



## ASSESSMENT OF THE PHYSICAL AND CHEMICAL PROPERTIES OF THREE CONTRASTING SOILS UNDER DIFFERENT LAND USE SYSTEMS

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### ABSTRACT

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This study was undertaken to evaluate the physical and chemical properties of three contrasting soils under four land use systems. The soil types considered were Vertic Cambisol, Haplic Lixisol and Ferric Luvisol while the land use types studied are cocoa plantation (CP), grazing land (GL), fallow land (FL) and cultivated land (CL). Soil samples were collected at 0-15cm and 15-30cm depths respectively from each of the locations. The soil samples were air dried and passed through a 2mm sieve and taken to the laboratory for analysis. The result of the study showed a higher sand content being recorded in Haplic Lixisol (CL) and Ferric Luvisol 2 (FL) followed by that of Vertic Cambisol (CP) and Ferric Luvisol 1 (GL) in the upper 0 to 15 cm depth and lower 15-30 cm. The soil pH within the soil types and depths could be categorized as slightly acidic to moderately alkaline. The organic carbon content of the soils was generally low; it varied from 0.18% to 1.29 % for 0 to 15 cm depth with Vertic Cambisol (CP) having the highest value. The mean available P content was not significantly ( $P \leq 0.05$ ) different among the soil and land use types. The total nitrogen recorded was generally low 1.006 - 1.304% at 0-15cm while at the lower depth it ranged between 0.566 - 0.768%. The exchangeable bases also decreased following cultivation. The result of the study shows that continuous cultivation without adequate management practices causes a decline in the physical and chemical properties of the soil.

**Contribution/Originality:** This paper contributes to existing literature that agriculture being the main user of land is constantly being affected by land use changes. It further seeks to assess how the physical and chemical properties of the different soil types are being affected by different land use types.

### 1. INTRODUCTION

In most countries of the world today, agriculture is the main user of land; it is one of the major driving forces in global and local environment change. Agricultural use of the land is basically affected by the land tenure system majorly in the rural areas where land use patterns are governed mainly by the requirements of the agricultural industry which is the core factor for the livelihood of the people. The use of land for settlements, construction, local markets, roads, churches and mosque buildings are of secondary importance unlike the conversion of agricultural land to artificial surfaces which can have several impacts on the soil, water, environment and biodiversity.

Land-use can be referred to as the use into which a piece of land is put. It center's on the human activities that relate to a particular parcel of land and it varies from one place to another be it a country, state, city or local

government area. Land use practices vary considerably across the world, its concerns the product and benefits obtained from the use of land as well as the management actions (activities) carried out by humans. Land use has a major impact on natural resources such as water, soil, nutrients, plants and animals such that land use information can be used to develop solutions for natural resources management issues and agricultural sustainability.

There is an immense pressure on the availability of agricultural land due to increases in population densities in Nigeria and the south west in particular. Most of the agricultural lands are continuously been cultivated leading to a severe depletion of the fertility status of the soils, once this happen majority of the resource poor farmer uses that as an excuse to open up more lands without adequate considerations of the land potentials and appropriate land use. The soil being one of the most important determinant factors affecting crop production serves as a resource foundation for nearly all land use types thereby playing a key role in agricultural sustainability. In order to meet this ever increasing need of human beings for food, it is necessary to come up with strategies aimed at prioritizing and expanding the ever growing agricultural sector through an assessment of the soil physical and chemical properties with respect to land use.

As reported by Nye and Greenland [1] a soil cannot be productive except it has desirable quality, physical characteristics and enough nutrients that will meet the plant needs. Agricultural soil must be kept in aggregated and well-aerated conditions so that crop growth will not be adversely affected [2] but this becomes an issue when the land is being continuously cultivated with bad management practices which only add to the deterioration of the soil. Lal and Kimble [3] reported that continuous cropping and cultivation of many of the world's soils which had previously been under forest or grass land, are the major cause of substantial decline in soil organic matter and soil structure. Soil organic matter content is an important indicator of soil productivity in agricultural soils because it binds mineral particles into stable aggregates [4].

The main aim of this study therefore is to evaluate three contrasting soils types as influenced by land use in the derived savannah ecology in South Western Nigeria, while the objectives are to examine the relationship between land use and soil properties and also determine the effect of land use on some essential plant nutrient elements and their availability.

## **2. MATERIALS AND METHOD**

### **2.1. Study Area and Sample Collection**

This study was carried out at four different locations of the Institute of Agricultural Research and Training (IAR&T), Ibadan ( $7^{\circ} 23' N$ ;  $3^{\circ} 51' E$  and 160 m above mean sea level), Nigeria (Fig. 1). The area is characterized by a tropical climate marked with wet and dry seasons. It is characterized by a bimodal rainfall pattern with rainfall peaks occur mostly in June and September. Annual temperature ranges from  $21.3$  to  $31.2^{\circ}C$ .

Four different locations with different agricultural land use types were sampled for the study. The land use types considered were:

#### **2.1.1. Cocoa Plantation**

It is a mono cropping system with no other crops planted there asides cocoa, it has been in existence for over 50 years. It is usually being maintained by manual weeding of the grasses and weeds from time to time.

#### **2.1.2. Cultivated Land**

This is land which is been used for cultivation of arable crops such as maize cowpea, soybean etc. it is cultivated yearly in the raining season and in the dry season with the aid of irrigation water.

**2.1.3. Fallow**

This is land which has not been put to any agricultural use but just has some weeds and grasses growing on it. It has been left fallow for about 10 years.

**2.1.4. Grazing Land**

This is land which has been used over the years for grazing livestock animals such as cattle, sheep and goat. It is filled with tall grasses such as elephant grass and other broad leaf fodder plants,

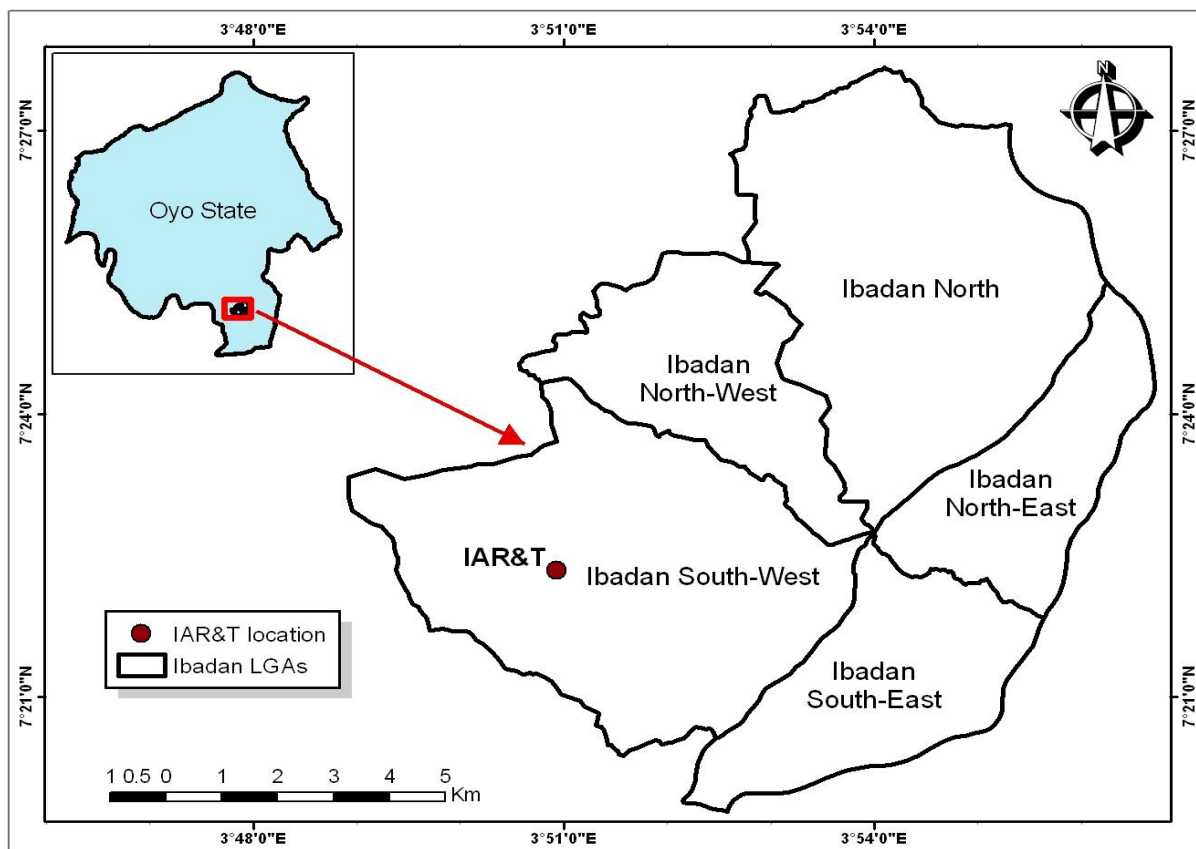


Figure-1. Map Showing Location of Study Area

Denton and Gbadegeshin [5]

**2.2. Soil Sampling**

Soil samples were taken from four (4) different locations within the Institute of Agricultural Research and Training under different land use, they are Cocoa plantation, Grazing land, cultivated land and fallow land. The samples were taken with the use of a soil auger at depth 0-15cm and 15-30cm respectively. The samples were taken with respect to the dominant soil types in each location while profile pits were dug for further clarification and classification of the soil type (Table 1). Three dominant soil types were identified in the location and classified according to USDA soil taxonomy as Vertic Cambisol (Egbeda series), Haplic Lixisol (Ibadan series), while the other two soils belong to Ferric Luvisol (Iwo and Egbeda series) [6].

Table-1. Land use type, classification and soil series

Landuse Type	USDA Classification	Soil Series (local)
Cocoa plantation (CP)	Vertic Cambisol	Egbeda
Cultivated land (CL)	Haplic Lixisol	Ibadan
Fallow land (FL)	Ferric Luvisol 2	Iwo
Grazing land (GL)	Ferric Luvisol 1	Egbeda

### 2.3. Soil Analysis

Physical and chemical analysis was carried out on the soil samples to determine soil pH, soil particle size distribution, available phosphorous, potassium, nitrogen and other necessary nutrient elements in the soil.

### 2.4. Determination of Soil Physical and Chemical Analysis

The soil samples were air-dried, crushed and allowed to pass through a 2 mm sieve. Particle size distribution was determined using hydrometer method [7]. Soil samples were analyzed for soil pH in both water and 0.01 M potassium chloride solution (1:1) using glass electrode pH meter [8]. Total nitrogen was determined by the macro-kjeldahl digestion method [9]. Available P was determined by the method described by Olsen [10]. Total N was determined by the Kjeldahl method [11]. Organic carbon content (OC) was measured by the Walkley-Black method [12]. Conversions between values of organic carbon and organic matter was made using Van Bemmelen factor of 1.724 on the assumption that, on average, SOM contains 58% of organic Carbon. Exchangeable cations were extracted with 1 M NH<sub>4</sub>OAC (pH 7.0) to determine K and Na using flame photometer and exchangeable Mg and Ca by atomic absorption spectrophotometer [13].

### 2.5. Statistical Analysis

This was performed using the GenStat statistical package edition 4 version 10.3. The analysis of variance (ANOVA) was determined and the means separated with the LSD at P < 0.05. The means of the parameters were used in computing the tables.

## 3. RESULTS AND DISCUSSION

### 3.1. Soil Physical Properties

Relatively higher sand content was recorded in Haplic Lixisol (CL) and Ferric Luvisol 2 (FL) followed by that of Vertic Cambisol (CP) and Ferric Luvisol 1 (GL) in the upper 0 to 15 cm depth and lower 15-30 cm though not significantly different at  $p < 0.05$ , (Table 2) this was followed by the silt fraction with values ranging from 20% to 24% at both depths and it was significantly different at 15- 30 cm depth with Vertic Cambisol (CP) having the highest percentage followed by grazed and fallow, arable land had the lowest percentage of 23 which could be as a result of the washing away of fine particle by erosion or attachment to crops during harvest. The clay fractions were not significantly different between the soil types and across depth. The soil textures of the different land use types at both layers of the different horizons were found to be the same. Although texture is an inherent property, the textural observation might be attributed to accelerated weathering as a result of continuous disturbance during farm management practices. This suggests that the different land use types did not have effect on the soil texture of the study area, since texture is an inherent soil property that is not influenced in a short period of time. The pH value of the soil types varied significantly. The highest was found to be under Ferric Luvisol 1 (GL) (6.90) followed by Vertic Cambisol (CP) and Haplic Lixisol (CL) (6.68 and 6.26) while Ferric Luvisol 2 (FL) recorded the least. The high pH value recorded on the Ferric Luvisol 1 (GL) could be as a result of the continuous urine deposits of the animals. The soil pH within the soil types and depths could be categorized as slightly acidic to moderately alkaline following the classification described by Brady and Weil [14].

**Table-2.** pH, particle size analysis of the soils at 0 to 15 and 15 to 30 cm depth.

Land Use	pH (H <sub>2</sub> O)	% sand	% silt	% clay	Texture
0- 15 cm Vertic Cambisol (CP)	6.68ab	56a	22a	22a	SL
Ferric Luvisol 1 (GL)	6.90a	56a	20a	24a	SL
Ferric Luvisol 2 (FL)	5.66	58a	22a	20a	SL
Haplic Lixisol (CL)	6.26b	62a	21a	16a	SL
15-30 cm					
Vertic Cambisol (CP)	6.71a	57a	25a	18a	SL
Ferric Luvisol 1 (GL)	6.73a	57a	4ab	20a	SL
Ferric Luvisol 2 (FL)	5.94b	58a	24ab	18a	SL
Haplic Lixisol (CL)	5.98b	66	23b	11	SL

Mean values within a column followed by the same letter(s) are not significantly different at  $p < 0.05$

GL = grazing land, FL = fallow land, CL= cultivated land, CP= cocoa plantation. SL= sandy loam.

### 3.2. Soil Chemical Properties

#### 3.2.1. Organic Carbon

The organic carbon content of the soils was generally low; it varied from 0.18% to 1.29 % for 0 to 15 cm depth with CP having the highest value this could be as a result of the large deposits of leaf litter that falls to the ground which decomposes and add to the humus content of the soil. While at depth it ranged from 0.37% to 0.95% though not significantly different from each other (Table 3). The average content of soil OC along the depth, were lower in GL, CL and FL land use types as compared to that of CP. At both depths FL had higher OC content as compared with GL and CL. Generally, cultivated soils have low organic matter content compared to native ecosystems since cultivation increases aeration of soil, which enhances decomposition of soil organic matter. In addition, most of the soil organic matters produced in cultivated lands are always removed. The low content of OC content indicates degradation of land under the different land uses.

#### 3.2.2. Available Phosphorus (P)

The mean available P content was not significantly ( $P \leq 0.05$ ) different among the soil types and land use types. Available P within depth 0 – 15 cm was highest under (CP), followed by FL while we recorded low available P under CL and GL (Table 3). The higher available P content under CP could be associated with increase in microbial activity that led to the mineralization of occluded P in this land use system. Relatively higher content of available P was found under FL than GL and CL which could be attributed to the renewal of soil nutrients during the fallow period.

#### 3.2.3. Total Nitrogen (TN)

The Total Nitrogen recorded was generally low and it was far below the critical limits expected in soils. The low nitrogen could be associated with the low organic matter in the soils. However, in this study, at 0 – 15 cm depth higher total nitrogen (TN) was recorded under CP followed by GL and FL, while CP had the lowest. The high nitrogen content recorded in the CL at both depths could be as a result of the application of inorganic fertilizers to the soil while GL, FL and CP had lower values. (Table 3). The low nutrient recorded under these land use and soil types depicts serious nutrient loss under these land uses and soil types and this reflects the extent of soil degradation which has occurred under these land uses.

#### 3.2.4. Ex. Potassium (K)

The concentration of exchangeable potassium (K) at 0 – 15 cm depth was higher in CP followed by GL, FL and CL soil types though there was no significant difference across all the land use types (Table 3). At depth of 15 – 30 cm, CP recorded the highest followed by FL) and CL) lands with GL recording the lowest. Low exchangeable K in 0 to 15 cm under CL soil type is likely the result of the effect of continuous cultivation and crop removal, whereas

the high exchangeable K concentration in FL could be due to accumulation of exchangeable K over time. This result indicates intensity of weathering, cultivation and use of acid forming inorganic fertilizers which affects the distribution of K in the soil system and influences its depletion.

### 3.2.5. Sodium (Na)

The values of exchangeable Na were found to be highest under CL soil type with a value of 0.25 Cmol<sup>-1</sup>kg while all the other soil types had the same value of 0.21 Cmol<sup>-1</sup>kg (Table 3), while in 15 to 30 cm depth higher available Na was recorded in CP soils followed by that of FL and GL, with CL soil types having the lowest. Although there were no significant differences in the available Na concentrations of the soils of the different soil types at p < 0.05.

### 3.2.6. Calcium (Ca)

For the three soil types and both depths the concentration of exchangeable calcium (Ca) followed the same distribution trend in order of FL, CP, GL and CL. In this study, the concentration of exchangeable calcium (Ca) in all of the land uses falls below the critical limit expected in soils as described by Agboola and Ayodele [15].

### 3.2.7. Exchangeable Magnesium (Mg)

The exchangeable magnesium (Mg) concentrations recorded in this study were moderate in concentration under the different soil types. Highest exchangeable magnesium (Mg) concentrations were recorded under CP followed by GL while CL recorded the lowest value at both depths (table 3). The low exchangeable Mg observed under CL might be due to leaching, soil erosion and crop harvest.

Table-3. Chemical properties of the soil at 0 to 15 and 15 to 30 cm depth under different land use systems.

Land Use	TN %	%OC	Ex. K mg <sup>-1</sup> kg	AV. P mg <sup>-1</sup> kg	Mg Cmol <sup>1</sup> kg	Ca Cmol <sup>1</sup> kg	Ex. Na Cmol <sup>1</sup> kg
0-15 cm							
Ferric Luvisol 1 (GL)	1.060a	0.18a	0.164a	3.3a	1.18a	0.74b	0.21a
Vertiv Cambisol (CP)	1.006a	1.29a	0.194a	15.9	2.36a	0.83ab	0.21a
Ferric Luvisol 2 (FL)	1.050a	1.14a	0.126a	4.9a	0.88a	1.11a	0.21a
Haplic Lixisol (CL)	1.304	1.04a	0.124a	4.8a	1.31a	0.49b	0.25a
15-30 cm							
Vertic Cambisol (CP)	0.638a	0.37a	0.144a	3.0a	1.70ab	0.72a	0.24a
Ferric Luvisol 1 (GL)	0.572a	0.95a	0.220a	21.7a	2.33a	0.74a	0.30a
Ferric Luvisol 2 (FL)	0.566a	0.66a	0.150a	2.3a	1.50ab	0.74a	0.25a
Haplic Lixisol (CL)	0.768	0.42a	0.152a	1.4a	1.20b	0.78a	0.20a

Mean values within a column followed by the same letter(s) are not significantly different at p < 0.05. GL = grazing land, FL= fallow land, CL= cultivated land, CP= cocoa plantation.

## 4. CONCLUSION

The result of this study indicates that cultivation diminishes soil nutrients, available P, exchangeable bases, organic carbon as well as total nitrogen and cause fluctuations in soil pH. Therefore in order to ensure high productivity in the studied soils, appropriate land management practices based on plant and animal residues, organic fertilizer (compost) incorporation, planting of cover crops and crop rotation will build up soil organic matter, soil nutrients and reduce drastically land degradation

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