Influence of Land Use Types on Soil Properties and Micronutrient Concentrations on Soils of Similar Lithology in Owerri, Southeastern Nigeria

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Abstract: **Poor crop yield in Southeastern Nigeria has been attributed to micronutrient deficiency. Properties of soil vary with land use system over time and the knowledge of these changes is vital for sustainable food productivity. This work examined the effect of three land use types namely; palm plantation farm (PMPF), pineapple orchard farm (POF) and plantain plantation farm (PPM) on soil properties and micronutrient concentrations on soils of similar lithology in Imo State Nigeria. Land use types guided the sampling locations. Soil samples were collected from these land use types, air dried, sieved using 2 mm mesh sieve and analysed using standard methods. Data of soil analysis were subjected to analysis of variance (ANOVA) and significant means were separated using Least Significant Difference (LSD) at 0.05 probability level. Relationship between micronutrients and soil properties were determined using correlation analysis. Results obtained showed variations in soil organic matter, total nitrogen and exchangeable bases among the land use types. The highest concentration of Cu (0.21 mg/kg) was recorded in PMPF while the highest concentration of Zn (17.95 Mg/kg) was recorded in PPM. Fe concentration was highest (77.68 Mg/kg) in PMPF while the highest Mn concentration (6.14 Mg/kg) was recorded in PPM. Significant positive correlations existed between soil pH and Zn (r = 0.5471), Zn and clay (r = 0.5422) and Mn and clay (r = 0.550) while Zn correlated negatively with total exchangeable acidity (TEA) (r = - 0.8586). Agronomic practices that will improve soil organic matter and pH is recommended so that levels of these nutrients that are below the critical levels will be improved.**

***Keywords*: Land use, micronutrients, lithology, soil properties, soil fertility**

I. INTRODUCTION

Decline in food production in Nigeria as a result of poor soil fertility has been a major problem facing the region at present [1]. These problems have resulted to adoption of many strategies aimed at improving soil productivity and crop yield. One of such strategy was continual evaluation of nutrient status of soils in lands that are under different management practices [2]. Land use changes have great influence on soil physico-chemical and biological properties. It influences soil organic matter, soil pH and mineralogical properties of soils [3]. Murty *et al*. [4] stated that land use practices affect the distribution and supply of soil nutrients by directly altering soil properties and by influencing biological transformations on the rooting zone. Land use systems cause significant variations in soil properties, terrestrial cycles and reduction of output [2]; [5].

Lands are put into numerous uses for food production, industrial and engineering purposes and other non-agricultural practices. Several authors have indicated that the availability of micronutrients in soils depends on land management system which directly or indirectly influences on soil pH, organic matter content, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere [6]. Large hectares of arable land in Nigeria have been reported to be deficient in micronutrients [7] and many of these deficiencies were brought about by the continuous use of inorganic fertilizers particularly nitrogen, phosphorus, and potassium by farmers, limited use of organic manures as well as non-recycling of crop residues. These lead to rapid exhaustion of micronutrients in soil output [2].

Evaluation of soil micro nutrients under land use practices has become vital especially in this era when diversification of Nigerian economy through agriculture due to downfall in prices of crude oil in the world is considered by all. Beside soil characteristics, land use pattern play a vital role in governing the nutrient dynamics and fertility of soils [6]. Due to continuous cultivation, soils under particular land use system may affect physico–chemical properties which may modify micronutrients content and their availability to plants. Evaluation of soil physicochemical properties along with micronutrients status in different land use system may have significant importance. Many researchers have been carried out to examine the influence of land use types on soil properties in different agro-ecological zones in Nigeria [8]. According to Senjobi and Ogunkunle [8] who examined the effect of land use on land degradation and productivity in Ogun State Nigeria, soil properties vary from one land use type to another. According to Wasihun *et al* [9], Changes in land use type and soil management can have a marked effect on soil physical and chemical properties.

Information about the extent of micronutrients deficient area as influenced by land use system is necessary for the scientists, administrators, farmers and fertilizer manufactures to determine the kind and quantity of fertilizer required for the particular region. According to Shehu [10] and Alemayehu and Sheleme [11] sustainable crop production in the Nigerian soil requires a good understanding of the fertility status of the soil in order to impose appropriate nutrient management strategies. Gebeyaw [12] stated that understanding the concentration of soil micronutrients as influenced by land use system will help in the management practices for sustainable food production. However, studies on the micronutrient content of soils under land use systems have not been fully investigated in this study area and this formed the basis of this investigation. The objective of this study therefore was to evaluate the effect of three land use types namely; palm plantation farm (PMPF), pineapple orchard farm (POF) and plantain plantation farm (PPM) on soil physicochemical properties and micronutrient concentrations on soils of similar lithology in Imo State, Southeastern Nigeria.

II. MATERIALS AND METHODS

The Study Area: The investigation was conducted during 2016 planting season in Owerri Imo State Southeastern Nigeria. Soil samples were collected from three towns namely: Ihiagwa Community, Umuchima Community and Eziobodo Community. Land use system guided the sampling locations. The sites coordinates were taken with a Geographical Positioning System (GPS) as shown in Table 1. The areas have an average annual rainfall range of 1950 mm – 2500 mm, annual temperature range of 27°C – 32°C and average relative humidity of 79% with an altitude of about 52 – 100 metres above sea level. The geological material of soils in the study area is an ultisol and is classified as typic haplustult [13]. Coastal Plain Sands (Benin formation) is the parent material of the soil. The soils of the area are characterized by low organic matter, cation exchange capacity and are highly eroded [14]. Tropical rainforest is the dominant vegetation of the area, though with remarkable ecological diversity that is caused by anthropogenic activities, especially farming and deforestation resulting into depleted vegetation as a result of demographic pressure. Applications of inorganic fertilizer and farm yard manure are major soil fertility restoration in the zone.

TABLE 1: Coordinates of the Study Locations

Locations	Land use	Longitude	Latitude
Ihiagwa	Pineapple orchard farm (POF)	5˚ 18' 42''N	7˚ 02' 31''E
Umuchima	Pineapple orchard farm (POF)	5˚ 22' 22''N	7˚ 03' 24''E
Eziobodo	Pineapple orchard farm (POF)	5˚ 21' 35''N	7˚ 05' 28''E
Ihiagwa	Palm plantation farm (PMPF)	5˚ 25' 14''N	7˚ 02' 31''E
Umuchima	Palm plantation farm (PMPF)	5˚ 26' 30''N	7˚ 04' 42''E
Eziobodo	Palm plantation farm (PMPF)	5˚ 19' 36''N	6˚ 02' 34''E
Ihiagwa	Plantain plantation farm (PPF)	5˚ 32' 20''N	7˚ 01' 16''E
Umuchima	Plantain plantation farm (PPF)	5˚ 26' 27''N	7˚ 03' 19''E
Eziobodo	Plantain plantation farm (PPF)	5˚ 24' 39''N	7˚ 01' 31''E

Soil Sampling: A reconnaissance visit was carried out to identify the sampling locations. Three land use systems were studied namely pineapple orchard farm (POF), palm plantation farm (PMPF) and plantain plantation farm (PPF). These three land use types were identified in the three communities as sampling locations. POF was six years of existence while PMPF and PPF were eight and seven years of age respectively. At each sampling site, three replicate samples of approximately 1kg of soil were randomly collected from an epipedon of depth 0 – 40 cm using spiral auger sampler. The three land use types are the treatments while three sample collections from each land use acts as replications. The samples were taken in labelled nylon bags to differentiate the sampling points, well mixed, grounded, air dried and sieved through 2mm size sieve and taken to the laboratory for analysis.

Laboratory Analysis: Distribution of soil particle sizes was determined by hydrometer method according to the procedure recommended by [15]. Bulk density (BD) was determined by core methods according to [16]. Total porosity of soil was calculated from the result of bulk density using the formula:

$$\text{Total porosity (TP)} \qquad 1-(\frac{BD}{pd}\ x\ 100\ ) \qquad (1)$$

where pd = particle density (2.65 g/cm^3) and BD = bulk density

Gravimetric moisture content (GMC) was determined using the formula

$$\text{GMC} = \frac{Wtmc}{Wtss}\ x\ 100 \qquad (2)$$

where Wtmc = weight of the moisture contained in soil sample; Wtss = weight of soil sample
Soil pH was determined using pH metre in soil / liquid suspension ratio of 1: 2.5 according to [17]. Organic carbon was determined using chromic acid wet oxidation method [18]. Total nitrogen was determined by kjeldahl digestion method using concentrated H_2S0_4 and sodium copper sulphate catalyst mixture [19].

Available phosphorus was determined using Bray II solution according to [20]. Exchangeable Mg and Ca were extracted using ethylene diamine tetra acetic acid (EDTA) [21]; while exchangeable K and Na were extracted using 1N Neutral ammonium acetate (NH_4OAC) and then determined using flame photometer [21]. Exchangeable Acidity was measured titrimetrically using 1 N KCl against 0.05N Sodium hydroxide [22]; while effective cation exchange capacity was calculated from the summation of all exchangeable bases and total exchangeable acidity. Percentage Base Saturation (PBS) was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

Statistical Analysis: Results from laboratory analysis were subjected to Analysis of Variance (ANOVA) while significant means among treatments were separated using Least Significant Difference (LSD) at 0.05 probability level and relationship between aggregate stability indices and soil properties was determined using correlation analysis. These analyses were done using Genstat discovery (3rd Edition).

III. RESULTS AND DISCUSSIONS

The Physical Properties of Soils Studied: The physical properties of soils in the studied area are shown in Table 2. The particle sizes in the three communities were dominated by sand fraction irrespective of land use system. The sand fractions in the three locations ranged from 861.3 – 879.6 g/kg. Silt fractions ranged from 56.13 – 91.07 g/kg while clay fractions ranged from 50.93 – 64.27 g/kg. The bulk density in POF, PMPF and PPF was 1.17, 1.13 and 1.21 mg/cm^3 respectively. Soil total porosity in POF, PMPF and PPF was 43.2, 41.5 and 44.8% respectively while the gravimetric moisture content in POF, PMPF and PPF was 381.1, 318.6 and 425.1 g/kg respectively.

There was no significant effect on the particle size distribution in the three land uses. This observation contradicted the observation of [23] that reported a significant effect on the clay, silt and sand fractions of the soil and attributed the differences to variations in climatic condition. However, the observation was in concord with [24] and [25] who observed no significant effect on soil particle size distributions under different land use systems. High sand fractions in the area could be attributed to the parent material (coastal plain sand) since the texture of the soil is highly influenced by the parent material and topography over time [7]. Again the high precipitation in the region that promote illuviation or leaching of silt and clay particles below the epipedon could contribute to high sand fractions. Variations in soil bulk density, soil total porosity and gravimetric moisture content could be attributed to different agronomic practices in these land use types [2].

TABLE 2: Physical Properties of the Studied Locations

Location	Land Use	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural class	Bulk density (mg/cm^3)	Total Porosity (%)	Gravimetric moisture content (g/kg)
Ihiagwa	(POF)	859.6	72.8	67.6	loamy sand	1.21	44.7	356.3
Umuchima	(POF)	939.6	2.8	57.6	loamy sand	1.12	41.3	422.4
Eziobodo	(POF)	839.6	92.8	67.6	loamy sand	1.18	43.5	365.4
	Mean	879.6	56.1	64.3	loamy sand	1.17	43.2	381.4
Ihiagwa	(PMPF)	789.6	117.8	92.6	loamy sand	1.14	42	354.4
Umuchima	(PMPF)	929.6	42.8	27.6	loamy sand	1.13	41.6	246.7
Eziobodo	(PMPF)	869.6	77.8	52.6	loamy sand	1.11	40.9	354.6
	Mean	862.9	79.5	57.6	loamy sand	1.13	41.5	318.6
Ihiagwa	(PPF)	904.8	37.6	67.6	loamy sand	1.14	42	453.5
Umuchima	(PPF)	789.6	152.8	57.6	loamy sand	1.32	48.8	445.3
Eziobodo	(PPF)	889.6	82.8	27.6	loamy sand	1.18	43.5	376.4

Mean	861.3	91.1	50.9	loamy sand	1.21	44.8	425.1
$LSD_{(0.05)}$	NS	NS	NS		0.04	2.43	17.32

NS = not significant, POF = Pineapple orchard, PMPF = palm plantation farm. PPF = plantain plantation

The Chemical Properties

The chemical properties of soils are shown in Table 3. There were significant differences in the chemical properties of the soils. The highest value of soil pH (6.84) was recorded in plantain plantation farm (PPF) and the sequence of increase in soil pH among the three land uses was (PPF) > (POF) > (PMPF). Soil organic carbon ranged from 2.52 - 3.79 g/kg with the highest value (3.79 g/kg) recorded in pineapple orchard farm (POF). The sequence of increase was POF > PPF > PMPF. Soil total nitrogen was low and ranged from 0.22 – 0.33 g/kg with the highest value (0.33 g/kg) recorded in POF and the sequence was like that of soil organic carbon. Soil available phosphorus in the three locations ranged from 39.95 – 43.75 mg/kg and the highest value (42.75 mg/kg) was recorded in palm plantation farm (PMPF). The highest value of total exchangeable bases was recorded in PPF with the value 1.64 cmol/kg. The sequence was PPF > PMPF > POF. The same sequence was observed in total exchangeable acidity. Similarly, the highest values of ECEC (2.42 cmol/kg) and base saturation (69.84 %) was recorded in plantain plantation farm (PPF).

These results showed that plantain plantation farm recorded higher soil chemical properties such as soil pH, exchangeable bases, ECEC and base saturation. This could be attributed to agronomic practices in the region. Majority of farmers in the area usually dump domestic wastes such as kitchen wastes, ash from firewood and other degradable materials generated from their home in the plantain plantation farm. Ash serves as a good liming material and so increases soil pH which favours the availability of exchangeable bases in plantain plantation farm more than other land uses. [25] made similar observation on the fertility status of soils in Southeastern Nigeria under different land use types.

TABLE 3. The Chemical Properties of Soil in the Studied Locations

Location	Land Use	pH (H_20)	OC (g/kg)	TN (g/kg)	AP (Mg/kg)	Ca	Mg	K	Na	TEA	TEB	ECEC	BS (%)
						←		(cmol/kg)				→	
Ihiagwa	(POF)	6.25	2.79	0.24	37.66	1.02	0.08	0.21	0.02	1.03	1.33	2.36	56.4
Umuchima	(POF)	7.2	8.18	0.71	39.97	1.04	0.04	0.22	0.04	1.22	1.34	1.58	84.8
Eziobodo	(POF)	5.72	0.4	0.03	43.75	1.06	0.04	0.24	0.05	1.09	1.39	2.48	56.1
	Mean	6.39	3.79	0.33	40.46	1.04	0.05	0.22	0.04	1.11	1.35	2.14	65.77
Ihiagwa	(PMPF)	5.55	2.37	0.21	45.99	1.08	0.02	0.24	0.03	1.21	1.37	2.58	53.1
Umuchima	(PMPF)	6.15	3.98	0.34	36.89	1.23	0.04	0.22	0.02	1.11	1.51	1.85	81.6
Eziobodo	(PMPF)	5.76	1.22	0.11	45.36	1.24	0.06	0.21	0.03	1.23	1.54	2.77	55.6
	Mean	5.82	2.52	0.22	42.75	1.18	0.04	0.22	0.03	1.18	1.47	2.40	63.43
Ihiagwa	(PPF)	6.94	6.18	0.53	42.49	1.36	0.1	0.23	0.03	1.12	1.72	2.08	85.2
Umuchima	(PPF)	6.09	2.06	0.18	38.29	1.12	0.23	0.19	0.02	1.23	1.56	2.39	65.3
Eziobodo	(PPF)	7.5	3.037	0.26	39.06	1.32	0.06	0.23	0.04	1.52	1.65	2.79	59.1
	Mean	6.84	3.76	0.32	39.95	1.27	0.13	0.22	0.03	1.29	1.64	2.42	69.87
	LSD(0.05)	1.01	0.32	0.13	3.84	0.03	0.01	NS	NS	0.01	0.18	0.29	1.77

NS = not significant, POF = Pineapple orchard, PMPF = palm plantation farm. PPF = plantain plantation

Soil Micronutrient Concentrations

The concentration of soil micronutrients are presented in Figure 1. Among the three land uses, there were variations in the concentration of these micronutrients. The concentration of Cu in palm plantation farm (PMPF), plantain plantation farm (PPF), and pineapple orchard (POF) was 0.21, 0.2 and 0.17 Mg/kg respectively and the sequence was PMPF > PPF > POF. The concentrations of Zn in PMPF, PPF, and POF were 3.92, 17.95 and 4.22 Mg/kg respectively. Zn concentration followed the sequence PMPF > POF > PPF with the highest value (77.68 mg/kg) recorded in palm plantation farm. Similarly, the concentration of Mn in the PPF, POF and PMPF was 6.14, 2.04 and 1.86 Mg/kg respectively. According to [26] and [27], values of Cu were moderate in PMPF, low in PPF and POF. Zn concentration was high in PPF, moderate in POF and low in PMPF. Fe concentration was high in the three land use types while Mn was low in PMPF and POF but high in PPF.

High concentration of some of these micronutrients in palm plantation farm and pineapple orchard farm could be attributed to increase in soil pH. According to [28], soil pH is an important soil factor controlling micronutrient availability. Similarly, at high pH, divalent forms of some micronutrients like Mn could be oxidized to trivalent and tetravalent forms which are insoluble in water and hence unavailable to plants thereby increasing their concentration in soil [29]. Also, increase in soil organic matter level in the plantain plantation farm could be responsible for high Zn and Mn level. This observation is in concord with [29] who stated that soil organic matter increases soil micronutrients due to the chelating property of soil organic matter in holding soil micronutrients.

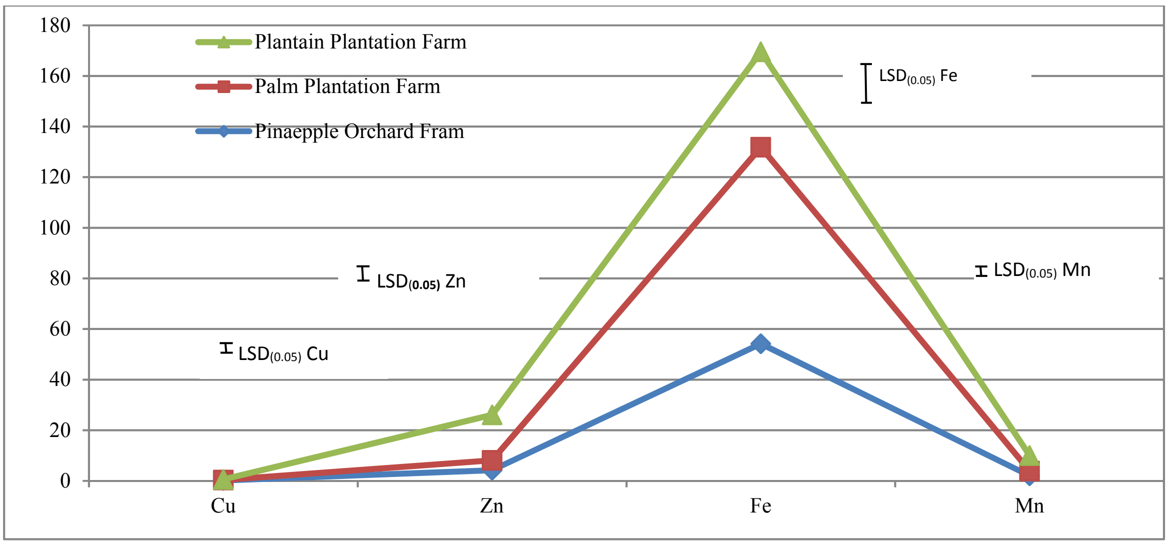

Fig. 1.Relationship between the micronutrients and soil physicochemical properties

Correlation between Micronutrients and Soil Physicochemical Properties:

The correlation between soil properties and the micronutrients are presented in Table 4. Significant positive correlations existed between soil pH and Zn (r = 0.0.5471), Zn and clay (r = 0.5422) and Mn and clay (r =

0.550) while Zn correlated negatively with total exchangeable acidity (TEA) (r = - 0.8586), Mn and TEA (r = - 0.6931). Increase in soil pH could result to an increase in micronutrient availability in the soil and could positively increase soil biodiversity, organic matter decomposition, soil porosity and soil aggregation. Positive relationship between clay and Mn, clay and Zn could be attributed to the chelating property in clay that helps to hold these nutrients in the soil. Similar observation was made by [30] who recorded positive significant correlation between Zn and organic carbon and attributed it to the complexing agents generated by organic matter which promotes Zn availability in the soil.

TABLE 4. Relationship between the Micronutrients and Soil Physicochemical Properties

Soil property	**Cu**	**Fe**	**Mn**	**Zn**
Base saturation	0.3402	0.2869	-0.3010	-0.2801
ECEC	-0.3151	-0.4824	0.4582	0.5117*
Clay fraction	-0.0953	0.3017	0.5500*	0.5422*
Organic Carbon	0.3973	0.3262	-0.2392	-0.1530
pH (H_2O)	0.1745	-0.2561	0.4116	0.5471*
TEA	0.2938	-0.2116	-0.6931*	-0.8586**
TEB	0.0577	-0.4264	0.3673	0.4234
Total nitrogen	0.4010	0.3320	-0.2415	-0.1570

*and ** = significant at 0.05 and 0.01 probability levels respectively

TEA = Total exchangeable acidity, TEB = total exchangeable base, ECEC = effective cation exchange capacity

IV. Conclusion

Soil properties vary from one land use system to another and determining the current nutrient concentration in these land use types is vital for soil nutrient management. This study examined the concentration of selected micronutrients and soil physicochemical properties of three land use systems in Owerri, Imo State Nigeria. It was observed that irrespective of land use type, soil particle sizes did not vary among the studied land use types. However, variations occurred in the concentration of Zn, Fe, Mn and Cu on palm plantation farm, pineapple orchard farm and plantain plantation farm and the values were below the standard critical levels. The values of these micronutrients were found to be high in plantain plantation farm. Therefore proper agronomic practices that will increase soil pH and organic matter in the soil should be practiced especially in palm plantation farm and pineapple orchard. Farmers should be encouraged to embrace organic farming as a way of boosting soil fertility status and micronutrient content of soils under agronomic practices.

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