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Temporal Variations in Micronutrients (Cu, Fe, Mn and Zn) Mineralization as Influenced by Animal and Plant Manure-Amended Marginal Soils, Southeastern Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Low soil fertility is identified as a major factor militating against crop production in many tropical cropping systems where fertilizer used is low and agricultural residues are not returned to the soil for its rejuvenation. The present study was therefore conducted to determine the influence of organic manure application on micronutrient cations (Cu, Fe, Mn and Zn) mineralization in five different marginal soils. Four sources of animal manure (cattle, goat, poultry and swine) and two sources plant residues manure (oil palm bunch and rice husk dust) and a control were added to the soils (alluvial deposits, basalt, basement complex rock, coastal plain sand sandstone and shale) at the rate of 10 t $ha^{-1}$and, incubated for 8 weeks at a temperature of 30°C. The soils were sampled at weekly intervals and analyzed for pH and available Cu, Fe, Mn and Zn. The results indicated that organic amendments increased soil pH regardless of the type of manure used. Cumulative mineralized Cu was highest in basalt (4.48 $mgkg^{-1}$) followed by basement complex rock (3.52 $mgkg^{-1}$) soils. Available Fe was highest in shale (4.93 $mgkg^{-1}$) followed by alluvial deposit (4.93 $mgkg^{-1}$) soils. Manganese was highest in basement complex rock (7.39 $mgkg^{-1}$) followed by coastal plain sand (4.22 $mgkg^{-1}$) soils. While, Zn was highest in basement complex rock (5.13 $mgkg^{-1}$)

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followed by shale (4.56 mgkg^{-1}) and alluvial deposit (4.48 mgkg^{-1}) soils. Similarly, the cumulative mineralized Cu, Fe, Mn and Zn contents were highest in poultry manure (6.53, 5.04, 4.64 and 5.39 mg kg^{-1}) respectively, followed by swine and goat manures. The lowest values for available Cu (1.73 mg kg^{-1}) and Zn (1.55 mg kg^{-1}) was in oil palm bunch while, Mn (1.33 mg kg^{-1}) was in rice husk dust.

Keywords: Cations; incubation; micronutrients; mineralization; organic manure; soil; temporal variation.

1. INTRODUCTION

Major agricultural soils of southeastern Nigeria are mostly characterized by sandy and pronounced soil degradation, strongly weathered, and are inherently poor in basic cations such as available micronutrients for crops use [1]. Therefore, crop yields on these soils are relatively low due to intensive farming leading to nutrient mining [2]. The use of chemical fertilizers alone to sustain high crop yield has not been quite successful due to enhancement of soil acidity, nutrient leaching, and degradation of soil physical and low organic matter status [3,4]. Consequently, attention is now shifted towards the use of low cost source of organic manures as soil amendment for crop production on these soils [1,2,5-7].

The decline in soil fertility has also been recognized [8-10] as one of the major biophysical constraints of agriculture, particularly Fe, Mn, Zn and Cu deficiencies most especially in soils of southeastern Nigeria [11]. Nutrient content of the soil is an important soil chemical property and different soil type has different properties [12], which are made available to plants as soil composition or supplemented to soil [13].

Previous studies have demonstrated the use of integrated organic residues such as dung of cattle, goat, waste of poultry and swine to improve soil biophysical conditions, enhance fertility status and yield of crops [14-16]. Li et al. [17] reported that Zn, Fe, and Mn contents in soil improved significantly with increasing soil organic matter content.

Soil organic matter in soil must undergo mineralization processes before releasing substantial quantities of micronutrients [10,18]. The suitability of organic materials as fertilizer depends to a great extent on its rapidity of mineralization and liberating the nutrients present in them [19,20]. Thus, the mineralization of organic manures in soil is affected by such soil properties as types of soils, depth of soil, temperature, soil moisture, pH, C/N ratio and lignin content of organic matter [19].

Proper management of various organic manures such as animal wastes is one way of improving fertility status of agricultural soils. Organic manures have been reported as significant sources of micronutrients in several agricultural lands [21,22] and contain significant amount of both macro and micronutrients for plants [14]. A long-term application of swine, poultry, or cattle manures amendment [8,18,23,24] have been reported to increase Cu, Fe, Mn and Zn contents substantially in the surface soil (0-30 cm).

The effect of soil amendment with organic materials, the decomposition and release of nutrients from the organic waste applied into the soils are greatly influenced by the nature of soil types, pH and, abiotic and biotic factors, specially the degree of humification [25]. Although, the decomposition and nutrient release of soil-applied manure has not been fully studied, the few available reports are mostly on carbon, nitrogen, phosphorus, potassium [26,27], calcium and magnesium [14,28].

Researches on cations such as Cu, Fe, Mn and Zn mineralization are very limited, and usually, poorly documented in soils of the tropical region. Some of these cations are selectively bounded to a group of exchange site for metals in organic molecule [29]; their availability may vary according to the characteristics and decomposition dynamics of organic materials. In four compost manure tested, [30] extracted Zn and Cu from sewage treated soils and obtained 79.3 and 32.0% relative to controlled soils. Anikwe and Nwobodo [31] reported values of Cu, Fe, and Zn which increased between 214 and 204 % in treated sites relative to non-treated sites. Taiwo et al. [32] reported concentration of Cu (20.42 mg kg^{-1}) and Zn (39.44 mg kg^{-1}) in treated soils over non-treated soils.

Previous studies however, have indicated significant correlations between the initial chemical composition of organic residues and mineralization amounts [14,15]. Although pot and field studies with crops may give direct information about the amount of plant-available nutrients, such studies are time and labour intensive and are less widely applied to examine organic *products* in soil.

Little information is currently available concerning temporal variations in nutrient availability following the addition of organic manure to marginal cropland areas which, believed that cation mineralization is independent of manure and soil types. However, nutrient from different sources of organic manure alone may not have the same effect on different soil types, and this may be due to the inherent nature of the soil on which the nutrient is applied. The study was therefore, conducted in a greenhouse environment, to examine the interactive effects of contrasting soil types and organic manures on mineralization and availability of micronutrients (Cu, Fe, Mn and Zn) as a function of incubation time.

2. MATERIALS AND METHODS

2.1 Study Area, Sample Collection and Preparation

Five composite soils (0-20 cm) samples used in this study were randomly collected from soils over alluvia deposits (AD), basalt (BS), basement complex rocks (BCR), coastal plain sands (CPS), sandstones (SS) and shale (SH) and these were located in Cross River State, Nigeria (Latitudes 4° 28’ and 6° 55’N and Longitudes 7° 50’ and 9° 28’E). After collection of the soil samples, unwanted roots and debris were removed before air-dried for 3 days. Four animal manures; poultry (PM), goat (GM), cattle (CM) and swine (SM) were obtained from the University of Calabar Farms Ltd while, the plant manures: rice husk dust (RHM) and oil palm bunch (PBM) were collected from Ugep rice and palm oil mills, respectively. The soil samples and organic materials were air-dried for 3 days, crushed and screened to pass through a 2 mm sieve for laboratory and greenhouse studies. The selected properties of the soils and nutrient composition of the organic manures are presented in Tables 1 and 2, respectively.

2.2 Incubation Study

The organic materials (CM, GM, PM, SM, RH and PB manures) were weighed into a 1-kg sample, of each soil type (AD, BS, BCR, CPS, SS and SH) respectively, at the rate of 0 and 10 t ha^{-1} on a dry matter basis. The soils and amendments as well as the controls were filled into 126 plastic containers of 2000 ml capacity. The containers were stored in the incubation chamber at a regular room temperature of 30°C. The mixture was moistened with 250 mL de-ionized water and mixed thoroughly. Occasionally the containers were shaken and extra water added as required to maintain 70% field capacity with distilled water. Soil samples were collected periodically at 7, 14, 21, 28, 35, 42, 49 and 56 days of incubation. At each sampling date, soil samples were collected through destructive sampling techniques where whole soil mass was taken. After collection, the samples were air dried and sieved by passing through 2 mm sieve, during which the samples were taken for analyses at a weekly interval [14]. The plastic containers were arranged in CRD with three replicates. The results will be expressed on oven dry weight basis. A total of 126 plastic containers were used during the whole incubation period (6 soil type x 6 manure and control treatments x 3 replicates = 126).

2.3 Laboratory Study

All the laboratory analysis conducted, followed the standard methods. pH of organic manures and soil was measured by the glass electrode method [33] after preparing the suspension at a ratio of 1:2.5, available micronutrients (Cu, Fe, Mn, and Zn) in treated soils were extracted by Coca-Cola method [34-36]. Their contents were determined using an atomic absorption spectrophotometer (UNICAM model SOLAAR 32: Astm D1691). Temporal variations of the selected chemical properties were determined through graphical method as a function of incubation time. Cumulative mineral cations were also determined as summation (∑) of weekly net values of available Cu, Fe, Mn, and Zn, respectively. The net mineralized micronutrient’ cations were determined as the difference between manure treated soils and the control at each sampling date.

2.4 Statistical Analyses

Data were statistically analyzed using the PASW Stat 18 to separate means, GenStat Discovery edition 4 Software to determine mean values, and Microsoft Excel Windows 2010 to produce bar and line graphs; the probability level was set at 5%.

3. RESULTS

3.1 Properties of the Soils

Some physical and chemical properties of the soil used in the incubation studies are presented in Table 1. The soils were generally sandy loam in nature, indicating that the soil was highly weathered. The average pH (4.88) of the soils was very strongly acidic and is typical of Ferric Acrisols [37] and may be responsible for the low exchangeable acidity level. The average organic C, total N and available P content of the soils were low, according to the soil fertility rating, used for soil data interpretation for Nigerian soils [38]. The soils were generally low in exchangeable bases. The low K content was probably due to the low level of illitic clay minerals in the soils. The average ECEC of 6.97 cmol kg^{-1} was moderately high compared with the threshold level of 4 cmo (+) kg^{-1}. The average base saturation of 60.95% was however on the average, indicating moderate soil fertility level [38]. Similarly, the extractable micronutrients were generally low in the soils.

3.2 Properties of the Organic Manures

The chemical composition of the organic manures used in the incubation studies is presented in Table 2. In the table, the animal manure had properties comparable with those manures from other farms and also compared well with values reported from other locations [2,5,6,39-46]. The animal manures used were generally high in the major and minor nutrients. The high Ca and Mg content were probably responsible for the relative high pH. Although the N, P and K contents appeared low in the plant manures, for practical purposes, it is important to note the input contribution of the various nutrients via rice husk and palm bunch manure in the soils, which included, the micronutrients [42,47].

3.3 Soil and Manure Effects

3.3.1 pH

Manure application significantly increased soil pH during incubation (Fig. 1) especially for basement complex rock and sandstone soils, the pH ranges from 3.8 in alluvia deposit soil to 5.51 in basement complex rock soil over the control. The manure pH ranged from 4.03 in control to 6.48 in goat manure treatments. The increase in pH as observed in plant manures (palm bunch and rice husk) and animal manures especially in poultry and swine manure was not statistically different. The pH values for each soil type varied widely as influenced by the type of manure applied. The variability in pH observed in this study is similar to that reported [3,48,49].

3.3.2 Copper (Cu)

Available Cu levels also varied significantly among the manure soils (Fig. 1). The least level (1.98 $mgkg^{-1}$) was obtained in coastal plain sand soil while the highest level (4.67 $mgkg^{-1}$) was obtained in alluvia deposit soil. The available Cu level measured in basalt and basement complex rock soils were not different from those in sandstone. Among the manure treatments, available Cu ranges from 2.77 $mgkg^{-1}$ in control to 7.97 $mgkg^{-1}$ in poultry manure. The result is in accordant with previous studies [18,22,30]. A significant soil x manure interaction was highly observed.

3.3.3 Iron (Fe)

Mean Fe levels (Fig. 1) in soils, ranged between 3.03 mg kg^{-1} and 8.98 $mgkg^{-1}$ in alluvia deposit and basement complex rock soil respectively, and these suggests marked differences among the soils. For the manure, the value of Fe ranged from 4.54 to 8.04 $mgkg^{-1}$in control and poultry manure, respectively. The finding agree with previous works reported [9,17,26]. Hence, available Fe varied widely according to soil and manure types.

3.3.4 Manganese (Mn)

Levels of available Mn varied significantly among the manured soils (Fig. 1). The values was lowest in coastal plain sand (4.24 $mgkg^{-1}$) and highest in alluvia deposit (6.44 $mgkg^{-1}$) soils. The values in the manured treatments ranged from 4.96 mg kg^{-1} to 9.34 mg kg^{-1} in palm punch and swine manures respectively and these, exceeded that of the control (3.43 mg kg^{-1}). The values determined in this study are within the range of values reported previously [20,18,29].

3.3.5 Zinc (Zn)

Similar to the other cations, available Zn varied widely among soils, manure and its level for particular manure was dependent on the soil type (Fig. 1). The values obtained was lowest in control (2.72 $mgkg^{-1}$) and highest in poultry manure (6.39 $mgkg^{-1}$). This result indicates that the amendment of soil with poultry manure led to the highest available Zn, but this was not statistically deferent from the value obtained from swine manure (6.06 $mgkg^{-1}$). The rice husk and palm bunch manures had values of 3.87 and 4.03 $mgkg^{-1}$ respectively, which are statistically the same. Among the soils, available Zn varied between 2.35 and 5.48 $mgkg^{-1}$ for sandstone and alluvia deposit soils, respectively. Previous studies [10,18,22,30] reported similar result. However, Zn availability in soil according to Alloway [50] reduces at higher soil pH due to increased adsorption, formation of hydrolyzed Zn, chemisorption on $CaCO_3$ and co-precipitation in Fe-oxides. But with the addition of organic matter in soil, Zn availability is enhanced with the formation of organic-zinc complexes, which are soluble, mobile and absorbable by plant roots. Generally, the availability of Zn was according to the soil and manure types.

3.4 Temporal Variations

3.4.1 pH

The pH of the soils changed markedly with time of incubation, as presented in Fig. 2. However, slight variations in pH values were detected in poultry, goat, swine and cow manures during the second week, respectively. The increase in pH was also reported [3,14,48,49]. The pH of alluvia deposits, basalt and basement complex rock soils for all the manure treatments showed only slight temporal variations during the incubation periods while, that of shale (a hydromorphic soil) was relatively stable in all treatments. There was however, no significant marked change in pH of coastal plain sand soil.

Table 1. Some initial physical and chemical properties of the soil (0-20cm) types used in the incubation study

Soil properties	Units	Soil types					
		Alluvia deposits	Basalt	Basement complex	Coastal plain sand	Sandstones	Shale
Physical properties							
Sand	gkg^{-1}	787	825	800	756	830	620
Silt	gkg^{-1}	172	80	130	77	48	150
Clay	gkg^{-1}	41	95	70	167	122	230
Texture		L	LS	SL	SL	LS	LS
Chemical properties							
pH KCl (1:2.5)		5.1	5.8	4.8	4.9	4.4	4.3
Organic carbon	gkg^{-1}	1.14	1.21	1.23	1.09	1.07	0.98
Exchangeable acidity	$Cmolkg^{-1}$	3.60	2.82	3.25	1.63	2.48	2.21
Exchangeable bases	$Cmolkg^{-1}$	4.75	5.23	5.45	2.05	3.47	4.85
ECEC	$Cmolkg^{-1}$	8.35	8.05	8.70	3.68	5.95	7.06
Base saturation	%	56.88	64.97	61.76	55.10	58.31	68.70
C/N ratio		4.59	3.80	7.76	6.06	13.36	14.0
Nutrient concentration							
Total nitrogen (N)	%	0.07	0.12	0.06	0.13	0.11	0.04
Av. Phosphorus (P)	$mgkg^{-1}$	16.20	12.83	18.2	14.51	18.2	13.7
Calcium (Ca)	$Cmolkg^{-1}$	3.27	2.32	2.61	0.86	2.40	2.75
Magnesium (Mg)	$Cmolkg^{-1}$	1.48	2.41	3.35	0.64	0.90	1.35
Sodium (Na)	$Cmolkg^{-1}$	0.17	0.11	0.08	0.13	0.16	0.12
Potassium (K)	$Cmolkg^{-1}$	0.11	0.46	0.21	0.52	0.21	0.63
Extractable micronutrients by Coca-Cola							
Copper (Cu^{2+})	$mgkg^{-1}$	1.01	1.05	0.72	0.80	0.50	0.11
Iron (Fe^{3+})	$mgkg^{-1}$	3.27	2.11	4.25	3.27	4.25	4.78
Manganese (Mn^{2+})	$mgkg^{-1}$	2.35	1.09	2.08	3.02	1.84	2.08
Zinc (Zn^{2+})	$mgkg^{-1}$	1.33	1.45	2.25	3.34	2.13	1.54

Table 2. Some chemical properties of animal and plant manures used in the incubation study

Chemical properties	Units	Animal manures				Plant manures	
		Cattle	Goat	Poultry	Swine	Rice husk	Palm bunch
pH		6.10	5.16	6.76	6.28	7.09	5.07
Organic carbon (OC)	gkg^{-1}	29.63	28.47	27.13	23.03	16.33	13.43
Nitrogen (N)	mgg^{-1}	1.24	1.37	2.33	1.17	0.84	1.12
C:N ratio		23.90	20.78	11.72	19.68	19.44	11.99
Phosphorus (P)	mgg^{-1}	1.89	1.38	4.58	2.25	1.07	1.49
Potassium (K)	mgg^{-1}	3.61	1.32	2.02	1.55	0.88	0.49
Calcium (Ca)	$mgkg^{-1}$	10.35	13.05	14.22	11.54	6.36	2.14
Magnesium (Mg)	$mgkg^{-1}$	5.20	4.09	19.25	11.77	3.16	0.68
Sodium (Na)	$mgkg^{-1}$	0.15	0.17	0.20	0.33	0.12	0.04
Copper (Cu)	$mgkg^{-1}$	14.60	13.48	18.04	26.06	11.84	14.41
Iron (Fe)	$mgkg^{-1}$	15.02	24.21	24.41	43.36	10.01	12.14
Manganese (Mn)	$mgkg^{-1}$	22.11	21.07	32.65	24.73	12.12	11.22
Zinc (Zn)	$mgkg^{-1}$	13.78	33.22	24.33	13.43	16.42	14.26

3.4.2 Copper

Significant temporal variations were established in available Cu levels in manure applied coastal plain sand soil. Although there was slight increase in available Cu during week 3 for poultry manure treatment (Fig. 2). No consistent trend in the variability of Cu was noticed in shale soil during incubation period. There was only occasional rise and fall in values of Cu with the peak values for poultry manure at week 6 and those of cow, goat and swine manure treatments at week 6, respectively. In sandstone soil, available Cu was also relatively stable for control and increased slightly for swine, cow, goat and poultry manures at week 5 and decline thereafter. In the cow manure treated alluvia deposit soil, available Cu increases during incubation with a peak increase (3.23 mg kg^{-1}) at week 4. The Cu values for poultry treated soil decreased sharply during week 2 and increase gradually thereafter with a peak (3.68 $mgkg^{-1}$) at week 4. However, [45] observed that a soil treated with chicken manure enhances soil fertility. Xu et al. [22] reported on the accumulation of Cu in soil and plant due to the application of different rates of swine manure. Udom et al. [30] observed the distribution of Cu in a tropical ultisol after long-term disposal of sewage sludge.

In basalt soil, significant temporal variations were notice in Cu levels in manure-treated soils (Fig. 2). Cu values for poultry manure treatments decreased and increased sharply from 7.29 to 5.1 and then, increased to 8.94 mg kg^{-1} during weeks 3 and 4, respectively, thereafter decreased gradually to 5.82 mg kg^{-1} at week 8. In swine manure treatment, Cu values decreased slightly from 7.44 at the initial week to 7.34 mg kg^{-1} at week 2, thereafter increased gradually to a peak with a value of 8.45 mg kg^{-1} at week 4 but later, decreased sharply to 5.38 mg kg^{-1} at week 6. In cow manure treated soil, Cu values increased gradually from 4.74 mg kg^{-1} to 5.73 mg kg^{-1} at week 2 and thereafter decreased gradually to 4.12 mg kg^{-1} at week 8. In basement complex rock soil (Fig. 2), the Cu values for poultry manure and swine manure treatments were significantly ($P<0.05$) higher relative to other treatments. Poultry manure treated soil climax at week 3 with a value of 4.54 mg kg^{-1} while, swine manure had a peak value (17.58 mg kg^{-1}) at week 4. The values of available Cu obtained in rice husk and palm bunch manure treatments were relatively and significantly ($P<0.05$) higher than those in control. Similar to results previously reported [42,47,51].

3.4.3 Iron

Among the soils, significant ($P<0.05$) temporal changes in available Fe were observed according to incubation period, and these were in turn influenced by the different manure types (Fig. 2). In alluvia deposit soil, the available Fe increased from 0.22 mg kg^{-1} at week 2 to 1.31 mg kg^{-1} at week 5. Iron in palm bunch manure treatment was increased from 2.25 mg kg^{-1} at week 4 to 3.25 mg kg^{-1} at week 5. These trends were noted in other treatments. In basalt soil, available Fe significantly ($P<0.05$) increased with the incubation period up to week 4 thereafter it declined. In basement complex rock soil, the same trend was also observed as in basalt soil. In coastal plain sand soil, goat and poultry manure treatments significantly ($P<0.05$) increased available Fe relative to other treatments. For instance, goat treatment had peaks at week 2 and 4 with values of available Fe (4.37 and 5.56 mgkg^{-1}) respectively, whereas, poultry manure treatment increased available Fe gradually from 6.45-6.82 mgkg^{-1} for weeks 4 and thereafter declined gradually at week 8 with available Fe content of 4.01 mgkg^{-1}. Rostami and Ahangar [10] reported the distribution of Fe in agricultural soil after the application of cow manure.

The content of available Fe in shale soil for all manure treatments varied little with time of incubations (Fig. 2). For cow material treatment, the available Fe increased during the first 3 weeks, followed by a decrease between weeks 3 and 8. For goat manure, the available Fe varied significantly ($P<0.05$) between week 2 and 5. In the poultry manure treatment, there were very little variations between week 2 and 4, thereafter declined from 6.45 in week 6 to 4.28 mgkg^{-1} at week 8. In sandstone soils, the content of available Fe obtained from poultry manure treatment varied widely from 6.75 mg kg^{-1} at week 3 to 5.03 mgkg^{-1} at week 7. However, available Fe values for all manure treatments varied according to time of incubation period (Fig. 2). Previous studies [10,15,16] reported changes in some soil properties at different incubation period.

3.4.4 Manganese

The values of available Mn extracted in soils treated with manure treatments varied with time of incubation (Fig. 2). In alluvia deposit soil, no reasonable change in available Mn was observed in all the manure treatments during the incubation, except for swine manure treatment, where increases were noted from weeks 4 to 8. In basalt soil, available Mn values for all manure and control treatments varied according to the incubation period. The values of Mn in swine manure treatment was significantly ($P<0.05$) higher, relative to other treatments. Similarly, in basement complex rock soil, cow manure treatment had available Mn values which are significantly ($P<0.05$) relative to other treatments. In shale soil, the values of available Mn were relatively and significantly ($P<0.05$) higher in animal manure treatments than the plants and control treatments. However, Cow manure treatment indicated a progressive increase in available Mn up to week 4 with 9.96 mg kg^{-1}, thereafter declined to 5.59 mg kg^{-1} at week 5 but later increased to 8.89 mg kg^{-1} in week 7. The sandstone treated soils exhibited the same trend as noted in shale treated soils. Here, the animal manure treatments yielded higher amount of available Mn than plants and control treatments.

3.4.5 Zinc

Significant temporal variations were not noticeable in Zn levels in manure treated soils, although a marked variations exist between the animal and plant manure treatments in the quantity of available Zn extracted (Fig. 2). In the figure, the values of available Zn obtained in alluvia deposit treated soils can be compared to the values of Mn extracted in basalt soils. However, discernable variations can be notice in control as well as for all the manure treatments during the incubation. Basalt soil treated with poultry manure had higher values of available Zn relative to other treatments. There were no tangible changes observed for all the manure treatments during the incubation period. In the basement complex rock treated soils, there were very little variations among the manure treatments during the incubation. However, in cow and poultry manure treatments, significant amount of available Zn was extracted, relative to other treatments. Coastal plain sand and shale treated soils have the same trend in the content of available Zn extracted.

In sandstone soil, animal manure had higher amount of available Zn than plant and control treatments. However, poultry and swine manure treatments produced higher content of available Zn relative to other treatments (Fig. 2). However, the result presented in Fig. 2, indicates that there was no substantial significant ($P<0.05$) variation in Zn during incubation period. However, [15,16,20,29] reported changes in some soil chemical properties at different incubation period.

3.5 Cumulative Mineralized Micro-nutrients

The data for cumulative mineralized micronutrients are presented in Table 3. In the table, the values of extractable copper varied significantly ($P<0.05$) from 2.08 to 4.88 mgkg^{-1} for coastal plain sand and basalt soils, respectively. Cumulative mineralized Mn and Zn were highest in basement complex rock (7.39

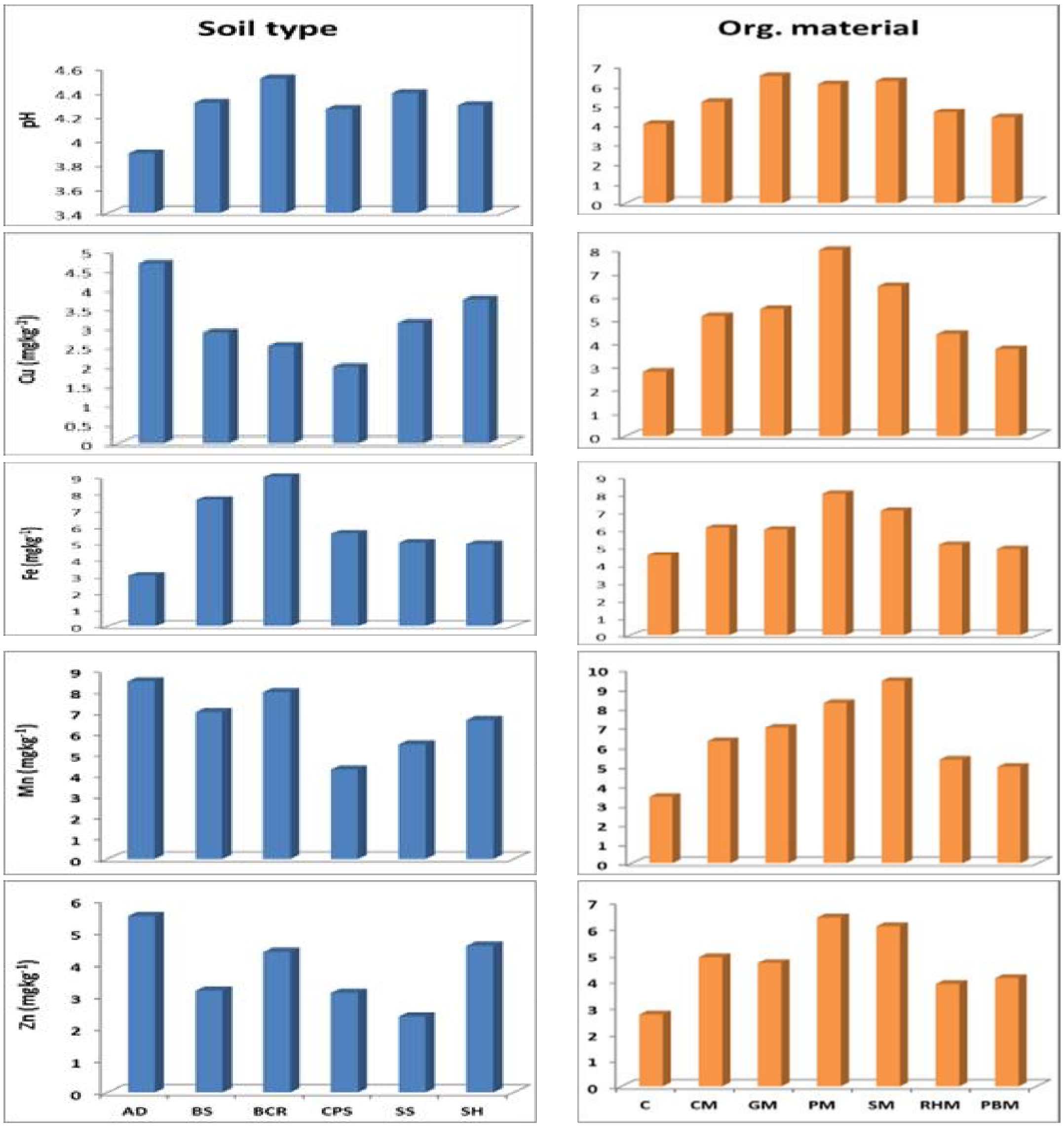


Fig. 1. Changes in pH and micronutrients cations as influenced by soil types (AD, BS, BCR, CPS, SS and SH) and organic materials (C, CM, GM, PM, SM, RH and PB)

and 5.13 $mgkg^{-1}$), respectively. Also, cumulative mineralized Cu was highest in basalt (4.48 $mgkg^{-1}$) followed by basement complex rock and shale derived soils (3.52 and 3.47 $mgkg^{-1}$), respectively. While, the cumulative mineralized Fe was highest in shale (5.69 $mgkg^{-1}$) followed by alluvia deposits and basement complex rock derived soils (4.93 and 4.39 $mgkg^{-1}$), respectively. On the average, the content of available (Cu, Fe, Mn and Zn) cations extracted, was significantly ($P<0.05$) higher in basement complex rock derived soils followed by basalt soils than in other soil types (Table 3).

Besides, the lowest values for Mn (2.45 $mgkg^{-1}$) and Zn (2.53 $mgkg^{-1}$) were obtained in sandstones derived soils, while the lowest values for Cu (2.08 $mgkg^{-1}$) and Fe (2.93 $mgkg^{-1}$) were determined in coastal plain sand derived soils.

Among the manure, cumulative mineralized Cu determined for swine manure (6.53 $mgkg^{-1}$) followed by poultry manure (4.17 $mgkg^{-1}$) and these were significantly ($P<0.05$) higher than the other manure treatments (Table 2). The highest values for cumulative mineralized Fe (5.04 $mgkg^{-1}$), Mn (4.24 $mgkg^{-1}$) and Zn (5.39 $mgkg^{-1}$)

were obtained in poultry manure, while the lowest values for Fe (2.05 $mgkg^{-1}$) and Mn (1.330 $mgkg^{-1}$) were determined from goat and rice husk manure, respectively and for Cu (1.73) and Zn (1.05 $mgkg^{-1}$) were extracted from palm bunch manure, respectively. Similar trends of micronutrients status of organic manure have been reported by others [9,10,18,22,29]. The cumulative mineralized micronutrients presented in Table 3 suggest that, all the organic manure contain appreciable amount of plant nutrients such as Fe, Mn, Zn and Cu, which varied widely according to the type of manure. It is also noteworthy that Fe content in rice husk (2.39 mg kg^{-1}) and oil palm bunch manure (2.25 mg kg^{-1}), are higher than in goat manures (2.05 mg kg^{-1}). On the average however, significant ($P<0.05$) higher amount of the cumulative mineralized (Cu, Fe, Mn and Zn) cations, was determined from the poultry manure followed by the swine manure. Rice husk and palm bunch manures produced lower content of the mineralized cations compared to the animal manures.

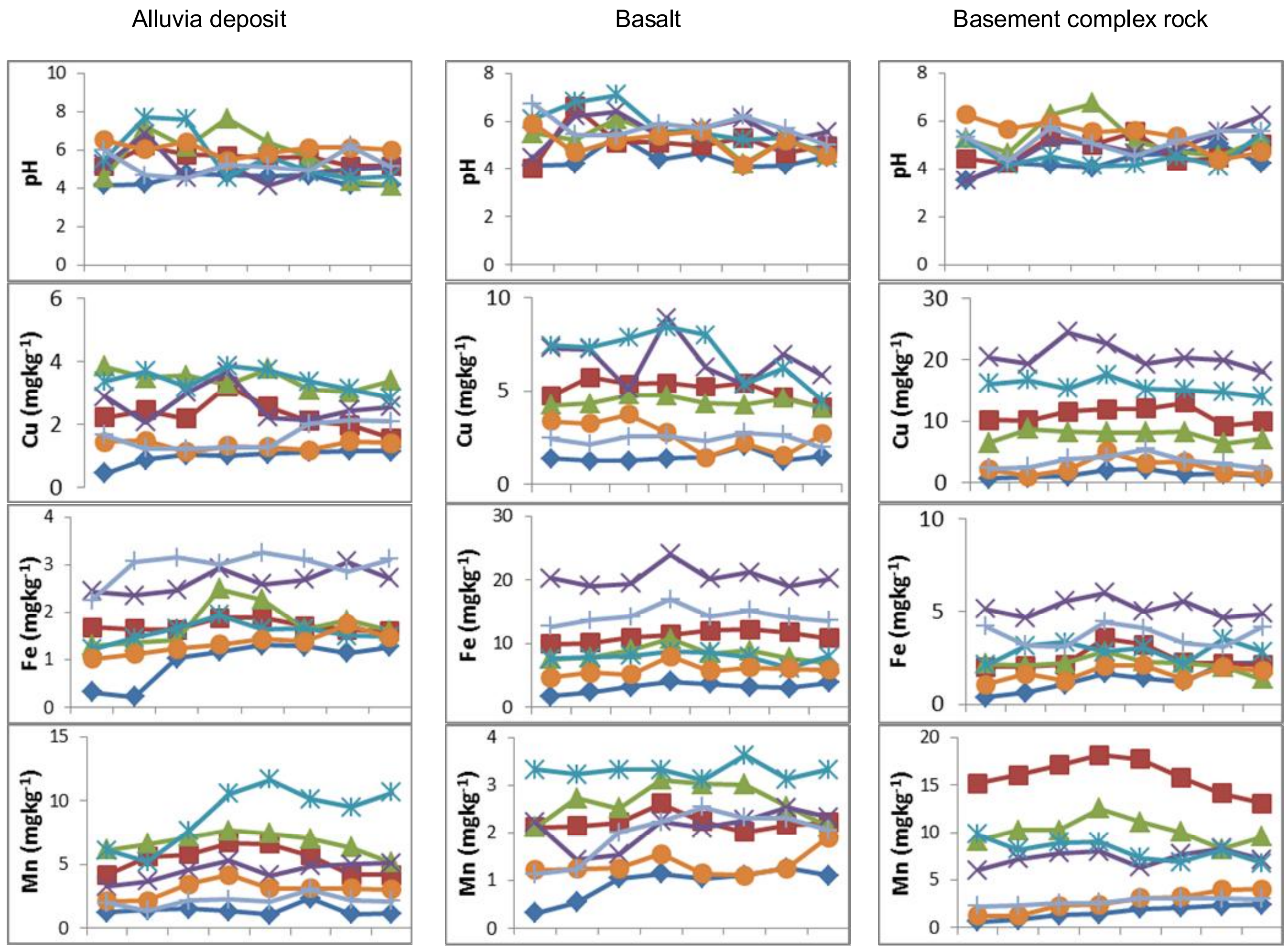
4. DISCUSSION

The increases in pH level of each soil varied with the type of manure applied. This could be due to the pH of the manure-treated soils which was generally higher than that of the control. The application of manure may have modified the soil environment through microbial activity with products of decomposition increasing pH over time (25). This findings was in agreement with previous studies [15,48,49]. In contrast, [52] found that pH deceased with duration of incubation of amended and unamended soil samples, while in a study on cow dung decomposition in a surface soil, [53] reported a decrease in soil pH over 9 weeks and an increase in the concentration of some cations up to 42-56 days.

Manure contains sufficient micronutrients which support decomposition (mineralized) during decomposing or application to soil. Iron, Mn, Cu and Zn are essential micronutrients for plant growth and knowledge of their dynamics in manure soils in desirable to enhance proper manure management. The results for available Fe, Mn, Cu and Zn have indicated varying responses of the soils to manure application. As expected, the use of these manure led to a higher level of available micronutrient cations than in control soils. These increases were attributed to mineralization from the manures. Occasionally (as in Fe, and Cu for poultry manure, Zn for goat manure, Mn for cattle manure treatments) sharp declines in available micronutrient were observed which may have been due to immobilization similar to that reported for N [19,20,54], suggested that a general trend in mineralization-immobilization dynamics.

Table 3. Cumulative mineralized micronutrients during incubation

Treatments	Cu	Fe	Mn	Zn
	←	($mgkg^{-1}$)	→	
Animal and plant material				
Cattle	2.14±0.03	3.12±0.22	3.27±0.10	2.89±0.02
Goat	3.44±0.12	2.05±0.03	2.97±0.10	3.67±0.22
Poultry	6.53±0.11	5.04±0.11	4.64±0.16	5.39±0.13
Swine	4.17±0.01	3.58±0.02	3.36±0.31	4.07±0.14
Rice husk	2.17±0.22	2.39±0.12	1.33±0.18	1.87±0.15
Palm bunch	1.73±0.07	2.25±0.24	1.96±0.11	1.55±0.17
Soil				
Alluvial deposits	2.67±0.02	4.93±0.42	3.44±0.14	4.48±0.32
Basalt	4.48±0.11	3.16±0.02	6.18±0.04	3.22±0.12
Basement complex rock	3.52±0.03	4.29±0.08	7.39±0.01	5.13±0.02
Coastal plain sand	2.08±0.12	2.93±0.11	4.22±0.15	3.11±0.14
Sandstone	2.13±0.10	3.24±0.10	2.45±0.02	2.53±0.20
Shale	3.47±0.22	5.69±0.11	3.13±0.05	4.56±0.32


Alluvia deposit
Basalt
Basement complex rock
pH
Cu (mgkg-1)
Fe (mgkg-1)
Mn (mgkg-1)

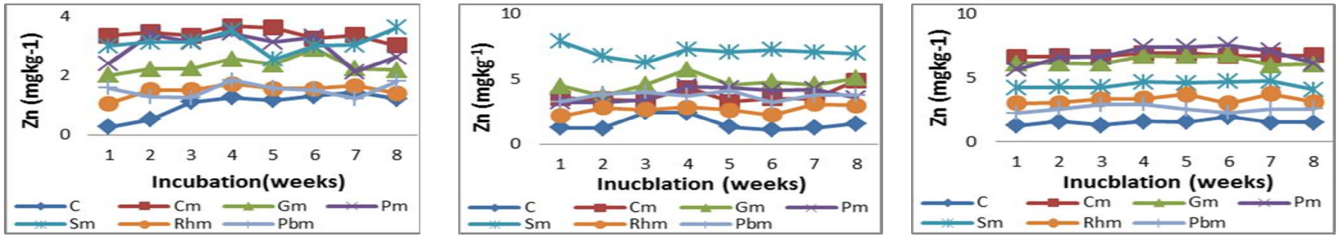
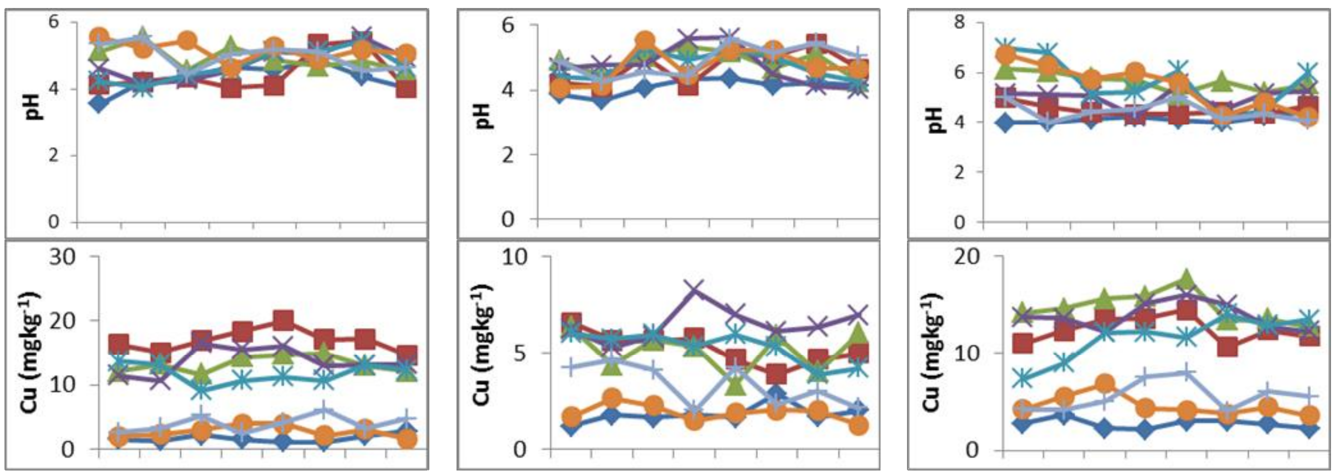


Fig. 2. Temporal changes in pH and micronutrient (Cu, Fe, Mn and Zn) cations durng in soils (Ad, BS and BCR) incubation

Coastal plain sand Shale Sandstone



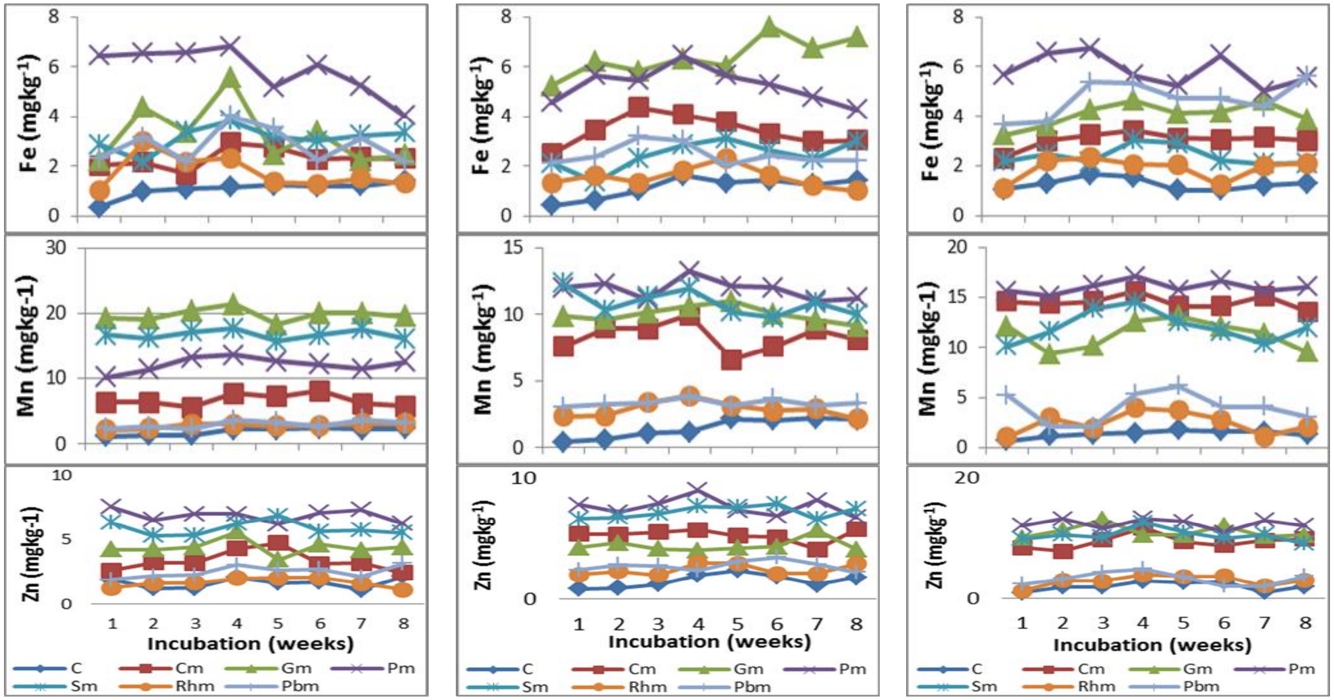


Fig. 3. Temporal changes in pH and micronutrient (Cu, Fe, Mn and Zn) cations in soil (CPS, SH and SS) durng incubation

Previous studies [10,15,16,55] reported on changes in some soil properties at different incubation period. The magnitude of the changes in available micronutrient cations levels varied with the soil and manure types, for Poultry and Swine manures rich in micronutrient. A greater release of the micronutrient was recorded for Poultry and Swine manures relative to other manure treatments. This finding is in agreement with previous study reported [56]. Therefore, the chemical composition of manure can influence the quantity of these nutrients released, and the rate at which they are released. Significant correlations have been reported between the initial chemical composition of organic residues and mineralization rate [8,22,23].

Manure had high significant influence on cumulative mineralization of Mn followed by Fe and Zn among the soils studied, while in Cu, little influence was observed among the soils under reviewed. The release of available Cu was greatest in Swine manure followed by Poultry manure. The low available Cu, Fe, Mn and Zn in plant manure treated soils compared to the animal manure treated soils, could be attributed to the low content in these plant materials. This finding is line with previous studies [42,51]. Several research findings have been reported on the distribution of heavy metals in organic wastes from different countries [7,22,23]. However, the significant available micronutrient values obtained in the treated soil over the control confirms that both the animal and plant manures are proficient source of these cations in the soil system [6,40,41,44,57]. Moreover, the fluctuation noted in the cumulative mineralized micronutrients could be due to variation in the microbial activities and C/N ratio in soil and manure used [12].

Among the soils, the basement complex rock soil showed the highest level of Mn and Zn followed by alluvia deposits and basalt soils which indicated the highest values of Fe and Cu in the soil under review, respectively. This agreed with previous study [13]. Based on these findings, it is observed that organic manure contained appreciable quantity of available micronutrients which are dependable of manure source and soil types. Nutrient content of some locally available organic materials and their potentials are alternative source of nutrients for arable crop requirements.

5. CONCLUSION

This study has shown that, the effect of manure and soil type on the soil properties was significant. Soil organic amendments (animal and plant manures) had beneficial effects on five different marginal soil types increasing pH and augmenting appreciable amount of some plant nutrients (Fe, Mn, Zn Cu) concentrations, especially when poultry and swine manures were used. Animal manures contain higher proportion of the micronutrients compared to the plant materials. The nutrients from different sources of organic manure alone did not have the same effect on different soil types, and this may be due to the inherent nature of the soil on which the nutrient is applied. Thus, continue applications of organic manures over time where nutrient depletion is a serious constraint to crop production will not only supply plant nutrients but, will also, enrich the agricultural soils with maximum benefits depending on the individual soil type in which the crops are being cultivated.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Ano AO, Agwu JA. Effect of animal manures on selected soil chemical properties (1). Nigerian Journal of Soil Science. 2005;15:14-19.
2. Mba CN, Mbagwu JSC. Effect of animal waste on physic-chemical properties of dystric lepstosol and maize yield in Southeastern Nigeria. Nigeria Journal of Sience. 2006;18;96-103.
3. Hue NV. Correcting soil acidity of a highly weathered ultisol with chicken manure and sewage sluge. Communication in Soil Science and Plant Analysis. 1992;27:241-264.
4. Nottidge DO, Ojeniyi SO, Asawalam DO. Comparative plant residues and npk fertilizer on nutrient status and yield of maize (*Zea mays* L.) in a humid Ultisol. Nigerian Journal of Soil Science. 2005; 15:1-8.
5. Ojeniyi SO. Effect of goat manure on the soil physical properties and okro yield in a rainforest area of Nigeria. Applied Tropical Agriculture. 2000;5:20-23.

6. Ihenacho LU, Okorie HA, Christo IE, Peter CAO. Effect of poultry manure rates on growth and yield of turmeric (*Curcuma longa* L.) in Nigeria. Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2015;8(1):34-38.
7. Vasanthi D, kumaraswamy K. Effect of manure-fertilizer schedules on the yield and uptake of nutrients by cereal fodder crops and on soil fertility. Journal of Indian Society of Soil Science. 2000;48(3):510-515.
8. Benke MB, Indraratne SP, Hao XY, Chang C, Goh TB. Trace element changes in sol after long-term cattle manure applications. Journal of Environmental Quality. 2008;37: 798-807.
9. Herencia JF, Ruiz JC, Morillo E, Melero S, Villaverde J, Maque-da C. The effect of organic and mineral fertilization on micronutrient availability in soil. Soil Science. 2008;173:69-80.
10. Rostami GH, Ahangar AG. The effect of cow manure application on the Distribution of Fe, Mn and Zn in agricultural soils. Journal of agriculture and Veteinary Science (IOSR-JAVS). 2013;6(2):60-66.
11. Enwezor WO. Ohiri SC, Opuwaribu EE, Udo EJ. A review of fertilizer use on crops in southeastern zones of Nigeria (in five vols.) (FFDD). Boboma Publ. Ibadan. 1990;47-70.
12. Brye R, Slation A, Mozaffari M, savin C, Norman J, Millar M. Short-term effects of land leveling on soil chemical properties and their relationship with microbial biomass. Soil Science Society of American Journal. 2004;68:924-934.
13. Ayalew T. Effects of soil types and nutrient levels on early leaf development of maize, bean and sunflower crops. African Journal of Agricultural Research; 2014.
14. Eneji AE, Irshad M, Honna T, Yamamoto S, Endo T, Masuda T. Potassium, calcium, and magnesium mineralization in manured-treated soils. Communications in Soil Science and Plant analysis. 2003;34(11&12):1669-1679.
15. Escobar MEO, Hue NV. Temporal changes of selected chemical properties in three manure amended soils of Hawaii. Bioresource Technology. 2008;99:8649-8654.
Available:http://dx.doi.org/10.1016/j.biortech.2008.04.069
16. Gulser C, Demir Z, Serkan IC. Changes in some soil properties at different incubation period after tobacco waste application. Journal of Environmental Biology. 2010;34: 671-674.
17. Li BY, Zhou DM, Cang I, Zhang HL, Fan XH, Qin SW. Soil micronutrient availability to crops as affected by long-term inorganic and organic fertilizer applications. Soil and Tillage Research. 2007;96:166-173.
18. Li BY, Huang, SM, Wei MB, Zhang HL, Sheng AI, Xu JM, Ruan XL. Dynamics of soil and grain micronutrients as affected by long-term fertilization in an Aquic inceptisol. Pedosphere. 2010;19:597-605.
19. Rahman MH, Islam MR, Jahiruddin M, Puteh AB, Mondal MMA. Influence of organic matter on nitrogen mineralization pattern in soils under different moisture regimes. International Journal of Agriculture and Biology. 2013;15:55-61.
20. Myint AK, Yamakawa T, Kajihara Y, Myint KKM, Zenmyo T. Nitrogen dynamics in a paddy field fertilized with mineral and organic nitrogen sources. American-Eurasian Journal of Agricultural and Environmental Sciences. 2010;7:221-231.
21. Uprety D, Hejeman, Szakova J, Kunzova E, Tlustos P. Concentration of trace elements in arable soil after long-term application of organic and inorganic fertilizers. Nutrient Cycling in Agroecosystems. 2009;85:241-252.
22. Xu Y, Yu W, Ma Q, Zhou M. Accumulation of copper and zinc in soil and plant within ten-year application of different pig manure rates. Plant, Soil and Environment. 2013; 59:492-499.
23. Abu-Zahra TR, Abubaker SM, Tahboub AB, Al-abbadi AA. Effect of organic matter sources on micronutrients and heavy metal accumulation in soil. Food, agriculture and environment. 2010;8:1199-1202.
24. Nikoli T, Matsi T. Influence of liquid cattle manure on micronutrients content and uptake by corn and their availability in a calcareous soil. Agonomy Journal. 2011; 103:113-118.
25. Walker DJ, Clemente R, Bernal P. contrasting effects of manure and compost on soil pH, heavy metals availability and growth of chemopodium album in a soil, Chemosphere J. 2004;57(3):844-851.
26. Pypers P, Verstraete S, Phan Thi C, Merckx R. Changes in mineral nitrogen, phosphorus availability and salt-extractable aluminum following the application of green manure residues in two weathered

soils of South Vietnam. Soil Biology and Biochemistry. 2005;37:163-172.

27. Adeniyan ON, and Ojeniyi SO. Effect of poultry manures, NPK 15-15-15 and Combination of their reduced levels on maize growth and soil chemical properties. Nigerian Journal of Soil Science. 2005;15: 34-41.
28. Maerere AP, Kimbi GG, Nonga DIM. Comparative effectiveness of animal manures on soil chemical properties, yield and root growth of amaranthus (*Amarathus cruentus* L.). Agricultural Journal of Science Technology (AJST). 2001;1(4):14-21.
29. Zhan YG, Zhang YY, Cai JP, Zhu P, Gao HJ, Jiang Y. Variation in available micronutrients in black soil after 30 years fertilization treatment. Plant Soil Environ. 2014;60(9):387-393.
30. Udom BE, Mbagwu JSC, Adesodum JK, Agbim NN. Distribution of Zn, Cu, Cd and Pb in a tropical Ultisol after long-term disposal of sewage sludge. Environment International. 2004;30:167-170.
31. Anikwe MAN, Nwobodo KCA. Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban Agriculture in Abakaliki, Nigeria. Bioresource Technology. 2002;83,241-250.
32. Taiwo LR, Omonode AR, Akande MO, Adediran JA. Potentials benefits and inherent dangers in cropping municipal waste dump sites case studies in the city of Ibadan, Nigeria. Global Journal of Environmental Sciences. 2003;2(2):102-105.
33. Thomas GW. Soil pH and soil acidity. In: Sparks DL. (Ed) pp. 475-490. Methods of soil analysis. Part 3-Chemical Method. SSA. Book Series 5, Madison, Wisconsin, USA; 1996.
34. Schnug E, Fleckenstein J, Haneklaus S. Coca-Cola extractant for the Evaluation of available micronutrient concentrations in soils for oil seed rape. Institute of Plant Nutrition and Soil Science, Fed Agric. Research Centre, Germany; 2001.
35. Eteng EU, Asawalam DO, Ano AO. Total and available micronutrients in soils of contrasting parent materials in Southeastern Nigeria. Journal of Agriculture, Biotechnology and Ecology. 2014;7(2):1-16.
36. Eteng EU, Asawalam DO. Evaluation of five extraction methods for predicting available forms of iron in soils of Southeastern Nigeria. Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2015;8(1):1-8.
37. Sillanpaa M. Micronutrients and the Nutrients Status of Soils: Global Study. FAO Soil Bulletin No. 48, FOA/FIDA, Rome; 1982.
38. Enwezor WO, Udo EJ, Usoro NJ, Ayotade JA, Chude VO, Udegbe CC. Fertilizer use and management practices for crops in Nigeria. series 2. Federal Min. of Agric., Water Res. And Rural Dev. 1989;52-56.
39. Obi ME, Ebo PO. The effect of organic and inorganic amendments no soil physical properties and maize production in a severely degraded sandy soil in Southern Nigeria. Bioresource Technology. 1995;51: 117-123.
40. Olojede AO, Igbokwe MC. Poultry manure as soil amendment for ridza (Plectranthus esculentus N. E. BR) and turmeric (*Curcuma longa* L.) production at Umudike, NRCRI Umudike annual reports. 2001-2002.
41. Boateng SA, Zickermann J, Kornahrens M. Poultry manure effect on growth and yield of maize. West African Journal of Applied Ecology (WAJE). 2006;9:1-11
42. Ojeniyi SO, Adesoye SO, Awodun MA and Odedina SA. Effect of oil palm bunch on soil and plant nutrients composition and yield of maize. Proceedings, 30th annual conference. Soil Science Society of Nigeria. 2006;177-181.
43. Ayeni LS, Adetunji MT. Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, yield and growth components of maize. Natural Science. 2010;8(1):60-67.
44. Agba OA, Ubi BE, Abam P, Ogbechi J, Akeh M, Odey S, Ogar N. Evaluation of agronomic performance of maize under different rates of poultry manure application in an ultisol of Obubra, Cross River State, Nigeria. International Journal of Agriculture and Forestry. 2012;2(40): 138-144.
45. Nweke IA, Nsoanya LN. Effect of poultry manure and inorganic fertilizer on the performance of maize (*Zea mays* L.) and selected physical properties of soils of Igbariam, Southeastern Nigeria. International Journal of Agriculture and Rural Development. 2013;16(10):1348-1353.

46. Nweke IA, Nsoanya LN. Effect of cow dung and urea fertilization on soil properties, growth and yield of cucumber (*Cucumis sativus* L.). Journal of Agriculture and Ecology Research International (JAERI). 2015;3(2):81-88.
47. Magdi T, Abdhamid A, Takatsugu H. Composting of rice straw with oilseed rape cake and poultry manure and its effects on Faba bean (*Vicia faba* L.) growth and soil properties. Bioresource Technology. 2004; 183-189.
48. Wong MTF, Swift RS. Role of organic matter in alleviating soil acidity. In: Rengel, Z, Ed, Handbook of Soil Acidity, Marcel Dekker, Inc., New York. 2003;337-358. Available:http://dx.doi.org/10.1201/9780203912317.ch12
49. Azeez JO, Van Averbeke W. Dynamics of soil ph and electrical conductivity with the application of three animal manures. Communications in Soil Science and Plant Analysis. 2012;43:865-874. Available:http://Dx.Doi.Org/10.1080/00103627509366539
50. Alloway BJ. Micronutrient deficiencies in global crop production. Springer-Verlag, Berlin, Heidelberg; 2008.
51. Awodun MA, Ojeniyi SO, Adeboye A, Odedina SA. Effect of oil palm bunch refuse ash on soil and plant nutrient composition and yield of maize. America Eurasian Journal of Sustainable Agriculture. 2007;1:50-54.
52. Martinez F, Cuevas G, Igleslas T, Waiter I. Urban organic wastes effects on soil chemical properties in a degraded semiarid ecosystem; 2002. Available:http://www.dd.go.th/Wcss2002/papers/2103.pdf (Accessed May, 2015).
53. Omaliko CPE. Dung decomposition and its effects on the soil component of tropical grassland ecosystem. Tropical Ecol. 1984; 25:214-220.
54. Zak DR, Grigal DF. Nitrogen mineralization, nitrification and denitrification in upland and wetland ecosystems. Oecologia. 1991;88:189-196.
55. Roy S, Kashenm M. Effects of organic manures in changes of some soil properties at different Incubation periods. Open Journal of Soil Science. 2010;4:81-86.
56. Duffera M, Robarge NP, Mikkelsen RL. Estimating the availability of nutrient from Processed Swine Lagoon solids through incubation studies. Bioresource Technology. 1999;70:261-268.
57. Dikinya O, Mufwanzala N. Chicken manure-enhanced soil fertility and productivity: Effect of application rates. Journal of Soil Science and Environmental Management. 2010;1:46-54.

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