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*RESEARCH ARTICLE*

# COMPARATIVE EVALUATION OF CHEMICAL, PHYSICAL PROPERTIES AND HEAVY METALS IN SOIL UNDER COCOA, CASSAVA FARM AND UNCULTIVATED LAND

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**ABSTRACT**

The comparative evaluation of the chemical, physical properties and heavy metals present in soil under Cocoa, Cassava and uncultivated land was carried out in Ambrose Alli University, Ekpoma. Soil samples from the top soil (0cm – 15cm) were collected with an auger from cocoa, cassava farms and uncultivated land at Iruekpen, Edo State for analyses. The soil was air dried, sieved and the sieved soil samples were analyzed for its texture, aggregate stability, chemical properties and heavy metals. The results indicated that Sand fraction in Cocoa plantation was higher than that of Cassava and Uncultivated land. The silt and clay fraction was higher in cassava farm than the other land use and the textural classes of the soils were loamy sand. The percentage of soil Aggregate Stability under cocoa plantation was 12% and was significantly ($p \leq 0.05$) higher compared to others. The organic carbon and nitrogen content and the heavy metals concentration such as copper, manganese were significantly ($P \leq 0.05$) higher in cocoa farm compared to other land use. The findings of the study provide valuable insights into the relationship between physical and chemical soil properties with land use practices. In conclusion, the different land use significantly influences the aggregate stability, chemical, physical properties and the heavy metals content of the soil.

**KEYWORDS**

Aggregate stability, cassava, cocoa, Heavy metals, land use, uncultivated land.

## 1. INTRODUCTION

Soil properties results from factors of soil formation such as parent material, climate, organism, relief, and time and these factors also influence the soil type. The knowledge of soil properties is very useful in determining soil characteristics, quality, and productivity. Soil chemical and physical properties contribute to various conditions affecting crop growth, erosion processes and land degradation (Negassa and Gebrekidan, 2004). Soil physical properties are significantly affected by cropping systems, especially tillage management, soil health, water and nutrient movements, aeration, soil temperature and nutrient cycling. Physical properties of soil, such as soil texture, structure, porosity and aggregation also play important roles in soil fertility and productivity. Soil aggregation is an important factor that affects plant growth, water infiltration, structure, microbial community, soil organic matter (SOM) dynamics and nutrient cycling (Six et al., 2004; Madari et al., 2005).

Heavy metals are natural components of the earth crust and as a result they are found naturally in soils and rocks with a subsequent range of natural concentrations in soils, sediments, waters and organisms. Human activities through industrial, agricultural, traffic, domestic, mining and other anthropogenic processes have contributed to elevate the toxic levels of these metals when compared to those contributed from geogenic or lithorlogical processes. Soil serves as a sink or reservoir for the metal contaminants due to the application of fungicides and chemical in cocoa plantation. Since these metals are not readily biodegradable, they persist and accumulate over a long time in the soils and vegetation resulting to environmental pollution (Mtunzi et al., 2015). An understanding of any soil pollutant and its dependence on soil's physico-chemical properties provides a basis for careful soil management that reduces the negative impact of the pollutant on the ecosystem (Aydinalp and Marinova, 2003). All negative effects of heavy metals start from their absorption by plants, and to a lesser extent by ground water contamination through leaching. As metals are absorbed by plants, they are thereby introduced into the food chain and once metals are ingested through contaminated food, they pose dangers to human health (Calace et al., 2002). Cocoa and cassava are important food crops in Nigeria and most part of the world which are consume regularly, moreso, the present or absorption of heavy metal in toxic forms will pose health challenges to the consumers. It is therefore the objective of the study to know how different land use affects some chemical, physical properties and heavy metals in soil under cocoa, cassava farms and uncultivated land.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Sample

Soil sample were collected from the top soil (0cm – 15cm) with an auger from cocoa, cassava farms and uncultivated / fallow land at Iruekpen, Edo State prior to the commencement of analyses. The soils were air dried, sieved with a 2mm sieve and the sieved soil samples were analyzed for it chemical properties and heavy metal concentration, texture and aggregate stability. The farms were located on latitude 6° 45' 0" North and longitude 6° 3' 0" East of the equator, with a mean annual rainfall of 1,500mm and temperature of about 15$^0$C to 34$^0$C. The soils of the area has earlier been classified as an afisols, this is because the base saturation is greater than 35%.

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### 2.2 Treatments

Three treatments which were; Cassava cultivated land (CCL) Cocoa Plantation (CP), Uncultivated Land (UCL). Soil sample were collected from above treatments.

### 2.3 Soil Analyses

Particle size distribution was determined by hydrometer method (Bouyoucos, 1962). The pH was determined in water (ratio 1:1, soil: water) (IITA, 1979). Organic carbon was determined by wet dichromate method, and available phosphorus in the soil was determined using Bray - 1 extraction method (Nelson and Sommers, 1975; Bray and Kartz, 1945). Total Nitrogen was determined by Kjeldahl method (Bremner and Mulvaney, 1982). Exchangeable cations; Calcium (ca), magnesium (mg), sodium (Na) and potassium (K) were extracted with $NH_4OAC$ pH 7.0 (Ammonium acetate). Potassium and sodium were determined with flame emission photometer while calcium (Ca) and magnesium (Mg) by the atomic absorption spectrophotometer (IITA 1979). Effective cation exchange capacity was evaluated by the summation of the total exchangeable bases and exchangeable acidity. The concentrations of some heavy metals, Fe, Mn, Zn, and Cu were determined using atomic absorption spectrophotometer (UnicamSolaar 32 model) following the standard procedures (American Public Health Association, 2000).

### 2.4 Determination of Soil Aggregate Stability Using the Wet Sieving Method (Kemper, 1965)

Samples of air-dry aggregate was placed on the uppermost of a set of graduated sieves (0.2mm) and immerse in water to stimulate flooding. A hundred grammes (100g) of soil from different land use was used for the analysis. The sieves were then oscillated vertically and rhythmically so that water is made to flow up and down through the screens and the assemblage of aggregates in these manners the action of flowing water was stimulated. At the end of the specified period of sieving (20 minutes) the nest of sieves was removed from the water and the oven dry weight of soil left on each sieve was determined (Kemper, 1965). This is done by dispersing the material collected from each sieve, using a mechanical stirrer. Percentage of Stable Aggregate (%SA):

$$\%SA = \frac{(Wt.retained) - (Wt.of\ Sand)}{(Total\ sample\ wt.) - (Wt.of\ Sand)} \times\ 100$$

### 2.5 Statistical Analyses

Data collected were analyzed using Analysis of Variance and Least Significant Difference (LSD) was used to separate means.

## 3. Results and Discussion

The results of chemical analyses from uncultivated land, cacao plantation and cassava cultivated land were presented in Table 1. The pH values ranged from 5.10 in Cocoa farm to 6.30 in the cassava farm. The pH of the soils under cocoa farm was moderately acidic while that of cassava and uncultivated land were slightly acidic. The soil pH recorded in cocoa farm corroborated with the previous work carried out on cocoa farm in Akure, Ondo State by (Ololade et al., 2010). The pH recorded in cassava farm was very suitable for the cultivation of cassava according to the earlier work done by Fermont (2008). The effect of soil pH is profound on the solubility of minerals and nutrients and it is regarded as a useful indicator of other soil parameters (Ololade et al., 2010).

Particularly, it provides useful information about the availabilities of exchangeable cations ($Ca^{2+}$, $Mg^{2+}$, $K^+$) in soils. When the soil is acidic, the availability of nitrogen, phosphorus, and potassium is reduced (Silva and Uchida, 2002). This is probably because at low pH values, oxides and hydroxides of iron and aluminum become soluble and tends to fix these nutrients (Njoyim et al., 2016). The values for soil organic carbon (SOC) were 21.37 g/kg in uncultivated land, 19.40 g/kg in cocoa farm and 17.27 g/kg in cassava. The lowest value obtained in the cassava farm could be attributed to the uptake by the cassava plants and low litters fall in the cassava farm however, there were no significant ($P \leq 0.05$) differences in organic carbon content among the different land use.

Total nitrogen (TN) ranged from 1.53 to 1.87g/kg and the total nitrogen (TN) content of the soils was adequate when compared with the critical values (1.5 – 2.0g/kg) for tropical soils according to (Enwezor et al., 1990; Osujieke et al., 2018). Available phosphorus of the soils ranged from 14.47 – 17.70mg/kg. Available P was medium for soil under the Cassava farm and low for soils under Cocoa plantation. The available P was significantly ($P \leq 0.05$) higher in cassava farm compared to that of the uncultivated land (CCL). The significant difference among available phosphorus in soils under the different land-uses could be attributed to organic material deposit, the rate of mineralization and leaching. According to a study, the causes of Phosphorus deficiencies have been attributed to high weatherability of the soils, clay type, leaching by intense rainfall and adsorption reaction by soil constituents (Osujieke et al., 2018).

The values for $Ca^{2+}$ under different land use range from 1.07cmol/kg in the uncultivated soils to 7.73cmol/kg in the cassava farms. The calcium (Ca) content for soils under the different land use differed significantly, calcium content in cassava farm was significantly ($p \leq 0.05$) higher compared to that of cocoa farm and the uncultivated land. The values for Magnesium ranged from 0.70 - 2.83cmol/kg, the magnesium content was significantly ($p \leq 0.05$) higher in cassava farm compared to soil sampled from cocoa plantation and uncultivated land. The Potassium ($K^+$) ranged from 0.05 - 013cmol/kg, the exchangeable K for soils under cassava farm was significantly ($p \leq 0.05$) higher compared to others forms of land use. The value of Sodium ranged from 0.57 to 0.70cmol/kg but there was no significant ($p \leq 0.05$) difference in the Na level among the different land use.

The exchangeable bases were low in the uncultivated soil and highest in the cassava farm. Critical values of basic cations as reported by showed that soils under study have very low to medium basic cations at various land-uses (Osujieke et al., 2018). Low values of basic cations have however been reported for most Nigerian soils (Akinrinde and Obigbeson, 2000). The low basic cations could be attributed to leaching and erosion losses by the high tropical rainfall as well as low content in the parent materials. The exchangeable acidity ranged from 0.25 - 0.45cmol/kg.

The soil acidity is lower in cassava and uncultivated farm compared to cocoa farm. The Aluminum content of the sampled soils ranged from 0.42-0.55cmol/kg the $Al^{3+}$ was lower in the cassava farm and highest in the uncultivated soil. The value for ECEC varies from the lowest in an uncultivated lands 3.29cmol/kg while the highest value was recorded in the Cassava farm with the value 12.01cmol/kg. The recommended limit of ECEC for optimal crop production is 15cmol/kg (Udo et al., 2017). It shows that the ECEC was low in all the land use and low ECEC of the soil may be due to the advance stage of weathering of the soils also the soils may be dominated by low activity clay such as kaolinite and oxides and hydroxides of metals (Ibiremo et al., 2011).

The total concentration of iron in the soil samples ranged from 8.73 - 26.34mg/kg. The lowest value were obtained in the cocoa farm and highest in the uncultivated lands. The concentrations of Fe in all the soil sampled were above the maximum permissible limit of 5.0mg/kg by (FAO, 2018). The high concentrations of total and available Fe could be from the soil parent materials (basalt, trachytes and rhyolite) which are natural sources of Fe in the soil. Excess amount of iron (more than 10mg/kg) causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness (Ruqia et al., 2015; Mofor et al., 2017).

The Mangenese (Mn) values ranged from 29.91- 94.63 mg/kg, the lowest (29.91 mg/kg) in the uncultivated farms to the highest (94.63 mg/kg) in the soils of the cocoa farms. The values Mn in soil under cocoa farm was significantly ($P \leq 0.05$) higher compared to others. The concentration of Mn in all the soil samples was above the maximum permissible limit of 0.20mg/kg by (FAO/WHO, 2018). The high concentrations of Mn could be from the soil parent materials which are natural sources of Mn in the soil and application of pesticides or fungicides. The Copper (Cu) values ranged from the lowest (0.53mg/kg) in the cassava farms to the highest (2.87mg/kg) in the soils of the cocoa farms. The values of Cu in cocoa farm was significantly ($P \leq 0.05$) higher compared to that of cassava farm and the uncultivated lands.

The concentration of copper in all the soil samples were above the maximum permissible limit of 0.20mg/kg by (FAO/WHO, 2018). Copper particulates are released into the atmosphere by windblown dust; volcanic eruptions; and anthropogenic sources, primarily copper smelters and ore processing facilities (Ruqia et al., 2015). It can also result from the application of pesticides and fungicides used often in cocoa plantation. The Zinc (Zn) values recorded ranged from the lowest (0.53 mg/kg) in an uncultivated land to the highest in soils from the cassava farms. The values of Zn in cassava farm was significantly ($P \leq 0.05$) higher compared to that of cocoa and uncultivated land. In uncultivated land and Cacao farm, the zinc content were lower while in the cassava farm the soils were higher than the permissible limit of 2.0mg/kg by (FAO, 2018). Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. It plays an important role in protein synthesis however; higher concentrations of zinc can be toxic to the organism (Mofor et al., 2017).

The particle size distribution describes the relative percentage of sand, silt and clay in any given soil. There was a preponderance of sand-sized fractions over the other sizes and this corroborate with the earlier work of who reported that sand fraction dominates other soil fractions (Okon et al., 2014). Soil texture plays a crucial role in determining the overall quality and productivity of soil. The textural class of the soil was Loamy sand which can support both cocoa and cassava production due to its specific properties. For cocoa production loamy sand allows excess water to drain preventing water logging and the roots have access to oxygen. The percentage of soil Aggregate Stability under cocoa plantation was 12% which was significantly (P≤0.05) higher compared to the other forms of land use. The land use under cocoa significantly (P≤0.05) influenced the Aggregate Stability as earlier reported (Dania et al., 2012). Soil aggregate stability is an important measure for assessing soil structural quality. Good soil quality is usually associated with good aggregate stability and provides a wide range of pore spaces from small to large. It is therefore obvious that good aggregate stability is an indicator of a good quality soil.

**Table 1:** Some Chemical Properties of soil from uncultivated lands and land used for cacao and cassava

| Land use type | pH | OC (g/kg) | N (g/kg) | P (mg/kg) | Ca | Mg | K | Na | Acidity | AL | ECEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ← | | | cmol/kg | | | → |
| CP | 5.14 | 19.40 | 1.53 | 14.47b | 5.30b | 1.30b | 0.12ab | 0.57 | 0.45a | 0.45 | 8.19b |
| CCL | 6.30 | 17.27 | 1.87 | 17.70a | 7.73a | 2.83a | 0.13a | 0.70 | 0.25b | 0.42 | 12.04a |
| UCL | 6.03 | 21.37 | 1.87 | 15.10b | 1.07c | 0.70c | 0.05b | 0.66 | 0.25b | 0.55 | 3.29c |
| LSD(P=0.05) | 0.67 | NS | NS | 2.07 | 1.37 | 0.31 | 0.08 | NS | 0.05 | NS | 2.74 |

Legend:

CP: Cocoa plantation

CCL: cassava cultivated land

UCL: Uncultivated land

**Table 2:** Cocoa plantation, Cassava cultivation farmland Uncultivated land Showing Some Soil Physical Properties

| | Particle size | | | | |
|---|---|---|---|---|---|
| Land use type | Sand | Silt g/kg | Clay | Textural class | AS (%) |
| CP | 880 | 28 | 92 | Loamy sand | 12.00a |
| CCA | 840 | 48 | 112 | Loamy Sand | 7.66b |
| UCL | 860 | 38 | 102 | Loamy Sand | 5.63c |
| LSD (P<0.05) | NS | NS | NS | | 1.50 |

Legend:

CP: Cocoa plantation

CCL: cassava cultivated land

UCL: Uncultivated land

AS - Aggregate Stability

**Table 3:** Heavy metals from uncultivated lands and land used for cacao and cassava

| Land use type | Fe | Mn | Cu | Zn |
|---|---|---|---|---|
| | ← | mg/kg | | → |
| Cacao | 8.73c | 94.63a | 2.87a | 1.93b |
| Cassava | 13.78b | 78.63a | 0.53b | 3.19a |
| Uncultivated | 26.34a | 29.91b | 0.60b | 0.53c |
| LSD (P=0.05) | 0.25 | 20.53 | 0.54 | 0.60 |

Legend

CP: Cocoa plantation

CCL: cassava cultivated land

UCL: Uncultivated land

## 4. Conclusion

The study was aimed at determining the effects of chemical, physical properties and heavy metals in soil under cocoa, cassava farm and uncultivated land. After soil analyses, it was observed that the different land-use types have influenced the soil chemical, physical properties and heavy metal. The pH was slightly acidic in cassava farm and uncultivated land and moderately acidic in cocoa farm. The values of organic carbon, total nitrogen and phosphorus in the soil among land use was above he critical values, the ECEC recorded in different land use were below the critical values, the heavy metal concentration of copper, manganese were significantly (P≤0.05) higher in cocoa farm compared to others. The results of the study showed that soils under cocoa plantation had significant (p0.05) higher aggregate stability compared to soil under cassava farm and uncultivated land. In conclusion, different land use has significant influence on the chemical, physical properties and heavy metal content of the soils and the crop cultivated in that area. Also, the results of the study can be used to assess the best land use practices that are optimal for Cassava, Cacao other crop production.

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