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COMPARATIVE ASSESSMENT OF SELECTED MICRONUTRIENTS UNDER THREE DIFFERENT LAND USE SYSTEMS IN ODIGHI, EDO STATE, NIGERIA

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ABSTRACT

This study carried out a comparative assessment of selected micronutrients under mixed tree plantation, cassava and secondary forest land use systems in Odighi, Edo State, Nigeria. The objectives of the study were to determine the concentrations of selected micronutrients under each of the three land use systems; evaluate the distribution of these micronutrients among the three land use systems; and examine the impact of the three land use systems on the selected micronutrients. Using transect sampling design, 18 soil samples were collected from each of the three land use systems giving a total of 54 soil samples for the study. The cassava land use was 7-10-year-old, mixed tree plantation was 10-15-year-old, while secondary forest was 25-year-old and above. Results showed that the concentrations of the selected soil micronutrients (iron, copper, manganese, and zinc) increased with increasing soil depth in all the examined sites except for manganese under cassava land use. The status of iron and zinc were rated excess while copper and manganese were rated optimum for crop production. The study observed significant ($p < 0.05$) variations for iron and manganese contents across the examined land uses and concluded that the direction and magnitude of changes in the status of micronutrients were a reflection of long-term impact of the different land uses and soil management measures. Liming of the soil and limited use of nitrogen-containing fertilizers are recommended to ameliorate zinc toxicity in the study area. Also, farmers in collaboration with agriculture extension workers should regulate the usage of organic and inorganic fertilizers as soil treatments to avoid excessive concentrations of iron and zinc in the study area.

Key words: cassava, land use system, micronutrients, mixed tree plantation, soil

INTRODUCTION

Soils are often impacted by anthropogenic activities, such as industrial and agricultural activities that may result in the decline of soil quality. Decline in soil quality is expected to intensify as more farmers are embracing intensive continuous cultivation thereby hindering the optimal growth of plants and agricultural sustainability (Yusufu and Abenu, 2019). In order to prevent soil degradation, empirical soil data and proper land evaluation are the most important prerequisite for the design of appropriate agricultural land use systems and soil management practices. Camarsa *et al.* (2014) and Lal (2015) identified soil as a non-renewable resource on a human life scale; therefore, once degraded, its process of restoration is very slow. Since soil is crucial for agricultural production and provides diverse ecological services for the wider society, constant monitoring of its condition is sacrosanct. Evaluating agricultural land use effects on soil properties is important in detecting changes in soil quality (Uzoh *et al*., 2020). These effects on soil properties provide vital evidences for evaluating agricultural sustainability (Ishaq and Lal, 2002).

Sustainable productivity of soil depends on its ability to supply essential nutrients. For soil to be regarded as a good medium for plant growth, it has to supply adequate micronutrients. Soil micronutrients (Fe, Cu, Mn and Zn) are present in small quantities, they play significant role in crop growth/development (Anthes and De Schutter, 2018). Soil micronutrients are very important for sustainable agriculture because they help in the formation of vitamin A in plants, essential for proper pollination, enable the formation of ethylene in ripening fruit, help regulate metabolic reactions in plants, activate and regulate enzymes, responsible for chlorophyll synthesis, regulates respiration and photosynthesis, increase water holding capacity of plant tissues, and others (FAO, 2011).

Studies have shown that the deficiency of micronutrients have become a major constraint to soil productivity and sustainability (Gebeyaw, 2015; Oviasogie *et al*., 2017; Abenu and Yusufu, 2021). Micronutrients deficiency is known to adversely affect plant development, quality and quantity (Imtiaz *et al.,* 2010). Hence, understanding deficiencies in soil micronutrients and ways to restore them becomes very important. Indications from developing countries reveal that soil micronutrients deficiency is becoming rampant especially in the West African region where several micronutrients' deficiencies have been reported (Foth and Ellis, 1997; Abenu and Yusufu, 2021).

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The concentrations of cationic micronutrients (Cu, Zn, Fe and Mn) in soils are dependent on the parent materials, land use and soil management practices (Pegoraro *et al.,* 2006). Intensified agriculture and over dependence on organic and inorganic fertilizers depletes the micronutrient reserves in the soil. Therefore, the evaluation of soil micronutrients properties under different farming systems is an important area of research in understanding the effect of varying land uses on soil quality. Kryzanowski *et al.* (1988) developed one of the most extensively used soil micronutrients classification scheme and identified three categories of soil as per micronutrients availability. The authors categorized the concentrations of Fe, Cu, Mn and Zn as deficient when < 2.00 mg kg^{-1}, < 0.50 mg kg^{-1}, < 1.00 mg kg^{-1} and < 0.50 mg kg^{-1}; marginal when 2.00-4.00 mg kg^{-1}, 0.50-1.00 mg kg^{-1}, 1.00-2.00 mg kg^{-1} and 0.50-1.00 mg kg^{-1}; and adequate when > 4.00 mg kg^{-1}, > 1.00 mg kg^{-1}, > 2.00 mg kg^{-1} and > 1.00 mg kg^{-1}, respectively.

A lot of studies have been done on macronutrients status of soils (Ugwa *et al.,* 2016; Ekpenkhio, 2018; Ota *et al.,* 2019; Adebo *et al.,* 2020; Ajala *et al*., 2021; Mbibueh *et al*., 2021; Orobator and Ekpenkhio, 2021; Kumar *et al.,* 2022), but very little attention is so far paid to soil cationic micronutrients (Fe, Cu, Mn and Zn) in relation to soil quality and sustainability with particular reference to different agricultural land use systems. However, there have been reports from different parts of the world of differences in concentrations of some micronutrients across land use systems and soil depths, with some of them being above the minimum critical values and others either deficient or adequate (Gebeyaw, 2015; Ivana *et al*., 2015; Onwudike *et al*., 2016; Sarker *et al*., 2018; Abenu and Yusufu, 2021).

Odighi in Edo State, Nigeria is a lowland tropical rainforest area where lands are put into different agricultural uses. However, these agricultural lands are rarely evaluated to determine the concentrations of their soil cationic micronutrients. At present, very limited data are available on the effects of agricultural land uses on soil contents of Fe, Cu, Mn and Zn in the study area. There is evidence that these four micronutrients could vary across both land use systems and soil depth along upland-lowland topographic settings in tropical ecosystems (Alarima *et al*., 2020). The objectives of the present study were to assess the concentrations of these selected four micronutrients (Fe, Cu, Mn and Zn) under three dominant land use systems in Odighi area of Edo State viz. mixed tree (*Gmelina arborea* Roxb. and *Tectona grandis* L.) plantation, cassava (*Manihot esculenta* Crantz) and secondary forest land uses; evaluate the distribution of the selected micronutrients among the three land use systems; and examine the impact of the three land use systems on the selected micronutrients. The study will provide not only the knowledge base that will help to improve agricultural productivity for smallholder and mixed plantation farmers, but also a scientific foundation for future research on the subject matter. Therefore, this study will offer current reference in the management of soils in the lowland tropical rainforest areas of Nigeria.

MATERIALS AND METHODS

Description of the Study Area

This research was carried out in Odighi community in Ovia North-East Local Government Area of Edo State because it is predominantly an agrarian community endowed with different agricultural land use systems such as arable farmlands, tree plantations and forested lands. Odighi community (Figure 1) is located within the geographical coordinates of Latitudes 6° 37' 5.24" N and 6° 36' 46.97" N of the equator, and longitudes 5° 45' 53.88" E and 5° 45' 49.16" E of the Greenwich Meridian and is spatially bounded by Uhiere, Owan and Agbanikaka villages to the North, and Igbakhue and Osasimwinoba villages to the South. The community is ca. 37.00 km from the capital city of Benin (as the crow flies), therefore they share similar climatic conditions. According to the Koppen's climatic classification scheme, Odighi falls within the tropical rainforest climate zone. The area is characterized by distinct dry and wet seasons, with mean annual rainfall, temperature and relative humidity of 2040.00 mm, 34°C and 80%, respectively (Atedhor *et al.,* 2011).

The soils are classified as Typic Kandiudults (Imadojemu *et al.,* 2018) and consist of the Benin rock formation underlain by limestone which are generally of lateritic clay sand with reddish brown coloration (Edema *et al.,* 2002). The soils are predominantly Ultisols with deep sandy horizons (Okoro *et al.*, 2000). Odighi is located in the rainforest type of vegetation, characterized by dense ever-green forest with thick vegetation. The vegetation is a multi-layered high tropical rainforest characterized majorly by teak (*Tectona grandis* L. f.), cacao (*Theobroma cacao*) and gmelina (*Gmelina arborea* Roxb.) trees, tall elephant grasses (*Pennisetum purpureum*) and arable crops such as cassava (*Manihot esculenta* Crantz), yam (*Dioscorea* spp.), plantain (*Musa paradisiaca*) and others. However, deforestation caused by anthropogenic factors such as industrial agriculture, timber logging and urbanization are fast depleting the natural vegetation.

Field Study and Soil Sampling

An extensive agricultural land use reconnaissance visit was conducted where mixed tree (*Gmelina arborea* Roxb. and *Tectona grandis* L. f.) plantation (Plate 1) and cassava (*Manihot esculenta* Crantz) land use (Plate 2) which served as treatment sites and uncultivated secondary forest (Plate 3) which served as control site were selected for investigation. The cassava land use was 7 to 10 years old, mixed tree plantation was 10 to 15 years old, while secondary forest was 25 years old and above.

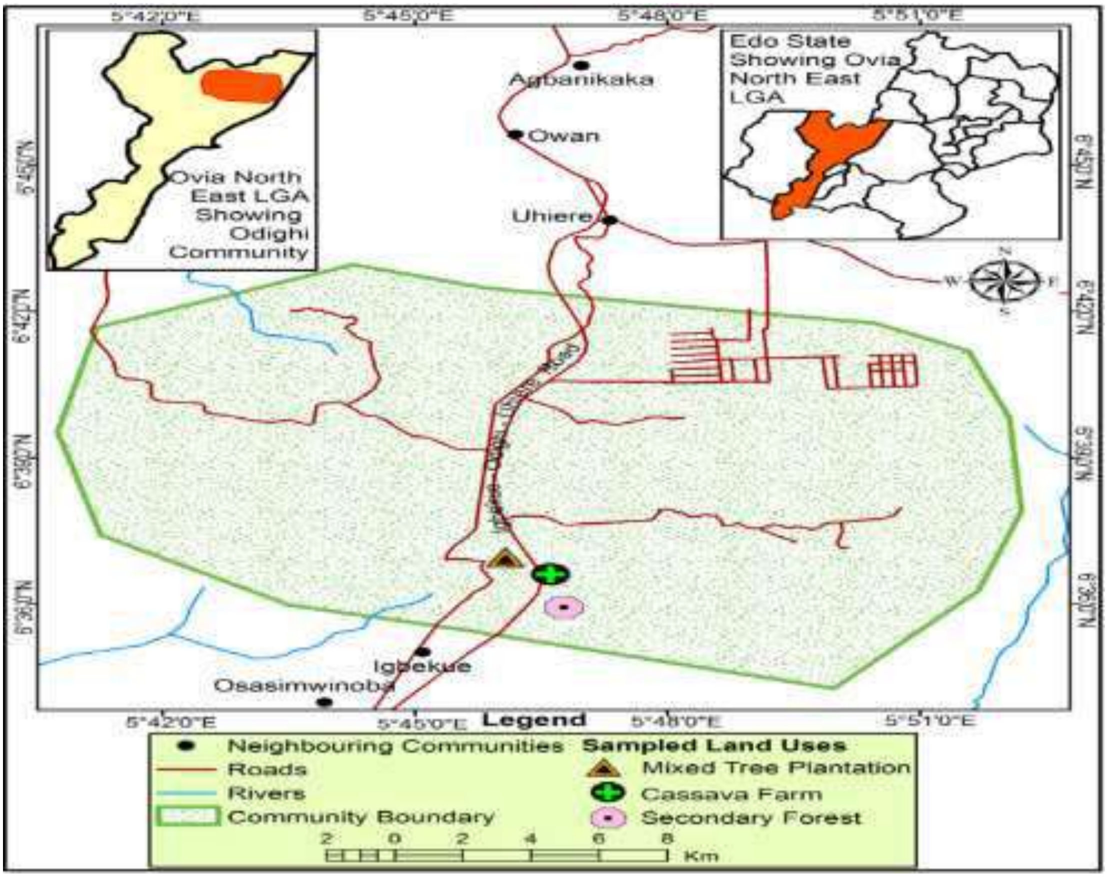

Figure 1: Odighi community showing sampled land uses as compiled with open street map database and field work

Soil sampling was carried out using the transect method (Johnson, 1961; Ahukaemere *et al.,* 2021). Soil samples were collected from three sampling points along each of the three 100.00 m transects at intervals of 50.00 m and two depths of 0-15.00 (surface soil) and 15.00-30.00 cm (subsurface soil) from each of the study sites, respectively.

This method of sampling from two depths helped to guarantee comparison between the surface and subsurface soils of the three land uses. The lower boundary of 30.00 cm depth was preferred because soil nutrient cycling occurs mostly within this depth and 85% of plant roots are concentrated here (De Oliveira and Valle, 1990). Ogidiolu (1997) argued that beyond the 0-15.00 and 15.00-30.00 cm soil depths, profile growth and differentiation of tropical soils are generally insignificant. Therefore, 18 soil samples each were collected from the three land uses (sample areas) giving a total of 54 soil samples for the study. All sampling points were geo-referenced using handheld global positioning system (GPS) receiver (Garmin® GPSMAP 64st). Some field observations were made and recorded. All the sampled sites had a similar soil forming environment in respect of relief, macro-climate and soil parent materials but differed in their respective land use activities. This scenario will help to establish differences in the selected soil micronutrients properties mainly due to the interaction effects of the three land uses and soil depths.

Plate 1: Mixed tree (*Gmelina arborea* Roxb. and *Tectona grandis* L. f.) plantation

Plate 2: Cassava (*Manihot esculenta* Crantz) land use

Plate 3: Secondary forest (uncultivated)

Laboratory Analysis

Soil samples collected from the study sites were air-dried at room temperature for 72 h before crushing any coarse lumps and passed through a 2 mm sieve to remove impurities and subsequently analyzed for soil micronutrients (Zn, Cu, Mn, and Fe) properties. 0.005-M of diethylenetriaminepentaacetic acid (DTPA) was used to extract available micronutrients from the soils and their concentrations were measured with Perkin-Elmer Analyst 300 atomic absorption spectrophotometer (AAS) with flame atomization (Lindsay and Norvell, 1978).

Data Analysis

Descriptive and inferential statistical analyses were carried out on the soil data in order to understand the nature and properties of their distribution, as well as to understand the degree of impact of the different land uses on the soil micronutrients. Table and bar charts were used to show the distribution of the micronutrients across the three land use systems. The range, mean, standard deviation and coefficient of variation (CV) were computed for the selected soil micronutrients indicators in the three land use systems and at each soil depths. Variability of soil properties which is a key feature of the soil (Mulla and McBratney, 2002) and gives a normalized measure of spread about the mean value was assessed using the Wilding (1985) classification scheme. Coefficient of variation (CV) values of < 15, 15-35 and > 35% indicated least, moderate and high variability, respectively. The threshold values for soil micronutrients according to Kryzanowski *et al.* (1988) was used to determine and compare the concentrations of soil micro-nutrients among the land uses. Using Microsoft Excel and Statistical Package for Social Sciences (SPSS) software packages, data were subjected to analysis of variance to test for differences in relation to three land use systems and soil depths.

RESULTS AND DISCUSSION

Available Iron (Fe)

The distribution of available Fe across the three land use systems and soil depths (Figure 2) indicated mean values of 26.27 mg kg^{-1} (0-15.00 cm) and 81.66 mg kg^{-1} (15.00-30.00 cm) in mixed tree plantation; 47.86 mg kg^{-1} (0-15.00 cm) and 152.31 mg kg^{-1} (15.00-30.00 cm) in cassava land use; and 22.63 mg kg^{-1} (0-15.00 cm) and 30.94 mg kg^{-1} (15.00-30.00 cm) in secondary forest respectively. The concentrations of available Fe in the study sites were in a decreasing order; cassava land use > mixed tree plantation > secondary forest in both soil depths (Table 1). This indicates that cassava cultivation had positive effects on the availability and concentrations of Fe in soils of the study area. Fe showed significant variations ($p < 0.05$) among the land use systems and across soil depths with soils under cassava land use measuring the highest Fe mean values both in the surface (47.86 mg kg^{-1}) and subsurface (152.31 mg kg^{-1}) layers (Figure 2 and Table 1). This result implies that there was a significant interaction effect of soil depths and land use systems on Fe concentrations in all the study sites. The higher Fe values found in cassava land use may be due to high soil organic matter content which increases soil micronutrients due to its chelating property in holding these essential nutrients. Blair *et al*. (1991) and Mamo (2011) stated that soil organic matter may promote the availability of micronutrients by supplying soluble complexing agents that interfere with their fixation.

Table 1: Summary of soil micronutrients properties

Micro-nutrients (mg kg^{-1})	Depth (cm)	Mixed tree plantation					Cassava land use					Secondary forest					*p*-value
		Range	Mean	Std.	CV (%)	Status	Range	Mean	Std.	CV (%)	Status	Range	Mean	Std.	CV (%)	Status	
Iron	0-15.00	19.60-42.80	26.27	7.32	27.88	Excess	24.30-78.42	47.86	20.30	42.43	Excess	18.20-26.80	22.63	3.07	13.60	Excess	0.00*
	15.00-30.00	38.70-164.00	81.66	44.80	54.88	Excess	17.80-268.00	152.31	92.71	60.87	Excess	20.10-69.80	30.94	14.99	48.47	Excess	0.00*
Copper	0-15.00	0.52-1.42	1.04	0.32	30.94	Optimum	0.81-2.60	1.43	0.59	41.69	Optimum	0.62-1.61	1.18	0.38	32.39	Optimum	0.25
	15.00-30.00	0.96-1.86	1.54	0.25	16.88	Optimum	0.90-2.90	1.58	0.56	35.44	Optimum	0.92-1.98	1.67	0.36	22.11	Optimum	0.79
Manganese	0-15.00	1.42-3.80	2.99	0.75	25.26	Optimum	2.40-4.50	3.38	0.69	20.45	Optimum	2.40-3.60	2.81	0.36	12.88	Optimum	0.17
	15.00-30.00	2.60-4.60	3.81	0.63	16.67	Optimum	1.90-3.90	2.82	0.73	26.02	Optimum	2.40-4.90	3.76	0.83	22.24	Optimum	0.01*
Zinc	0-15.00	9.62-16.90	12.87	2.24	17.46	Excess	9.80-21.40	15.71	4.06	25.87	Excess	8.90-16.00	12.94	2.66	20.56	Excess	0.11
	15.00-30.00	12.60-22.40	16.73	3.67	21.97	Excess	14.20-20.40	16.64	2.46	14.79	Excess	11.10-20.60	15.82	2.77	17.52	Excess	0.78

Std. - standard deviation, CV - coefficient of variation, * - significant

Also, the higher concentrations of Fe in cassava cropland may also be ascribed to the use of ferrous (ii) sulfate ($FeSO_4$) fertilizer for soil treatment during the farming season. Meanwhile, Prasad *et al.* (2010) earlier identified combined use of organic and chemical fertilizers to be capable of improving the soil available Fe content. This result was supported by the findings of Aluko and Fagbenro (2000) who observed higher values of micronutrients with the increase of soil organic matter and total nitrogen.

Furthermore, values of Fe increased significantly ($p < 0.05$) as soil depth increased in all the land use systems (Table 1). This result is not surprising because most soils in southern Nigeria (Ultisols) have high Fe in the subsurface, maybe as a result of co-migration with clay. Contrastingly, the study by Abenu and Yusufu (2021) observed a decline in Fe values as soil depth increased and reported marginal values for Fe concentrations under arable (maize and guinea corn) cropland, implying that crop yield may be mildly affected. This variance in outcome could be ascribed to the fact that their investigation was carried out in a different ecological zone in the Savannah North Central zone of Nigeria. Kryzanowski *et al.* (1988) and Sims and Johnson (1991) indicated that the threshold levels of Fe for crop production was 2.00-4.00 mg kg^{-1} and 2.50-4.50 mg kg^{-1}, respectively. The mean values of Fe were ca. 5 to 33 times more of its critical level; therefore, they qualify for excess Fe (Tilahun *et al.*, 2015). As a result, Fe toxicity could be expected which may inhibit crop productivity and production. This finding is in agreement with Tena and Beyene (2011) and Tilahun *et al.* (2015) who reported that amounts of available Fe are generally high in tropical soils and Fe toxicity is more common than deficiency. Also, Gebeyaw (2015) observed similar high Fe values while assessing micronutrient status in different land use soils. Generally, the high Fe values observed in all the sites might be due to low levels of soil pH in the study area; as pH is one of the most influential factors of Fe availability in soil. In lower soil pH, there is a tendency of higher availability of Fe in soil.

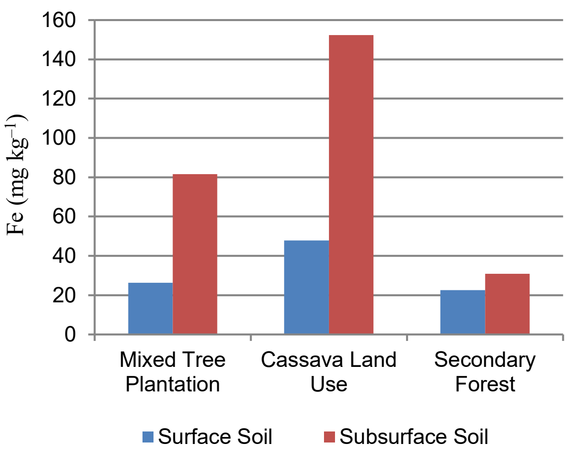

Figure 2: Available Iron (Fe) distribution across the three land use systems and soil depths

Available Copper (Cu)

The distribution of available Cu across the three land use systems and soil depths revealed mean values of 1.04 mg kg^{-1} (surface soil) and 1.54 mg kg^{-1} (subsurface soil) in mixed tree plantation; 1.43 mg kg^{-1} (surface soil) and 1.58 mg kg^{-1} (subsurface soil) in cassava land use; and 1.18 mg kg^{-1} and 1.67 mg kg^{-1} for surface and subsurface soils in secondary forest (Figure 3). The concentrations of available Cu in soils of the examined land use systems (Table 1) were in decreasing order of cassava land use > secondary forest > mixed tree plantation in surface soil and secondary forest > cassava land use > mixed tree plantation in subsurface soil. The higher mean Cu value (1.43 mg kg^{-1}) detected in surface soil of cassava farm might be as a result of the application of manure and mineral fertilizers such as copper (ii) sulfate ($CuSO_4$) fertilizers as well as the use of herbicides. $CuSO_4$ is often used as fertilizer to increase the Cu content of soil which can help to rectify acidic soils to improve crop yield. Field observation and interaction with the farmers suggests fertilizer usage. Non-significant variations ($p > 0.05$) were observed among the three land uses both at the surface and subsurface layers. However, the results assumed to be an indication of declining Cu status with increasing soil depth in all the land use systems. This suggests that Cu was not strongly retained by the surface soil but became available at the subsurface soil. This outcome may be ascribed to translocation processes due to excessive rainfall and poor drainage that removed Cu contents from the surface layer into the subsurface layer. Generally, the results implied that the different land use systems and soil layers did not significantly impact the concentrations of Cu in the studied sites. Similar results were obtained by Mathayo *et al.* (2016). Referring the critical value of 1.00 mg kg^{-1} suggested by Kryzanowski *et al.* (1988), the concentrations of Cu in soils of all the land use systems and at each depth were rated high status, implying that all the studied soils showed optimum amount of Cu for crop growth. This result is at variance with the work of Abenu and Yusufu (2021) who reported that concentrations of Cu were deficient in both surface and subsurface soils of some arable cropland. However, their study was carried out in a savannah agro-ecology zone different from the present investigation. Furthermore, observations indicated that Cu values were significantly lower than 60.00 mg kg^{-1}. Any concentration of Cu above 60.00 mg kg^{-1} is considered to be toxic and detrimental to plant growth and productivity (Senkondo *et al.,* 2015).

Available Manganese (Mn)

Figure 4 shows that the distribution of available Mn across the three land use systems and soil depths recorded mean values of 2.99 mg kg^{-1} (0-15.00 cm) and 3.81 mg kg^{-1} (15.00-30.00 cm) under mixed tree plantation; 3.38 mg kg^{-1} (0-15.00 cm) and 2.82 mg kg^{-1} (15.00-30.00 cm) under cassava land use; and

1.18 mg kg^{-1} (0-15.00 cm) and 1.67 mg kg^{-1} (15.00-30.00 cm) under secondary forest, respectively. The values of available Mn in surface soil (0-15.00 cm) was in an increasing order; secondary forest < mixed tree plantation < cassava land use while subsurface soil (15.00-30.00 cm) was cassava land use < secondary forest < mixed tree plantation, respectively (Table 1). Results indicated significant variations ($p < 0.05$) in Mn values among the three land use systems in the subsurface soil. However, similar to available Fe and Cu, Mn concentrations increased down the soil in all the sites except for cassava farmland which demonstrated a reverse trend and decreased with declining soil depth. This implies that the surface soil of cassava site had higher Mn values compared to the subsurface layer, as it was also higher against the other land use systems.

This result may be due to ash build-up in the form of amorphous and crystalline oxides as a consequence of slash and burn method of land preparation prior to cassava planting (Certini, 2005). Additionally, the application of synthetic fertilizers such as manganese (ii) sulfate ($MnSO_4$) and manganese (iv) oxide (MnO_2) fertilizers on surface soils of cassava farm during agronomic activities could have also accounted for the high Mn values. This result is in agreement with the findings of Oti and Ekpe (2017) who found higher values of Mn in surface soil layer. The status of Mn concentrations in all the evaluated land uses was within the normal tolerance range (> 2.00 mg kg^{-1}) and was rated optimum which is adequate for crop productivity (Kryzanowski *et al.,* 1988; Sims and Johnson, 1991).

Available Zinc (Zn)

Figure 5 presents the distribution of available Zn across the three land use systems and soil depths with mean values of 12.87 mg kg^{-1} (surface soil) and 16.73 mg kg^{-1} (subsurface soil) in mixed tree plantation; 15.71 mg kg^{-1} (surface soil) and 16.64 mg kg^{-1} (subsurface soil) in cassava land use; and 12.94 mg kg^{-1} (surface soil) and 15.82 mg kg^{-1} (subsurface soil) in secondary forest respectively. Zinc concentrations in the soils of the studied land uses was in excess and categorized in a decreasing order of cassava land use > secondary forest > mixed tree plantation in the surface soil and mixed tree plantation > cassava land use > secondary forest in the subsurface soil (Table 1). Depth distribution of Zn values was consistent with the behavioural trend of Fe and Cu. This means that Zn concentration increased with soil depth in all the land uses and suggests that all the examined land use systems had a depleting effect on surface soil Zn contents. The results depicted non-significant ($p > 0.05$) increases or decreases among the three land use systems and between soil depths. This implies a non-substantial interaction effect of land use system and soil depth on Zn concentrations in soils of the study area.

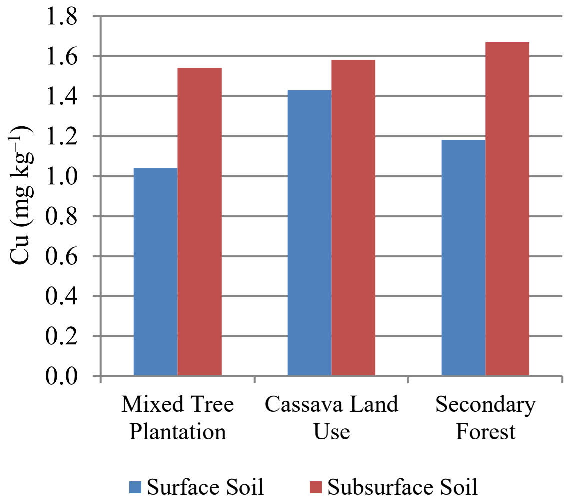

Figure 3: Available copper (Cu) distribution across the three land use systems and soil depths

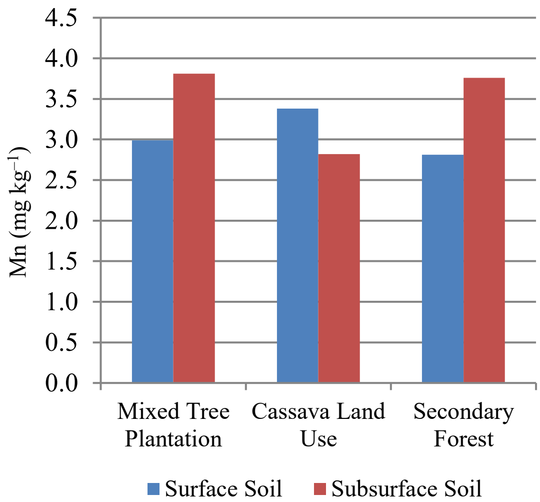

Figure 4: Available manganese (Mn) distribution across the three land use systems and soil depths

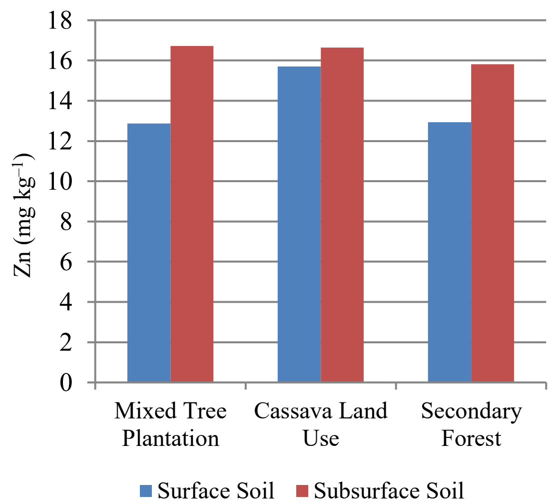

Figure 5: Available zinc (Zn) distribution across the three land use systems and soil depths

In the surface soils, results indicate that cassava land use had comparatively higher mean Zn value (15.71 mg kg^{-1}) than mixed tree plantation (12.87 mg kg^{-1}) and secondary forest (12.94 mg kg^{-1}). This connotes positive effect of cassava farming on Zn contents and may be credited to the application of zinc sulfate ($ZnSO_4$), zinc oxide (ZnO) or zinc chelate fertilizers on surface soils as inorganic soil amendments. Interactions with the local farmers suggest the use of different fertilizers. The mean and range values of Zn in soils of all the sites were substantially more than the threshold value (1.00 mg kg^{-1}) as they were ca. 12 to 16 times greater than its critical level. Consequently, they qualify for very high to excess Zn status (Kryzanowski *et al.,* 1988). Thus, the question of Zn toxicity arises both in the control and treatment sites as it was beyond the permissible limits. This implies that the parent materials of soils in Odighi were rich in Zn. This finding for excess Zn disagrees with Tilahun *et al.* (2015).

CONCLUSION

It is evident from this study that soil micronutrients is influenced by different agricultural land use systems of varying ages, as well as differences in their soil management practices. Generally, concentrations of the studied cationic micronutrients (Fe, Cu, Mn and Zn) were found to increase with increasing soil depths in all the land use systems except for Mn in cassava farm. These essential soil nutrients may have been dissolved into the deep layer of the soil. Therefore, the subsurface soil of the studied land uses is playing an important role as a micronutrients storage zone. Available Fe and Zn were found to be in excess amounts across the study sites and soil depths, especially in cassava land use which has been under intensive continuous cultivated for between 7 and 10 years. Cu and Mn were in optimum concentrations among the land uses; thus, adequate for soil productivity. Substantial interaction effects of land uses and soil depths were observed in this study as indicated by significant variations of Fe and Mn concentrations. Although none of the evaluated trace elements were found to be deficient in status, the study recommended liming especially in cassava land use, and the limited use of nitrogen containing fertilizers to ameliorate Zn toxicity in the study area. Also, appropriate fertilizer management programs should be conducted through agricultural extension and rural development agencies.

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