DISCOVERY

58(319), July 2022

Distribution of copper and manganese in soils of different land use in Imo state, Nigeria

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To Cite:
Promise O, Kenneth O. Distribution of copper and manganese in soils of different land use in Imo state, Nigeria. *Discovery*, 2022, 58(319), 776-783

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Peer-Review History
Received: 02 May 2022
Reviewed & Revised: 06/May/2022 to 13/June/2022
Accepted: 15 June 2022
Published: July 2022

Peer-Review Model
External peer-review was done through double-blind method.

DISCOVERY SCIENTIFIC SOCIETY

ABSTRACT

Poor crop yield in southeastern Nigeria has been attributed to micro-nutrient deficiency. Properties of soil vary with land use system over time and the knowledge of these changes is vital for suitability food productivity. This work investigated the distribution of micro-nutrient elements (copper and manganese) in three different land uses in Imo state: namely Palm plantation (PP) fallow land (FL) and cassava (CP). Soils were collected from these land use types, air dried, sieved, using 2mm sieve and was analyzed using standard methods. The mean values of Organic Carbon, Total Nitrogen, Organic matter Available and Exchangeable Cation Exchange capacity were recorded as 0.45% 0.05% 1.04% 29.4ppm 2.49cmol/kg, 0.36%, 0.11%, 0.62% 39.8ppm 2.48cmol/kg and 4.46% 0.04% 0.66% 18.41% and 4.8cmol/kg for plantain plantation for CP and fallow land respectively. Data collected was subjected to analysis of variance (AVOVA) and significantly means were separated using least significant Difference (LSD) at 0.05 probability level. Relationship between micro-nutrients and soil properties were determined using correlation analysis. Results obtained showed variation in Total Nitrogen, Effective Cation Exchange Capacity (ECEC) and Available Phosphorus among the land use types. The highest concentration of Cu (0.0061mg/kg) was recorded in PP(40-60cm) depth while the highest concentration of Mn (0.071mg/kg) was recorded in PP(40-60cm) depth. Significant positive correlations existed between Cu and Al(r=0.789*) Cu and TEA(r-0.888*)Mn and Al(r=0.783*)Cu correlated negatively with sand(r=0.0345) while Mn correlated negatively with silt (r=-0.00146). Agronomic practices that will improve soil organic matter and PH is recommended so that levels of the nutrient that are below the critical levels will be improved. Percentage CV shows little variation for sand in all depths. Clay was high in variation in all depths. 98.8% for palm plantation 89% for fallow land and 84.4% for cassava plantation respectively.

Keywords: Micro-nutrients; soil properties; cassava plantation

1. INTRODUCTION

Micro-nutrients are chemical elements necessary for plant growth in only extremely small amounts. Although required in minute quantities however, micro-nutrients have the same agronomic importance as macro-nutrients and play vital roles in the growth of plants. These metallic chemical elements include Zinc (Zn), Iron (Fe), Copper (Cu) and Manganese (Mn), among others. Most micro-nutrients are associated with the enzymatic systems of plants. For instance, Zn is known to promote the formation of growth hormones, starch and seed development, Fe is important in chlorophyll formation, Cu in photosynthesis and Mn activates a number of important enzymes and is important in photosynthesis and metabolism (FFTC, 2001). The transformation from the fallow and shifting cultivation practices prevalent among farmers to intensive continuous cultivation of soils and the use of improved crop varieties which take up many nutrients from the soil are major causes of deficiency of these micro-nutrients. Soil plays a vital role in determining the sustainable productivity of an agro-ecosystem. Sustainable productivity of soils depends upon its ability to supply essential nutrients to the growing plants. Field trials have shown that the deficiency of micro-nutrients in soils has become a major constraint to the productivity and sustainability of soil (Jiang *et al.,* 2009). Large hectares of arable land in Nigeria have been reported to be deficient in both macro and micro-nutrients and these deficiencies were brought about by factors such as 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 (Ibrahim *et al.,* 2011).

Others include plantation farm and continuous cultivation of arable lands. These activities change soil physicochemical properties including soil micro-nutrients over time (Bonuma & Progers, 1998), as a result of top soil removal by erosion (FAO, 1998), soil acidification and organic matter depletion (IFPRI, 2010).

Evaluation of micro-nutrient status of soils has become very vital in making policies and recommendations for sustainable agricultural development. Imo state Nigeria is a tropical region where lands are put into different uses especially for agricultural purposes and unfortunately, these agricultural lands are not often evaluated to determine the status of micro-nutrients in the soil. Therefore, the objective of this work was to evaluate the micro-nutrient status of soils under three different land uses type in the Imo State, Nigeria.

2. MATERIAL AND METHODS

The study area

The research study was carried out in three different location (Palm Plantation, fallow land and cassava cultivated land) in Umuchima and Futo in Owerri West LGA in Imo State. Umuchima is located within latitudes 540 5'N and 60 35'N and longitude 60 35'E and 70 28'E. It occupies a total land area of 100km2 and located in the rain forest zone of Nigeria with annual temperature of 28^{o}C and annual rainfall distribution ranging between 1800mm and 2500mm. It is situated within tropical rain forest that has evergreen broad leaves.

Sample Collection and Preparation

Soil samples were collected randomly from three different land uses at 0-20, 20-40 and 40-60cm depth. Samples were collected and labeled in bags. Soil samples were air dried, crushed to pass through 2mm sieve and packaged for laboratory analysis. The sieved fine earth fractions were taken for laboratory analysis.

Laboratory Analysis

Particle size analysis was carried out using Bouyoucous hydrometer method as described by Gee and Or (2002). Five percent (5%) calgon (sodium hexamethaphosphate) solution was used as dispersing agent.

Silt-clay ratio was calculated using the results from particle size analysis.

Bulk density was obtained with core sampling method using the procedure of Grossman and Reinsch (2002).

Total porosity was determined from bulk density using the equation $Tp=1 - \frac{bd}{pd}\frac{bd}{pd} \times 100$

Moisture content was determined with the formula $Mc = \frac{w2-w3}{w3-w1}\frac{w2-w3}{w3-w1} \times 100$

The following chemical properties was carried out;

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Soil organic carbon was determined using the Walkey and Black digestion method (Olsen and Sommers, 1982).

Organic matter was calculated by a factor of 1.724 from organic carbon (Van Bemmelen's correction factor).

Total Nitrogen was determined by Macro-Kjeldalh digestion method (Bremer and Mulvancy, 1982). Soil pH was determined using 1:2:5 soil/water ration in both water and KCl (Thomas, 1996). Available Phosphorus was determined using Bray II method (Oslen and Sommers, 1982). Exchangeable Basic Cations (Ca, Mg, Na and K) was extracted with ammonium acetate. Ca and Mg was measured by ethylene diaminetetracetate acid titration while K and Na was estimated by flame photometer (Thomas 1982). Exchangeable Acidity (Al and H) was extracted with 1m KCl (Mclean, 1982). Effective Cation Exchange Capacity was determined by the summation of exchangeable bases and exchangeable acidity (Ca, Mg, Na, K, Al, H). Percentage Base Saturation (%BS) was obtained using the formula $\frac{TEB\ TEB}{ECECECEC} \times 100$

Determination of Copper and Manganese

The concentration of individual micronutrient was analyzed with atomic adsorption spectrometer (AAS). After wet digestion with concentration of mixture of HCL and HNO_3 for Cu and Mn (Brunce and weteside, 1984).

Co-efficient of Variation as ranked using wilding *et al*,(1994)

Level (%)	Ranking
C V≤15	Low variation
CV>15	Moderate variation
CV≤35	High variation

Statistical Analysis

Data collected was presented in tables. Analysis of variance (ANOVA) was used to compare the soil properties and significant difference, mean comparison were made using the least significant difference (LSD) method with p(0.05), Variability was done using coefficient of variation to relate copper and manganese with some soil properties. Co-efficient of Variation as ranked using wilding *et al*, (1994).

3. RESULTS AND DISCUSSION

Physical properties of the studied soil

The result obtained showed that all soils of the studied areas were sandy. The sand content of PP varied from 91.2-97.3% with a mean value of 93.9%, at 0-20cm depth PP recorded highest sand fraction, clay and silt content ranges from 0.2-5.2% and 2.5-4.7% with a mean value of 2.5 and 3.6 respectively. Soil moisture content was highest at depth of 40-60cm depth. In PP land use, there is variation in soil fraction distribution ranging from clay to sand (98.8-3.4) indicating high variation in clay sand and low variation in sand fractions. While in the other soil properties the variation is low generally.

In fallow land use, sand fraction varied from 88.7-95.8%, clay 3.2-4.2% and silt 1.5-7.2% with a mean value of 93.11, 3.32 and 3.6% respectively. Moisture content is also higher (8.3%) in 40-60cm depth with a mean value of 12.9. The variation in FL varied from clay> silt> sand indicating that there is higher variation in the clay and silt fraction compared to sand. CP recorded the distribution of sand, silt and clay to have varied from 86.7-96.8% sand,1.5-6% silt and 1.5-7.3% with a mean value of 92.9 8.3 and

3.7 respectively. The variation of sand fraction ranges from clay silt and sand (84% 28% and 5.9%) respectively. In this land use it was recorded that variation was high in bulk density.

Table 1: Physical Properties of the Area Studied With CV and Ranking

Land use	Dept (cm)	Sand (%)	Silt (%)	Clay (%)	TC	BD gcm-3	MC (%)	TP (%)	S/C
	0-20	97.34	2.5	0.16	S	1.13	7.51	5.8	15.6
PP	20-40	93.16	4.68	2.16	S	1.08	7.47	60	2.16
	40-60	91.16	3.68	5.16	S	1.14	8.34	57	0.71
	Mean	93.88	3.62	2.49		1.2	7.8	58.3	6.1
	CV	3.4	30.4	98.8		2.5	6.3	2.6	8.53
	RANKING	L	M	H		L	L	L	L
	0-20	95.84	1.5	2.66	S	1.08	5.0	60	0.56
FL	20-40	88.66	7.18	4.16	LS	1.12	5.21	58	1.7
	40-60	94.84	2	3.16	S	1.09	8.34	59	0.6
	Mean	93.11	3.56	3.32		1.0	12.9	59	0.95
	CV	4.2	88.5	89		2	14.5	72	90.3
	RANKING	L	H	H		L	L	H	H
	0-20	86.68	6	7.32	LS	1.08	6.70	60	0.8
	20-40	96.84	1.5	1.66	S	1.14	7.93	57	0.90
CP	40-60	95.34	2.5	2.16	S	1.05	6.55	61	1.15
	Mean	92.95	8.33	3.71		1.0	7.0	59	0.95
	CV	5.9	28.3	84.4		46	11	3.5	15.8
	RANKING	L	M	H		H	L	L	M
	LSD(0.05)	11.84	6.0	6.5		0.09	2.74	4.2	0.5

PP=Palm Plantation, CP=Cassava Plantation, FL= Fallow Land, CV= Coefficient of Variation

L.S.D= Least Significant Diference, L=Low Variation, M= Moderate Variation, H=High variation Textural Class S=Sandy LS= Loamy Sand

Chemical properties of the studied soil

The results of the chemical properties of the studied area is as shown in (Table 4.2). From the results obtained soils were generally acidic with mean values ranging from 5.3 5.43 to 5.45, the acidic nature of the soil could be attributed to the parent material, high rainfall prevalent in the trees.

Organic carbon of the studied soil showed that soils were generally low in content which may be as a result of lost of vegetation of the area over a long period of time (post 2000) with concentration value ranging from 0.1 to 1.1% with a mean value of 0.45% in all depths studied, percentage CV showed little variation in all depths. Palm plantation (12.40%) cassava plantation (0.7%) and fallow plantation (0.67%).

Results of the studied area showed that soils were generally low in basic cations with values varying from 0.21cmol/kg-1 to 0.77cmol/kg-1.The highest concentration was found in fallow land (0-20cm) dept. with a mean value of 1.65cmol/kg-1, this result may be attributed to the parent material and leaching away of basic cations (OTI 2002) percentage CV were significantly high in all depths ranging from palm plantation (42.1%) cassava (64.0%) and fallow land (74.7%).

ECEC were high in the studied soil with values ranging from 2.6cmol/kg-1 to 4.8cmol/kg-1 in the depths studied shown in table (4.2). The highest ECEC value was found in the fallow land (0-20cm) dept with value of 7.3cmol/kg-1 while the lowest ECEC was found in the palm plantation (20-40cm) dept. ECEC showed differences in CV with low variation in palm plantation (13.25%) A moderate variation in cassava plantation (36%) and high variation in fallow land (44%)

Total N values in the studied soils were low ranging from 0.03% to 0.11% in all the depths studied with a mean value of 0.11% (Table 4.2). This could be as a result of low organic carbon and organic matter content of the soil. Percentage C.V value showed high variation in palm plantation dept with a value of 92%, cassava plantation 9.1% which is low variation and fallow land 25% which is moderate. Available phosphorus of the studied soils showed value of 9.1ppm to 28.5ppm with a mean of 29.2ppm the highest concentration was in fallow land (20-40cm) dept showing 28.35ppm. Percentage Cv showed little variation in palm plantation (11.63%) high variation in cassava plantation (62.8%) and high variation in fallow land with a value of (44%) respectively.

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Table 2: Chemical Properties of the Area Studied With Cv And Ranking.

Land use	Depth (cm)	Ph in H_2O	pH in KCl	Oc (%)	Total N (%)	Ca	Na^+	Mg (cmol/kg)	K^+	H	OM (%)	Av.Pppm	ECEC	Al	TEB	TEA	%BS
	0-20	5.46	4.41	0.12	0.01	0.16	0.07	0.01	0.15	2.4	0.20	9.1	2.79	0.6	0.39	2.4	13.9
PP	20-40	5.50	5.59	0.12	0.01	0.24	0.08	0.036	0.19	1.6	0.20	15.68	2.14	0.4	0.54	1.6	25.2
	40-60	5.34	4.67	1.13	0.09	0.08	0.05	0.003	0.09	2.3	1.93	14	2.54	0.5	0.22	2.32	55.8
	MEAN	5.43	5.43	0.45	0.05	0.42	0.06	0.047	0.14	2.1	1.04	29.4	2.49	1.1	0.38	2.10	31.6
	C V	1.53	11.42	12.40	92	19.4	33.3	4.3	35.7	20.9	95.2	11.63	13.25	9.1	42.1	20.9	69
	RANKING	L	L	L	H	M	M	L	H	M	H	L	L	L	H	M	H
	0-20	5.47	4.48	0.44	0.03	0.16	0.07	0.03	0.02	2.5	0.75	17.22	2.6	0.6	0.21	2.4	8.02
CP	20-40	5.58	4.62	0.42	0.03	0.08	0.05	0.06	0.04	2.6	0.72	17.01	3.3	0.06	0.77	2.6	22.5
	40-60	5.30	4.40	0.24	0.02	0.24	0.06	0.035	0.06	1.2	0.41	16.73	1.5	0.03	0.39	1.2	24.5
	M EAN	5.45	4.5	0.36	0.11	0.16	0.06	0.22	0.04	2.1	0.62	39.8	2.5	3.1	0.45	2.06	18.3
	C V	3.01	0.6	0.7	9.1	25	33.3	22	33	1.9	73.3	62.8	36	10.3	64	12.1	49.9
	RANKING	L	L	L	L	M	M	M	M	L	H	H	H	L	H	L	H
	0-20	5.42	4.42	4.42	0.08	0.1	0.04	0.02	0.08	3.1	1.72	15.26	7.3	3.1	4.2	3.12	57.3
FL	20-40	5.12	4.48	4.48	0.05	0.16	0.07	0.01	0.07	3.2	0.08	28.35	3.51	3.2	0.31	3.2	8.83
	40-60	5.36	4.47	4.47	0.01	0.24	0.06	0.01	0.12	3.2	0.20	11.62	3.7	3.2	0.44	3.28	11.8
	MEAN	5.3	4.45	4.47	0.04	1.6	0.06	0.01	0.09	3.1	0.66	18.41	4.8	3.1	1.65	3.2	25.9
	CV	3.01	0.66	0.67	25	25	33	100	33	1.9	73	48	44	2.0	14.9	40	95
	RANKING	L	L	L	M	M	M	H	M	L	H	H	H	L	H	H	H

PP=Palm plantation, CP=Cassava plantation, FL= Fallow land, CV= Coefficient of variation, L.S.D= Least significant difference, L=Low variation, M= Moderate variation, H=High variation, OC=Organic carbon, TN=Total nitrogen, AV.P Available phosphorus, %BS=Base saturation, Ca= Calcium, Mg=Magnesium, TEB=Total Excheageable Bases, TEA=Total Excheangeable Acidity

Total concentration of Copper and Magnanese in studied soil

The total concentration of Cu and Mn was shown in table 3. The result of the total value of Cu and Mn in PP ranged from 0.041-0.052 and 0.064-0.0071 with a mean value of 0.005-0.07 respectively. In the FL land use, the values were 0.053-0.061 and 0.072-0.084 with a mean value of 0.06 and 0.08 respectively. The values increases with increases in depth. In CP the total concentration of Cu and Mn ranges from 0.42-0.52 with a mean value of 0.04 and 0.06.The mean vales were not significantly related to each other.

Table 3: Total Concentration of Copper and Manganese in the Studied Soil

Land use	Dept	Manganese	Copper
	0-20	0.064	0.044
PP	20-40	0.067	0.041
	40-60	0.071	0.052

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	Mean	0.07	0.05
	0-20	0.079	0.053
FL	20-40	0.072	0.056
	40-60	0.084	0.061
	Mean	0.08	0.06
CP	0-20	0.059	0.052
	20-40	0.061	0.048
	40-60	0.06	0.042
	Mean	0.06	0.04
(LSD 0.05)		0.01	0.01

Correlation of some soil physiochemical properties showed.

The results of correlation among some soil properties showed in table 4) in the correlation analysis, TEA correlated positively with Cu (r=0.89**) and AL also correlated positively with Cu (r=0.79) this is to say that increase in TEA increases the amount of Cu in the soil and also increases the availability of Al in the soil. However Mn correlated positively with Al indicating that increase in one increases the other. This is in agreement to (Fageria *et al* 2002) report that high pH allows Mn adsorption in the soil particles, decreasing their availability. pH also correlated negatively with Mn (r=-0.27) indicating that increase in one decreases the other.

Table 4: Correlation between the Micronutrients and Soil Physiochemical Properties Studied

	Cu	Mn
Sand	-0.0345	0.45
Silt	0.231	-0.0146
Clay	0.0375	0.088
BD	0.032	-0.0129
TP	-0.401	0.080
Mc	-0.103	-0.161
ECEC	0.0384	0.655
BS	-0.205	0.404
TEB	0.007	0.534
TEA	0.888**	0.574
Al	0.789*	0.783*
H	-0.020	0.404
Na	-0.039	-0.179
Mg	-0.013	-0.0365
Ca	0.020	0.562
Av.P	0.384	-0.025
TN	0.248	0.362
OC	-0.021	0.267
pH	0.0451	-0.269
OM	-0.21	0.266
K	-0.0275	0.312
Cu	1	O.519
Mn	0.519	1

**Correlation Is Significant at 0.01 Level (2 tailed)*Correlation Is Significant at 0.05 Level (2 tailed)

Relationship between the micronutrient and soil physiochemical properties studied

The results of correlation among some selected soil properties showed that Cu correlated positively with TEA(r=0.888**) Cu also correlated positively with Al(r=0.789*) while Mn also correlated positively with AL(r=0.783*).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

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

porosity and soil aggregation. Positive relationships between Cu and TEA, Mn and AL could be attributed to the acidic nature of soils.

4. SUMMARY AND CONCLUSION

Soil properties vary from one land use system to another and determining the current nutrient concentration in these land uses types is vital for soil nutrient management. This study examined the concentration of selected micronutrients and soil physiochemical properties of three land use systems in Owerri, Imo state Nigeria. It was observed that irrespective of land use type soil particles sizes did not vary among the studied land use types. However variations occurred in the concentration of Cu and Mn of PP (palm plantation) FL (fallow land) and CP (Cassava plantation) and the values were below the standard critical levels. The values were found to be high in palm plantation (PP).Therefore proper agronomic practices that will increase soil Ph and organic matter in the soil should be practiced especially in palm plantation land and cassava land. Farmers should be encouraged to embrace organic farming as a way of boosting soil fertility status and micro-nutrient content of soils under agronomic practices.

Percentage CV shows little variation for sand in all the depths. %BS, TEB and OM show a high variation in the various depths. With values of 95% 74% and 44% respectively TABLE (4.2) Na and Ca showed moderate variation in all depths respectively with values of 19% 25% and 33%.

RECOMMENDATIONS

Base on the findings of the study there is a need to improve soil fertility. The overall soil physical and chemical properties of the area, the following could be a viable option.

1. The use of agroforestry planting of trees in regard to economical and environmental landscape
2. Incorporation of organic materials into the soil to hold micro-nutrients and prevent it from ground water leaching.
3. Mulching this is to help reduce erosion, retain moisture provide nutrients and suppress weed growth.
4. Liming materials should be employed adequately as a good management practice to increase soil pH thereby making micro-nutrient available in soil.

Funding

This study has not received any external funding.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS