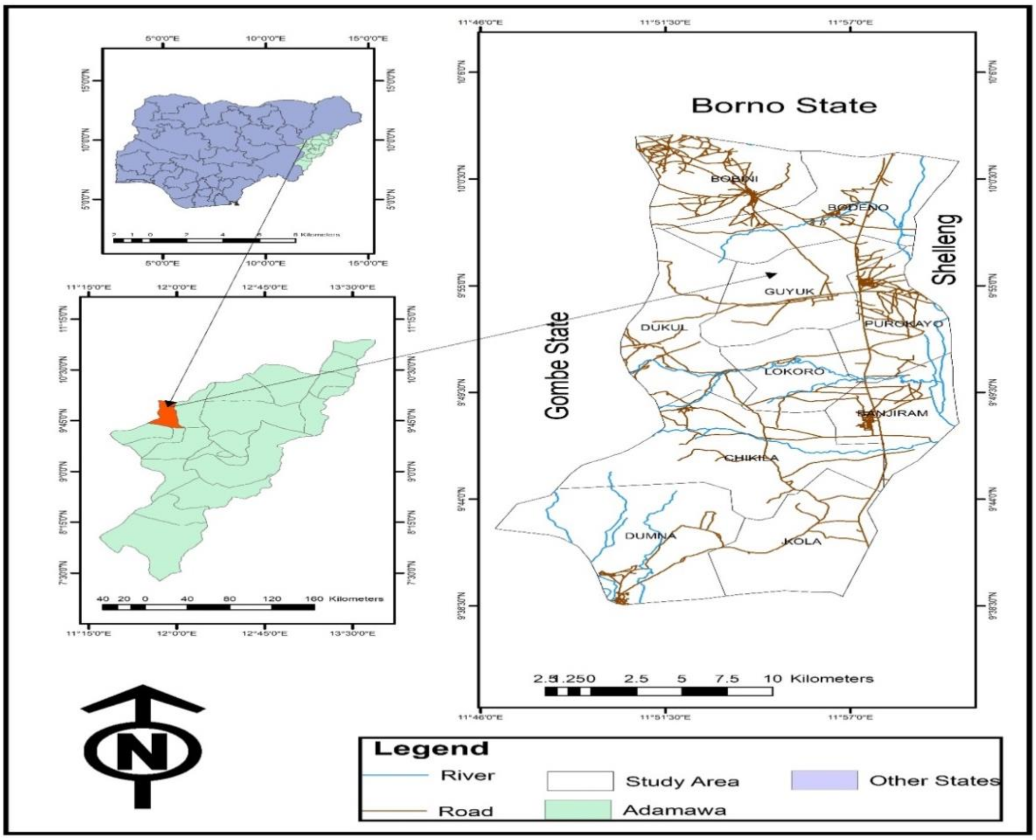

Figure 1: Map of Study Area

During this period, the area comes under the strong influence of the hammattan (winds that originate from the Sahara and blow across the Sahel region). The hammattan are very dry, with relative humidity to fall between 10-20% during the dry season. The temperature characteristics are typical of the West African savannah climate. Temperature in this climate region is high throughout the year because of high solar addition income, which is relatively evenly distributed throughout the year [14]. Maximum temperature can reach 40^{o}C particularly in April while minimum temperature can be as low as 18^{o}C between December and January. The most significant factors influencing soil formation within the study area are the climatic variables of temperature and rainfall and vegetation. Guyuk Local Government Area has Limestone types of soils, which has high ferric properties with iron oxides concretions, and are most of the time red to deep brown in color in the B horizons [2].

They are lateritic, hydromorphic and in semi-arid places like Pellas area, line enriched and called calcic luvsols [11]. Vegetation cover is sparsely distributed in the study area due to the prevailing climatic condition. Guyuk Local Government Area is found in the Sudan savannah vegetation zone made up of sparse vegetation and short grasses of about 1.5m to 2.0m high with some stunted trees [2]. The typical trees found in the study area are mainly baobab, mahogany, shear butter, and acacia which are used for medicinal purposes. The silk cotton grows as high as 9m to 15m and is used for making mattresses and pillows. The vegetation is being exploited as firewood and or thatch roofing and mat making.

2.2 Sources and method of data collection

The data used for this study was collected from different sources and therefore, there mode of collection also differs distinctly.

2.2.1 Acquisition of Primary data

The primary data used was obtained through field survey and taking soil sample from the field as shown in Figure 2.

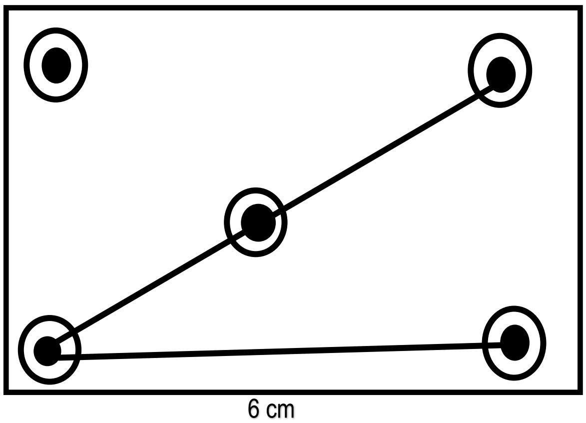

Figure 2: Soil Sampling Methods

Key: Point of sample collection and Buffer distance covering nearby area.

2.2.2 Total porosity

The total porosity was obtained using equation 1 and 2.

$$(\%) = \left(1 - \frac{BD}{PD}\right) \times 100 \quad (1)$$

$$C.V. = \frac{d}{x} \times 100 \quad (2)$$

Where *C.V.* = Coefficient of Variation, S = Standard derivation, X = assumed Mean and 100 = Percentage level

2.2.3 Soil samples Collection

Soil samples were collected from four (4) districts of Banjiram, Bobini, Chikila, and Dukul in different farmlands. A GPS hand receiver was used to locate the sample points. On each field, a demarcated subfield of (60meter X 60meter square) was demarcated for sample collection. The following predetermined depths were sampled; 0-15cm for top soil and 15-30cm for bottom soil respectively using a soil auger. Samples were picked at regular intervals. That is, square of uniform size grid cells were created (Quadrant). Samples were collected at selected node (intersection) with a known coordinate point. Five (5) replicates of soil samples were collected. That is, one each from the four extreme corners of the grid and one at the center of the grid bringing it to the total of five (5) samples in (figure 2) above, in which it was air dried, crushed and mixed thoroughly and pass through 2mm mesh sieve size to remove stones and other organic residues and take one kilogram (1kg) as composite for laboratory analysis from each land-use types. From each sample plot, soil samples were bagged and labeled with a clear and explicit identifier (permanent marker). On each sample plot, the Geographic coordinates, plot Id, texture (loamy, clay, sandy or their combination), elevation, soil pH and slop was recorded on field data sheet.

2.3 Data Analysis

2.3.1 Laboratory analysis

The soil samples were analyzed at the Soil Science department, Faculty of Agriculture and Agricultural Technology, Modibbo Adama University Yola, Nigeria.

The soil properties analyzed include particle size distribution (texture), bulk density, porosity, moisture content, soil pH, caution exchange capacity (CEC) and soil organic matter (SOM).

a. Soil particle size distribution (texture) were determined by the bouyoucos hydrometer method were sodium hexametaphosphate was used as a dispersing agent.
b. Bulk density: the soil bulk density was determined from the uncultivated or disturbed soil samples using the core sampling method after drying a defined volume of soil in an oven at 105oc for 24 hours [6]. It was calculated as the ratio of the mass of oven dried soil to the volume of the sampling core.
c. Porosity: porosity was calculated from the values of bulk density (BD) and particle density (PD) using relation in equation 1 [5]
d. Moisture content: moisture content was determined using the gravimetric method. This was calculated as soil field weight minus oven dried soil weight divided by the dry soil weight.
e. Soil pH: soil pH was measured potentiometrically using a digital pH-meter in the supernatant suspension of 1:2.5 soil to water ratio [4].
f. Soil organic carbon: organic carbon (OC) was measured by wet digesting method [20].
g. Soil organic matter: organic matter content was determined by multiplying the values of soil organic carbon by a factor of 1.72.
h. Soil cat ion exchange capacity (CEC): Exchange capacity was determined by using ammonium acetate saturation method [4]. The results obtained from laboratory analysis were analyzed using both descriptive and inferential statistics.

3. Results and discussion

3.1 Soil physical properties

Results of soil analysis at two depth 0-15cm, 15-30cm are represented in Table 1 and 2.

Table 1: Soil Physical Properties among the four district at the depth of 0-15cm

Location	Physical Characteristics				Textural Class
	Depth (cm)	Sandy %	Clay%	Silt%	
Banjira	0-15cm	51.60	26.40	22	Sandy, clay, loam
Bobini	0-15cm	71.60	20.40	8	Sandy, clay, loam
Chikila	0-15cm	39.60	39.60	18	Loam
Dokul	0-15cm	59.60	24.40	16	Sandy, clay, loam

Table 2: Results variation in soil physical properties among the four districts at the depth of 15-30cm

Location	Physical characteristics				Textural class
	Depth	Sandy %	Clay%	Silt%	
Banjira	15cm-30cm	55.60%	24.40%	20%	Sandy, Clay, Loam
Bombinu	15cm-30cm	65.60%	28.40%	6%	Sandy, Clay, Loam
Chikila	15cm-30cm	47.60%	32.40%	20%	Loam
Dokul	15cm-30cm	63.60%	26.40%	10%	Sandy, Clay, Loam

The percentage for sandy, clay and silt as taken from the field and tested in the laboratory accounts for 51.60%, 26.40%, 22% at a depth of 0-15cm and 55.60%, 24.40cm, 20cm at a depth of 15-30cm respectively in Banjram. The highest content of soil is the sandy soil. Sandy soil been characterized with high porosity because of it open space with the combination of clay soil and silt soil at a little percentage makes it the soil a little darker and serves as a habitat for microorganism such as earth worm. These organisms on decay increase the nutrient content of the soil. Thus this combination makes it possible for cultivation of crops such as groundnut at such shallow depth of 0-15cm the crops that can grow at such depth are crops that have shallow roots that do not need high depth for proper growth such as the groundnut. At deeper depth of 15-30cm, the soil becomes sandier with the combination of clay and silt soil. At this depth infiltration continues to increase as the soil become more porous.

In Bobini, the test of soil at the depth of 0-15cm and 15-30cm shown in Table 1 and 2 describe various physical characteristics in percentage as analyzed in the laboratory. At the depth of 0-15, the properties account for the following 71.60%, 20.40% and 8% while at a depth of 15-30cm, it accounts for 65.60%, 28.40% and 6% respectively. The high concentration of sandy soil at the upper part of the soil makes the soil poor in terms of fertility as such agriculture is hardly practiced but with increase in depth of the soil more than 15cm comes a reduction in the sandy nature of the soil and a little increase in the clay content of soil. This increase of clay makes the sand a little bit sticky and retains water a little but at this zone there is reduction of 2% in the silt content of the soil. This reduction in silt at this depth tends to affect the type of crop which can be cultivated at this area. At Bobini, the major type of crop to be planted can be maize but most times under constant irrigation practice as the soil do not retain water for long because of the high concentration of sandy soil at this area.

In Chikila, there is variation in the soil as to other district. A test of soil sample collected at the depth of 0-15cm accounts for 39.60% sandy, 39.60% clay and 18% silt while at the depth of 15-30cm it accounts for 47.60% sandy, 32.40% clay and 20% silt. There is an aggregate in times of the soil concentration. Such that the mixture of these soils at both depths improves the water retention capacity of the soil and increases the nutrient content of the soil as the soil as the silt content increases. The high concentration of clay is responsible for the sticky and water retention capacity of the soil. At deeper depth of 15-30cm, there is an increase of 8% that account for the 47% of the sandy soil and a reduction of 7.20% in the clay content of the soil. The reduction in this clay content does not affect the water retention capacity of the soil. An increase of 2% is noticed in the silt soil which increases the silt content to 20%. Some of the crops that are found to be cultivated at this area include; maize, guinea corn, rice, beans, millet etc. These soil properties at Chikila make it possible for agricultural practices as the soil has good characteristics of agricultural soil.

In Dokul, the test at different levels of the soil is seen to differ. At the depth of 0-15cm, the soil physical characteristics accounts for 59.60% sandy, 24.40% clay and 16% silt while at the depth of 15-30cm, it accounts for 63.60% sandy, 26.40% clay and 10% silt. At the upper part of the soil, which is the depth of 0-15cm, there is high concentration of sandy but with the presence of a clay soil at a good proportion of 24.40% there is neutrality in the soil content and in times of it productivity. The 16% concentration of silt soil in this area makes it possible for the growth of some crops such as beans and groundnut thus this soil more often support the growth of cover crops as mentioned above. Moving down to deeper depth of 15-30cm, there is more increase in both the sandy and the clay but a reduction in the silt content of the soil. The mixture of this soil makes it difficult to support the growth of many crops hence agricultural practice tends to be difficult because of the high infiltration caused by the high percentage of sandy soil content.

3.2 Soil chemical properties

Table 3 show the soil chemical properties among the four districts at the depth of 0-15cm while Table 4 show the soil characteristics among the four districts at the depth of 15-30cm

Table 3: Soil chemical properties at the depth of 0-15cm

Location	Chemical characteristics							
	Depth	pH	B.D(g/cm^3)	% MC	P.D(g/cm^3)	Porosity %	%OC	%0m
Banjira	0-15cm	6.6	1.39	93	2.35	40.93	1.30	2.24
Bobini	0-15cm	5.7	1.47	97	2.50	41.20	1.10	1.89
Chikila	0-15cm	6.3	1.30	91	2.35	44.75	1.40	2.41
Dokul	0-15cm	5.6	1.42	94	2.50	43.30	1.00	1.72

Source: Department of soil science laboratory Modibbo Adama University Yola.

Table 4: Chemical characteristics of soil at the depth of 15-30cm

Location	Chemical characteristics							
	Depth	pH	B.D(g/cm^3)	% MC	P.D(g/cm^3)	Porosity %	%OC	%0m
Banjira	15cm-30cm	6.7	1.41	91	2.50	43.60	1.40	2.41
Bobini	15cm-30cm	5.1	1.41	96	2.35	40.08	1.20	2.06
Chikila	15cm-30cm	6.5	1.35	91	2.50	46.00	1.30	2.24
Dokul	15cm-30cm	5.5	1.41	94	2.35	40.08	1.20	2.06

Keys: BD=Bulk Density, PD=Portion Density, MC= Moisture Content, OG=Organic Carbon, OM= Organic Matter

In Banjiram, the analysis of chemical properties of soil at a depth of 0-15cm and 15-30cm tested in the lab is reflected in table 1.3 and 1.4 above. It is recorded that the at the depth of 0-15cm, the PH value of the soil is 6.6 thus it is not too acidic nor alkaline and hence support agricultural farming in this location and at the deeper depth of 15-30cm the soil still maintains it PH value but increase by 0.1 hence the PH value becomes 6.7 hence still good for cultivation of crops as it is not too alkaline or acidic. The moisture content of soil at a depth of 0-15cm account for 93% and at deeper depth of 15-30cm the moisture content is 91% thus the moisture content is high thereby having a good water retention capacity. The porosity at a depth of 0-15cm is tested to be 40.93% of the soil hence there are pore spaces in the soil that allow water to get filtered into the soil as it is not heavily covered by clay soil that makes it difficult for water to percolate. Organic carbon at a depth of 0-15cm account for 1.30% and 1.40 at a depth of 15-30cm. this contain decayed remains of both plant and animal in the soil that increases the fertility of the soil. At a depth of 0-15cm organic matter account for 2.24% and at a depth of 15-30cm, it accounts for 2.41%. Hence organic matters such as earth worm are present in the soil at Banjira.

In Bombinu, the result of the test run at the lab as shown in the table 1.1 and 1.2 show that at a depth of 0-15cm there is stability in the PH value as it reads 5.7 but at deeper depth the soil PH value decreases to 5.1 thus crops planted at this deep may lack PH content to support it growth but the upper part, there is stability and thus crops that grow at this depth do not suffer from PH content lack. The moisture content of the soil at Bombinu at a depth of 0-15cm account for 97% thus having a very good water retention capacity and hence crops may not suffer from lack of water at this location. This stability continues down to a depth of 15-30cm accounting for 96% of moisture content thus the presence of organic matter and carbon holds the soil together and make sit to retain more water. A porosity of 41.20% is seen at the depth 0-15cm and 40.08% at the depth of 15-30cm this pore spaces availability makes it possible for water to move down the soil at good flow. The organic carbon present at a depth of 0-15cm account for 1.10% and at the depth of 15-30cm, it accounts for 1.20cm thus the presence of high organic carbon keeps the soil tight and increases it nutrient. The test shows that at a depth of 0-15cm, organic matter account for 1,89% and at deeper deep depth of 15-30cm, it accounts for 2.06% hence it is seen that the deeper the soil the higher the rate of organic matter concentration.

In Chikila, the chemical test of soil reveals a lot of properties about the soil as shown in table 1.3 and 1.4 at the depth of 0-15cm, the PH value accounts for 6.3 and at a depth of 15-30cm, it accounts for 6.5 hence it can be said that there is variation in the PH value of the soil as the soil goes deeper, this PH value is good for cultivation of crop at Chikila. The moisture content of soil at a depth of 0-15cm is 91% while at a depth of 15-30cm, it accounts for 91 still. This is a clear evidence of water retention of the soil hence with good water retention capacity of soil comes along good agricultural practice. The porosity of the soil at the depth of 0-15cm account for 40.93% of the chemical properties of the soil while at a depth of 15-30cm, it accounts for 43.60% this signifies the openness of the soil thus water moves into the soil quickly. The organic carbon of the soil within the depth of 0-15cm account for 1.40 and within the depth of 15-30cm it accounts for 1.30cm thus there is stability of decayed matter in the soil which rise the nutrient content of the soil. The organic matter of the soil within the depth of 0-15cm is 2.41% and at a depth of 15-30cm, it accounts for 2.24% thus increase the number of soil microbes in this area, hence agricultural farming is heavily practiced in this area.

In Dokul, the sample of sand collected and analyzed as summarized in the table 1.3 and 1.4 above show different chemical properties of the soil. The PH value at the depth of 0-15cm is at normal which is 5.6 and hence the stability in the PH is obtained while at the depth of 15-30cm, the PH value of the soil is 5.5 which express stability in the PH value of the soil and hence crops that it roots are within this range tend to grow very well without deficit in it PH level. The moisture content of the soil at this area within the depth of 0-15cm account is about 94% while at deep depth of 15-30cm it still maintains the same moisture content as due to the presence of the clay soil. The porosity which is the ability of soil to drain water through pore spaces in the soil account for 43.30% at a depth of 0-15cm and 40.08% at a depth of 15-30cm thus there is good pore space that water is infiltrated into the soil due to the concentration of sandy soil as it has more porous space than other soil type. The organic carbon of the soil at a depth of 0-15cm account for 1.00% and at 15-30cm it accounts for 1.20% thus there is fluctuation in the organic carbon due to depth of the soil owing to the palezoic era. The organic matter of the soil at the depth of 0-15cm account for 1.72% and at a depth of 15-30cm, it accounts for 2.06% thus the deeper the soil the higher the concentration of organic matter. Thus this concentration of organic matter tends to favor crops that it roots reach deep.

4. Conclusion

This study aimed at assessing the differences in selected physical and chemical properties of the soil resulting from long-term agricultural land-use from the samples collected in Guyuk local Government area under four (4) districts (Banjira, Bobinu, Chikila and Dukul).

Although there are limitations due to the selected soil properties, the number of land-use considered, depth of sampling (0–15 cm and 15–30 cm), and years of establishment of the land-use types, nevertheless, the study has important managerial implications. The findings showed that in many years of continuous cultivation with conventional tillage practices significantly degraded soil physical properties, SOC, and soil Chemical properties. Soil conservation measures such as manuring, mulching, and conservation tillage should be adopted to improve the soil properties. Also, the conversion of forest to continuous arable agricultural land further increased the soil's acidity and will require soil liming and application of P-based fertilizer to maintain or improve the soils' productivity.

The study also analyzed the physical and chemical characteristics properties of soil have been carried out in four districts in Guyuk local government area. The result has shown that the physiochemical soil properties have been affected due to the findings in the result above. The Soil analysis determines the levels of plant nutrients in the soils which was carried out. The study therefore recommended that phosphorus and exchangeable potassium should be artificially supplemented. And It is also pertinent that some measures be applied in line with the studies carried out in the four district so as to maintain a balance in the physiochemical properties of soil. Some of this measures recommended include; stoppage of bush burning as to avoid the increase in alkalinity of the soil, biological control of pest is also a good measures as chemical are not used and hence the remains of the pest serve as manure for the soil which increases it fertility. Finally, it is essential that government impose strict measure in respect to the over use of soil.

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