Impact Assessment of Organic Farming on Soil Nutrients and Heavy Metal Content

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ABSTRACT

Environmental sustainability of recent adoption of organic farming as a wholesome practice in sub-Saharan Africa needs to be investigated, in order to guide agricultural policy makers. Consequently, an assessment of soil chemical properties was done in an organic farm with different land uses. The experiment was 5×3 factorial design (five land uses and three soil depths) replicated temporally (two contrasting seasons) and spatially (four replications). Samples collected systematically at 0 - 20, 20 - 40 and 40 - 60 cm depths were analysed for pH, organic carbon, nutrients and heavy metals. Results indicated that manure application limed the soil. Soil pH ranged from 5.1 to 6.3 in grass-land and 5.8 to 6.4 in amaranth farm during dry and wet seasons, respectively. Generally, nutrients and heavy metals were concentrated at 0-20 cm depth. The effect of season on the parameters was erratic. Amounts of mobile, exchangeable and labile Cu were 0.13 - 0.19, 0.07 - 0.15 and 1.39 - 1.74 mg kg⁻¹, respectively while water soluble and mobile fraction Zn ranged from 0.15 - 0.20 and 0.29 – 0.62 mg kg⁻¹. Comparatively, all the metals labile pool was most abundant, while Pb was the most abundant metal. There was no evidence of heavy metal accumulation in the organic system.

INTRODUCTION

The intensive use of inorganic fertilizers for boosting crop productivity has been linked to rapid decline in soil fertility in the tropics (Babajide, Olabode, Akanbi, Olatunji, & Ewetola, 2008) and also environmental pollution (Dada, Togun, Adediran, &

Nwilene, 2014). Hence, farm management practices that do not use inorganic fertilizers are being adopted. Organic farming is a management system that maintains soil fertility and at the same time minimizes all form of pollution that might result from agricultural practices. Sustainable farming systems such as organic farming are seen as potential solution to the continued loss of biodiversity and sustainable healthy food production (Muller et al., 2012). The degree to which this is achievable in the African farming system is yet to be widely demonstrated through research.

Land application of farmyard manure is a common practice in many parts of the world as a means of recycling plant nutrients in crop production as well as a method of waste disposal (Kirchmann & Thorvaldsson, 2000; Kumar, Gupta, Baidoo, Chander, & Rosen, 2005). The intensification of animal husbandry has led to the use of feed additives such as heavy metals and veterinary antibiotics to control animal diseases in all classes of livestock including poultry (Chen, Zhang, Luo, & Song, 2012). Most heavy metals are added to animal feeds to prevent disease and increase weight gain and feed conversion, but they are largely expelled in the faeces and urine (Bolan, Adriano, & Mahimairaja, 2004). Nicholson, Smith, Alloway, Carlton-Smith and Chambers (2003) observed that more than 90% of the Cu in animal diets was lost in the faeces. Hence, manures have become an important source of heavy metals application to agricultural land,

accounting for approximately 40% of total annual inputs of Zn and Cu and 11% of Cd inputs (Veeken & Hamelers, 2002). The possible environmental consequences of applying livestock manures containing inorganic additives and the residues of organic contaminants derived from animal feedstuffs (Hu, Zhou, & Luo, 2010; Knapp, Dolfing, Ehlert, & Graham, 2010; Lopes, Herva, Franco-Uria, & Roca, 2011) is however, yet to be given the needed full research attention.

Recent global advocacy on the promotion of organic farming has led to the application of livestock manure to soil. The manure contains a significant input of nutrients but also of metals, some of them being toxic e.g. cadmium and lead (Madrid, López, & Cabrera, 2007). Heavy metals in soils may affect the stability and productivity of soil ecosystems, harm plant growth, influence the safety of the human food chain and promote the emergence of micro-organisms with antibiotic resistance genes (Berenguer, Cela, Santiveri, Boixadera, & Lloveras, 2008; Chee-Sanford et al., 2009).

Many researches in sub-Saharan Africa, on the practice of organic farming has centred on crop responses to organic amendments and few has evaluated the net effect of the organic practices on the soil health and quality, at least in the sub Saharan African region. Hence, the justification to hypothesise that organic manures are the single major source of heavy metals to soil under organic farming.

Consequently, the objectives of the study were to:

1. Assess the effect of different agricultural land use types under organic farming on some soil chemical properties and soil copper, lead and zinc fractions.

2. Determine the depth distribution of soil nutrients and heavy metal fractions under different land uses in organic farming.

MATERIALS AND METHODS

Site Description

The experiment was conducted at the organic agriculture skill development plot, Federal University of Agriculture, Abeokuta. This project site is located in the transition zone between tropical sub-humid and savannah climate, characterized by distinct wet and dry seasons (Bimodal rainfall distribution). The wet season begins in April and continues through October. This area has mean annual rainfall of about 1400 mm, mean annual temperature of about 22.2°C and mean annual maximum temperature of about 33.3°C. The study site lies between latitude 7° $12^'$ to 7° $20^'$ N and longitude 3° $20^'$ to $3^o28^'$.

History of the Site

The organic farm was established in the year 2007, weed control is mostly done manually, the farming practice involves the use of organic fertilizers like compost, manures and excludes synthetic agrochemicals, fertilizers or any inorganic pesticides. The organic materials mostly used are cured poultry manure and compost (made from poultry manure or cow dung, plant debris, and kitchen waste); the pests are controlled by applying organic bio-pesticides. The soil in the organic farm is classified as Hydraaquentic Humaquent. The details of the fields used for the experiment is presented in Table 1. The farm is partitioned into different land uses as seen in the Table 1. Annual application of 10 tonnes ha^{-1} organic amendments was done to each of the land use, while mono-cropping was done on the plots.

Experimental Design

The experiment was 5×3 factorial arrangement repeated in two seasons (dry and rainy seasons) and replicated four times. The factorial experiment consists of five (5) land uses and three (3) soil depths. The five land uses are control, amaranth cropland, celosia cropland, pineapple plantation, plantain plantation while the three soil depths are 0-20, 20-40 and 40-60 cm. The total experimental units are: $5 \times 3 \times 2 \times 4$, representing land use, soil depth, seasons and replications. This gives a total of 120 experimental units

Table 1
History of fields used for the experiment

Crop farm	Year under Organic farm	Plot size	Type of manure applied & rate
Vegetable 1 (Amaranth)cropland	3	3 m × 3 m	*Compost at 10 tonnes per hectare
Vegetable 2 (Celosia) cropland	3	3 m × 3 m	Compost at 10 tonnes per hectare
Pineapple plantation	5	3 m × 4 m	**Poultry manure at 10 tonnes per hectare
Plantain plantation	5	3 m × 4 m	Poultry manure at 10 tonnes per hectare
Grassland soils	>8 (control)	4 m × 4 m	None

*Made from poultry manure or cow dung, plant debris, and kitchen waste
**Typically, the manure metal composition is variable but may contain an average of 48, 52.5, 28 and 2.15 mg kg^{-1} of Cu, Zn, Cd and Pb, respectively.

Soil Sampling

Soil samples were collected with the aid of a soil auger from the land use types. Four replicate samples were collected on each land use type. Samples were randomly and systematically collected during dry (December 2014 to February 2015) and rainy (May-July, 2015) seasons at sampling depths of 0-20 cm, 20-40 cm and 40-60 cm. Collected composite soil samples were air-dried passed through a 2 mm sieve and labelled for analyses.

Soil Analyses

Soil pH was determined in 1:2 soil: water suspension (McLean, 1982). Organic carbon was determined using wet oxidation method (Walkley & Black, 1934). Particle size analysis was determined using the hydrometer method (Bouyoucos, 1962). Available phosphorus was determined using Bray 1 method (Bray & Kurtz, 1945). Total

Nitrogen was determined by micro Kjeldahl digestion method as described by Bremmer and Mulvaney (1982). The exchangeable bases were extracted using neutral ammonium acetate. The exchangeable Na and K in the filtrates were determined by Flame photometer while the exchangeable Ca and Mg were determined by atomic absorption spectrophotometer. The Effective Cation Exchange Capacity (ECEC) was expressed as the summation of exchangeable cation and exchangeable acidity (Rhoades 1982). Exchangeable acidity was evaluated titrimetrically (Mclean, 1982).

Soil heavy metal fractions were determined according to Akpa and Agbenin (2012) as follows:

1. Mobile fractions: 10 g of air dried 2 mm sieved soil was put in a well labelled sample bottles then 30 ml of 1.0M ammonium nitrate (NH_4NO_3) solution was added.

2. Exchangeable fractions: 10 g of sieved soil was put in a sample bottle then 30 ml of 0.1M calcium chloride ($CaCl_2$) solution was added.

3. Labile fractions: 10 g of well sieved soil (2 mm) was put in a sample bottle then 30 ml of 0.05M etylenediaminetetraacetic acid (EDTA) was added.

4. Water soluble fractions: 10 g of the sieved soil was put in different sample bottle then 30 ml of deionized water was added.

For each fraction, soil + solution mixture was shaken for 2 hrs, centrifuged for 10 minutes then filtered using Whatmann No 42 filter paper to give a clear filtrate. The Zn, Cu and Pb in each filtrate from each fraction were determined using atomic absorption spectrophotometer (AAS). The detection limit for lead, zinc and copper are 0.05, 0.003, 0.003 mg kg^{-1} respectively.

Statistical Analysis

Data collected were subjected to Analysis of Variance at 5% probability level and mean values were separated using Least Significant Difference (GENSTAT). The data obtained were also subjected to Pearson correlation analysis to measure the relationship.

RESULTS

Agricultural land use had highly significant effect at $p \leq 0.05$ on soil pH as shown in Table 2. Amaranth cropland had the highest pH followed by celosia cropland, plantain farm, pineapple farm, while control (grassland) had the least pH. Soil depth also had significant effect on soil pH ($p \leq 0.05$) under different agricultural land uses. Soil depth at 0-20 cm had highest soil pH but not significantly different from the pH at 20-40 cm depth while 40-60 cm had the least soil pH as shown in the Table 2. Season effect was also highly significant on pH ($p \leq 0.01$). The wet season produced significantly higher pH than dry season.

Land use had a highly significant ($p \leq 0.05$) effect on available P. Celosia and amaranth croplands produced significantly higher available phosphorus than other land use types, celosia farm land and control plot had the highest and lowest available P, respectively. Soil depth had significant effect on available P, soil depth at 0-20 cm had the highest available P (17.22 mg kg^{-1}) while the least value was recorded at soil depth of 40-60 cm (7.47 mg kg^{-1}). Available P decreased significantly with increasing soil depths.

The effect of agricultural land use also shown in Table 2, showed a significant effect on soil organic matter ($P \leq 0.05$). Plantain farm had the highest soil organic matter content (14.15 g kg^{-1}) which was significantly different from other agricultural land use types while control had the least value (9.49 g kg^{-1}). Soil organic matter content decreased down the depth with 0-20 cm soil depth having the highest value (17.18 g kg^{-1}) and the least value (8.44 g kg^{-1}) was observed at depth 40-60 cm. There was also significant interaction of the three factors on some of the parameters.

The effects of land use on soil nitrogen content, some exchangeable cations and effective cation exchange capacity are presented in Table 3. Across soil depths and seasons, total nitrogen, exchangeable calcium, Mg and ECEC did not differ significantly (p <0.05) among the different land uses. Land use types had highly significant (p <0.05) effect on both exchangeable Na and K contents. Amaranth and celosia croplands produced significantly higher values (0.54, 0.48 cmol kg⁻¹ and 0.31, 0.27 cmol kg⁻¹, respectively) compared with the control which had the least values (0.23 and 0.10 cmol kg⁻¹) of exchangeable Na and K, respectively. Although, the effect was not significant, calcium was the highest among the exchangeable bases followed by Mg, then Na and K. There were higher values in celosia cropland and plantain farm for almost all nutrients except in exchangeable K and Na. Soil depth had significant (p < 0.05) effect on soil nutrients under different agricultural land uses. Nutrients are more concentrated at depth of 0-20 cm. The values were significantly reduced at the other depths. Total N and exchangeable cations decreases down the depth, however, the trend shown in Mg was different. No significant difference was recorded in ECEC at different soil depths. Total N, Na, Mg and ECEC varied significantly with season. It was also observed that wet season had significantly higher total N and Mg contents compared with the dry season while there was significant reduction in the ECEC value and exchangeable Na content in dry season and rainy season.

Table 2

The effects of different agricultural land use and soil depth on soil pH, available phosphorus and organic matter in wet and dry seasons

Treatments	pH 1:2 (H_2O)	Avail P (mg kg⁻¹)	SOM (g kg⁻¹)
Land use (L)			
Control	5.43	6.10	9.49
Pineapple plantation	6.13	8.75	10.14
Plantain plantation	6.16	6.84	14.15
Amaranth cropland	6.36	14.91	12.84
Celosia cropland	6.19	20.34	10.78
LSD (5 %)	0.15**	4.18**	2.32**
Depth (cm) (D)			
0-20	6.18	17.22	17.18
20-40	6.12	9.48	8.82
40-60	5.86	7.47	8.44
LSD (5 %)	0.12**	3.24**	1.80**
Season (S)			
Dry	5.85	11.55	12.00
Wet	6.26	11.23	10.95

Table 2 *(continue)*

Treatments	pH 1:2 (H_2O)	Avail P (mg kg^{-1})	SOM (g kg^{-1})
Season (S)			
LSD (5 %)	0.10**	NS	NS
L × D	0.265**	7.24**	NS
L × S	0.22*	5.91**	3.28**
L × S	0.22*	NS	NS
L × D × S	0.37*	NS	5.68**

*Significant at 5 %. ** Highly significant at 1%. NS means not significant. LSD represent least significant different. SOM signifies soil organic matter

Table 3

Effects of land use and soil depth on total nitrogen, soil exchangeable cations and effective cation exchange capacity in wet and dry seasons

	N	Ca	K	Na	Mg	ECEC
	(g kg^{-1})	----------------------------(cmol kg^{-1})---------------------------------				
Land use (L)						
Control	0.55	12.13	0.10	0.23	0.99	23.60
Pineapple plantation	0.42	10.66	0.13	0.28	0.97	28.40
plantain plantation	0.58	12.66	0.20	0.39	1.23	21.10
Amaranth cropland	0.58	11.88	0.31	0.54	1.14	27.60
Celosia cropland	0.68	12.50	0.27	0.48	1.20	18.80
LSD 5%	NS	NS	0.05**	0.08**	NS	NS
Depth (cm) (D)						
0-20	0.74	13.84	0.25	0.45	1.35	28.00
20-40	0.55	13.07	0.18	0.36	0.97	23.10
40-60	0.40	8.98	0.18	0.34	0.99	20.60
LSD 5%	0.19**	1.90**	0.04**	0.06**	0.17**	NS
Season (S)						
Dry	0.40	12.47	0.21	0.43	0.98	34.40
Wet	0.72	11.46	0.20	0.34	1.22	13.40
LSD 5%	0.15**	NS	NS	0.05**	0.14**	6.10**
L × D	NS	NS	NS	NS	ns	NS
L × S	NS	NS	0.07**	0.12**	0.31**	NS
D × S	NS	2.69**	NS	0.09*	NS	NS
L × D × S	NS	NS	NS	NS	NS	NS

*Significant at 5 %. ** Highly significant at 5 %. NS means not significant. LSD represent least significant difference

Agricultural land use had no significant effect (p < 0.05) on water soluble Cu and Pb (Table 4). However, effect of land use was significant on water soluble Zn, the highest mean value (0.20 mg kg^{-1}) was recorded in celosia crop land while lowest value (0.15 mg kg^{-1}) was recorded in amaranthus crop land. Soil depth had no significant effect on water soluble heavy metals (Table 4). Seasonal variation had significant influence on water soluble Cu and Zn; while water soluble Cu reduced in value from dry to wet season (0.04 – 0.03 mg kg^{-1}), water soluble Zn increased from dry to wet (0.15 – 0.19 mg kg^{-1}). Season had no effect on water soluble Pb.

Land use had a significant effect (p < 0.05) on mobile Cu, Pb and Zn as observed in Table 4. Control and pineapple plantation had significantly higher value of mobile Cu than other land uses; there were no significant differences in the effect of soil depth but decreases were observed in values down the depth. Wet season soil had significantly higher mobile Cu (0.22 mg kg^{-1}) than dry season soil (0.10 mg kg^{-1}). There were no significant differences in the amount of mobile Pb in control, pineapple farm, amaranth and celosia croplands which differ significantly from plantain plantation. No significant difference was observed at different soil depths, there was seasonal variation in amount of mobile Pb in which wet season soil had higher amount (1.48 mg kg^{-1}) than dry season soil (0.10 mg kg^{-1}).

The different organic land use, soil depth and cropping season had highly significant effect (p < 0.01) on mobile Zn. Control plot differed significantly from other agricultural land uses, whereas the lowest value was recorded in pineapple and plantain farm. Soil depth at 0-20 cm had significantly higher value of mobile Zn compared to the other depths. The mobile Zn value in rainy season was higher than that of dry season.

The effect of land uses and soil depths shown in Figure 1 had highly significant effect (p < 0.01) on water soluble Cu. The water soluble Cu content in the soil as shown in the interaction between land use and depth ranged from 0.01-0.08 mg kg^{-1}. At depth 40-60 cm, pineapple farm had the highest value, compared with other agricultural land uses, while the least value was obtained in control, amaranth cropland and celosia cropland at depth 40-60 cm and 0-20 cm, respectively. The seasonal changes in water soluble Cu content based on different agricultural land use is presented in Figure 2. Water soluble Cu differs significantly under the different land use types during dry season. Amaranth and Celosia croplands had highest and lowest values (0.062, 0.021 mg kg^{-1}), respectively, Pineapple and plantain farm lands had significantly higher water soluble Cu than other land use types that but no significant differences observed between dry and rainy season. Soil depth had a varying effect on water soluble Cu (Figure 3). There were no significant differences in values of water soluble Cu at the 0-20 and 20-40 cm soil depths at in both seasons, depth of 40-60 cm produced significantly highest amount of water soluble Cu during rainy season than in the other depths while depth of 20-40 cm had the least value during the dry season, soil depth of 20-40 cm was higher than 40-60 cm depth which had the least value.

Table 4
Effect of different land uses, soil depths and cropping season on water soluble heavy metals

	Water soluble			Mobile heavy metals		
	Cu	Pb	Zn	Cu	Pb	Zn
	------------------------------- mg kg⁻¹ ---					
Land use (L)						
Control	0.03	0.14	0.17	0.19	0.97	0.62
Pineapple plantation	0.04	0.14	0.19	0.19	0.87	0.29
Plantain plantation	0.04	0.15	0.16	0.14	0.44	0.29
Amaranth cropland	0.04	0.14	0.15	0.13	0.91	0.44
Celosia cropland	0.02	0.14	0.20	0.14	0.96	0.42
LSD	NS	NS	0.04*	0.05*	0.28**	0.19**
Depth (cm) (D)						
0-20	0.03	0.14	0.17	0.17	0.81	0.69
20-40	0.03	0.14	0.19	0.16	0.90	0.29
40-60	0.03	0.14	0.16	0.15	0.79	0.25
LSD	NS	NS	NS	NS	NS	0.15**
Season (S)						
Dry	0.04	0.14	0.15	0.10	0.18	0.27
Wet	0.03	0.14	0.19	0.22	1.48	0.56
LSD	0.01*	NS	0.03*	0.03**	0.175**	0.12**
L × D	0.03**	NS	ns	0.09*	NS	0.33*
L × S	0.03*	NS	0.06*	Ns	0.39**	NS
D× S	0.02**	NS	NS	Ns	NS	NS
L×D×S	NS	NS	0.05**	0.13*	NS	0.47*

*Significant at 5 %. ** Highly significant at 1%. NS means not significant. LSD represent least significant difference.
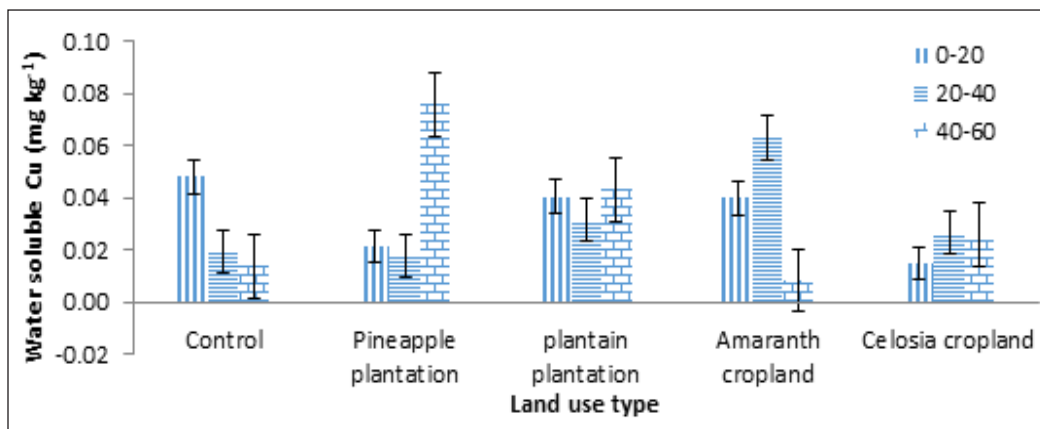

Figure 1. Effect of land uses and soil depths on water soluble Cu; vertical bars indicate standard errors of the mean
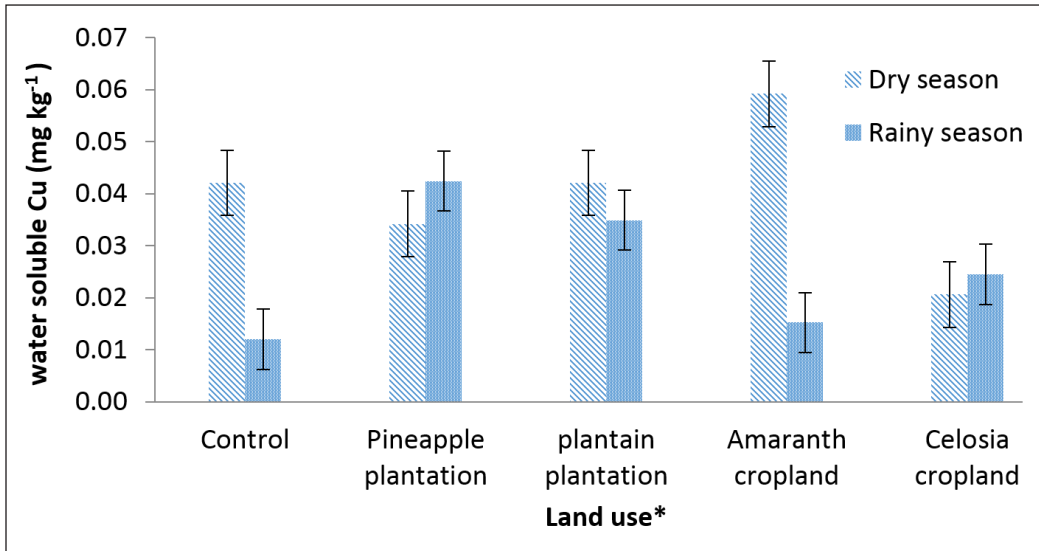
Figure 2. Seasonal water soluble Cu as affected by agricultural land uses
Note: *vertical bars indicate standard errors of the mean
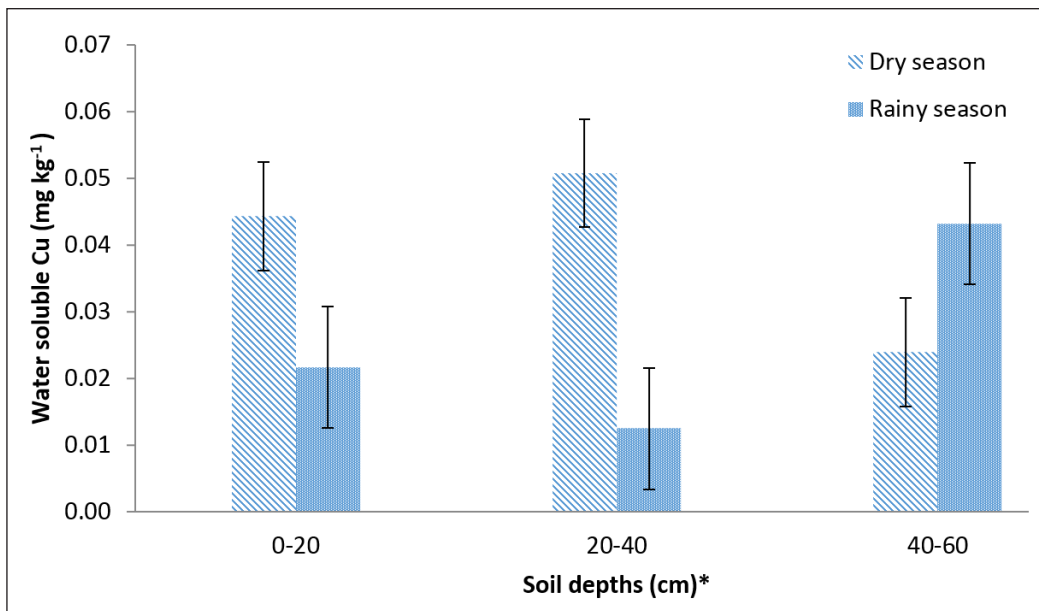

Figure 3. Interaction between soil depth and seasonal changes on water soluble Cu
Note: *vertical bars indicate standard errors of the mean

The effect of different organic land uses, soil depth and seasonal variations on exchangeable heavy metals is presented in Table 5. Organic land use had significant effect ($p < 0.05$) on exchangeable fraction of Cu which ranged from 0.07 - 0.15 mg kg^{-1}. Plantain had the highest value while celosia had the least. The effect of soil depths

Table 5
The Effect of different organic land uses, soil depths, seasonal variations on exchangeable heavy metals

	Exchangeable metals			Labile metals		
	Cu	Pb	Zn	Cu	Pb	Zn
	------------------------- mg kg^{-1} -----------------------------					
Land uses (L)						
Control	0.10	0.58	0.37	1.74	2.03	2.04
Pineapple plantation	0.11	0.78	0.21	1.59	3.35	1.97
plantain plantation	0.15	0.69	0.19	1.71	2.93	1.85
Amaranth cropland	0.11	1.00	0.35	1.39	3.75	2.27
Celosia cropland	0.07	1.62	0.37	1.39	3.95	2.35
LSD	0.03**	0.66*	NS	0.28*	0.49**	NS
Depth (cm) (D)						
0-20	0.11	0.82	0.33	1.77	3.12	2.90
20-40	0.10	0.90	0.29	1.37	2.89	1.79
40-60	0.12	1.09	0.27	1.54	3.59	1.59
LSD	NS	NS	NS	0.21**	0.38**	0.35**
Season (S)						
Dry	0.11	1.30	0.16	1.61	3.82	1.86
Wet	0.11	0.57	0.43	1.51	2.58	2.33
LSD	NS	0.41**	0.17**	NS	0.312**	0.28**
L × D	NS	NS	NS	0.48*	0.86**	0.77**
L × S	0.05**	NS	NS	0.39*	0.70*	NS
D × S	NS	NS	NS	NS	NS	0.49**
L × D × S	NS	NS	NS	NS	NS	NS

*Significant at 5 %. ** Highly significant at 1%; ns means not significant. LSD represent least significant different.

and cropping seasons were not significant on the exchangeable Cu. Exchangeable Pb was significantly (p < 0.05) affected by the ~~on~~ different organic land uses and cropping seasons but soil depth did not show any significant effect on Pb. Celosia cropland had the highest exchangeable Pb value (1.62 mg kg^{-1}) compared to plantain farm with the least value (0.69 mg kg^{-1}). Dry season produced higher exchangeable fraction of Cu which differs significantly from the value obtained in rainy season. The different agricultural land uses and soil depths had no significant (p < 0.05) effect on Zn but cropping season had highly significant effect on exchangeable Zn. Wet season highly significantly increased soil exchangeable Zn than dry season. As shown in Table 5, there was a significant effect (p < 0.05) of the land use and depth on labile

fraction of Cu while no significant effect of seasonal changes was recorded. Plantain farm had greater value of labile Cu (1.71 mg kg^{-1}) than other agricultural land uses. Soil depth of 0-20 cm had significantly higher labile Cu (1.77 mg kg^{-1}) compared to depth 20-40 cm and 40-60 cm which were slightly different from each other. Land use, soil depth and cropping season had highly significant effects on Labile fraction of Pb. The highest labile Pb occurred in vegetable croplands (amaranth and Celosia) while control had the least value. Soil depth at 20-40 cm had the lowest labile Pb compare to 40-60 cm which had significantly higher value. The effect of seasonal variation was significantly higher in dry season than in the rainy season, higher labile Pb was recorded in dry season than rainy season. There was no significant difference at $p < 0.05$ for agricultural land use on labile fraction of Zn but highly significant ($p < 0.01$) effect was observed in the different soil depths and cropping seasons. The labile fraction of Zn decreases as soil depth increases with 0-20 cm having greater value and depth 40-60 cm having the least value of labile Zn. The amount of labile Zn increased significantly in rainy season than in dry season.

The soil quality index is shown in Table 6, the agricultural land uses had total N, available P and exchangeable K as moderate levels (15-30 mg kg^{-1}, 0.26-1.28 cmol kg^{-1}) for plant growth in amaranth (15 mg kg^{-1}, 0.31 cmol kg^{-1}) and celosia cropland (20.34 mg kg^{-1}, 0.27 cmol kg^{-1}) than other land use that are deficient. In all the agricultural land uses, values of exchangeable Mg were moderate, while the values of exchangeable Ca were extremely high (> 5.00 cmol kg^{-1}) in all agricultural land uses.

The correlations between soil pH, organic matter and the major soil nutrients are presented in Table 7. Soil organic matter, total nitrogen, and the exchangeable cations had significant positive relationship with the pH. Soil organic matter had very significant positive relationship with total N, available P, K, Mg and Na. Similarly, available P positively correlated with K, Mg and Na. Potassium also had significant relationship with Mg and Na contents of the soil while calcium only had relationship with Na.

Table 8 shows the correlations among different fractions of heavy metals and pH of soil under organic farming system. Mobile copper only had significant positive correlation with mobile Zn while it had negative relationship with labile lead, exchangeable lead, and water soluble copper. Mobile Pb correlated positively with mobile Zn and water soluble zinc while it has negative correlation with exchangeable lead, zinc and labile lead. Mobile zinc showed significant positive correlation with other fractions of Zn. There were no correlations of water soluble fractions of the heavy metals with other fractions. Exchangeable Cu positively correlated with fractions of Pb while exchangeable lead only had relationship with labile Pb. Labile copper positively correlated with labile zinc. Other possible correlations were not significant at 5% probability level.

Table 6
Quality Index for selected soil properties of the organic farm

Land use	Total N (g/kg)	Remarks	Avail P	Remarks	K	remarks	Ca	Remarks	Mg	Remarks	Na	Remarks
Control	0.55	Low	6.1	Low	0.1	low	12.13	High	0.99	Moderate	0.23	No adverse effect
Pineapple plantation	0.42	Low	8.75	Low	0.13	low	10.66	High	0.97	Moderate	0.28	No adverse effect
plantain plantation	0.58	Low	6.84	Low	0.2	low	12.66	High	1.23	Moderate	0.39	No adverse effect
Amaranth cropland	0.58	Low	14.91	Moderate	0.31	moderate	11.88	High	1.14	Moderate	0.54	No adverse effect
Celosia cropland	0.68	Low	20.34	Moderate	0.27	moderate	12.5	High	1.2	Moderate	0.48	No adverse effect

Note, Total N(g/kg) > 5 High, 1-5 Moderate, < 1 Low, Avail P (mg/kg⁻¹) from 15 - 30 Moderate, < 15 Low, Exchangeable K (cmolkg⁻¹) > 1.28 High, 0.26-1.28 Moderate, <0.26 Low ,Exchangeable Ca (cmolkg⁻¹) >5.0 High, 0.5-5 Moderate, 0.05-0.5 Low, Exchangeable Mg (cmolkg⁻¹) >4.2 High, 0.42-4.2 Moderate, <0.42 Low, Exchangeable Na (cmolkg⁻¹) > 0.65 High, <0.65 No adverse effect.

DISCUSSION

Sequel to the pressure on land as a result of increasing demand for food, land resources are being over exploited. There is need for more information on of the agricultural production capacity of land and its dynamics in order to promote land management practices that seeks to improve land productivity in a sustainable way (Bindraban, Stoorvogel, Jansen, Vlaming, & Groot, 2000; Lal, 2009). The proposition of organic farming system as a safe and sound ecologically friendly system that would not only boost food production but improve soil productivity was hypothesised. The result of this study implied that the soil pH was improved under different land uses after some years of organic farming. The soil pH improved from being very acidic to slightly acidic after three years of vegetable cropping using organic inputs. The liming effect of the manure application could have been due to the addition of basic cations like Ca, K, Ma from the manure to the soil. These cations will subsequently displace H$^+$ from the soil exchange complexes. This result is confirming the recent discovery by Olowoboko, Azzez, Olujimi and Babalola (2018), who reported that addition of animal manures increased the soil pH in some tropical soils in Nigeria. Specifically, amaranths and celosia production had the highest soil pH probably because they are short duration crops and their uptake of lime inducing nutrients (Ca and Mg) could have been lower compared with other crops investigated. Hence, the amendments have higher amount of the cations to lime the soil. On the other hand, pineapple and plantain are perennials and heavy feeders that could relatively mine the soil of the basic cations. The duo of the latter crops have been reported to have high amounts of Ca and Mg in their fruits (indicative of high extraction from the soil) by Hossain, Akhtar and Anwar (2015) and Kasa and Yohanis, (2017). There seems to be the accumulation of basic cations, P and organic matter at shallow soil depths. This is reflected in the higher soil pH at 0-40 cm depth. Generally, during rainy season, the soil was more alkaline. In reaction, perhaps the acidity of the soil was diluted by the excess water usually recorded in the organic farm.

Table 7

Correlations among soil nutrients, pH and soil organic matter on organic farming system

	pH	SOM	N	Available P	K	Ca	Mg	Na
SOM	0.234*							
N	0.183*	0.298**						
Available P	0.406**	0.327**	0.101					
K	0.471*	0.316**	0.17	0.591**				
Ca	0.046	0.015	0.125	0.067	0.181*			
Mg	0.262*	0.337**	0.277	0.333**	0.445**	0.259*		
Na	0.386*	0.318**	0.102	0.562**	0.962**	0.228	0.357*	
ECEC	-0.149	0.157	-0.123	0.045	-0.015	0.114	-0.163	0.059

Table 8
Correlations among different fractions of heavy metals and pH in organic farming system

	M- Cu	M-Pb	M- Zn	WS-Cu	WS- Pb	WS- Zn	Exch-Cu	Exch- Pb	Exch-Zn	Lab- Cu	Lab- Zn	Lab- Pb
Mobile Pb	0.47											
Mobile Zn	0.211**	0.373**										
Water soluble Cu	-0.13*	-0.171	0.097									
Water soluble Pb	0.088	-0.072	-0.072	0.133								
Water soluble Zn	0.132	0.256*	-0.018	-0.034	0.007							
Exchangeable Cu	0.159	-0.003	-0.103	0.097	0.099	-0.119						
Exchangeable Pb	-0.209*	-0.206*	-0.17	-0.029	-0.018	0.113	-0.205*					
Exchangeable Zn	0.141	0.351**	0.53**	0.09	-0.028	0.007	-0.069	-0.112				
Labile Cu	0.138	-0.097	0.124	0.112	0	-0.016	0.115	-0.113	-0.042			
Labile Zn	0.186	0.167	0.325**	-0.097	-0.083	-0.05	-0.116	0.02	-0.001	0.207*		
Labile Pb	-0.312**	-0.351**	-0.199	0.154	-0.063	0.049	-0.21*	0.286*	-0.177	0.054	0.053	
pH	-0.009	0.245	0.06	0.024	0.069	0.046	-0.098	0.01	0.075	-0.173	0.15	0.045

Note, M=Mobile;, WS = Water soluble; Exch = Exchangeable; Lab= Labile

Soil organic matter is one of the primary indicators of soil quality (Komatsuzaki & Ohta, 2007). The study revealed significant changes in soil organic matter on different land uses in organic farming system. It was observed that plantain plantation at rainy season had greater soil organic matter than the planted grass land. The values obtained under pineapple plantation were comparable to those on the planted grassland. These differences were due to the general increase in soil organic matter and subsequent improvement in soil fertility on organic farming system. Kapkiyai, Karanja, Qureshi, Smithson and Woomer (1999) and Lemenih, Kaltun and Olsson (2006) reported significant improvement in soil organic matter after long-term applications of organic residues in soils of Kenya and Ethiopia. The accumulation of organic matter in the plantain plantation could also be due to the large amount of biomass of plantain stems, leaves and other plant parts that are usually returned to the soil for decay at harvesting. The study further showed that soil organic matter had significant positive correlations with pH and soil nutrients. This is not surprising as soil organic matter is well known to be a supplier of plant nutrients. Hence farming systems that improve soil organic matter such as the organic farming are desirable.

The distribution of soil nutrients as affected by different agricultural land uses indicated that land maintained for 3 years with organic inputs for celosia cropping significantly accumulated more nitrogen than others. Generally, plantain,

celosia, and amaranths are surface feeders and have low biomass. Their life cycles (excluding pineapple) is also short (couple of weeks). This could have resulted in the accumulation of nutrients in the soil. On the contrary, plantain is perennial crop having high nutrients requirement, this leads to the excessive mining of soil nutrients. Similar results were reported by Diacono and Montemurro (2010). Higher total nitrogen in the rainy season is probably due to the leaching of soluble nitrate and other N forms from the environments to the soil at the time of sampling. This could be beneficial for crop growth as most of the cropping activities are done during rainy season. Nitrogen had positive and significant correlations with soil pH and organic matter while the correlation with other soil nutrients were not significant. Sharpley and Smith (1995) also recorded higher nitrogen and phosphorus in soils under the application of organic manure. Calcium decreased considerably as the depth of soil sampling increased from 0-20cm to 40-60 cm. Calcium also varied with season, higher values were obtained at the topsoil and subsoil during dry and rainy seasons, respectively. This could imply that calcium tends to concentrate at the topsoil during dry season but as it rains, the salt gets dissolved and move down the soil profile; the process could be termed calcium leaching. In all, dry season recorded greater values of exchangeable cations than rainy season. The cation exchange capacity which is a measure of the amount of cations a soil can hold; followed a similar trend as the exchangeable cations. Most of the cations

decrease in their concentrations from the topsoil to the subsoil. These are the expected trends and the dilution effect of rains on the salts of these cations could be responsible for these observations. There was a general increase in soil fertility level under the different land use types in the organic farm as there seemed to be no significant change in the effective cation exchange capacity of the soils in the semi-natural grass land compared to those on the land use types where organic farming has been practice for about 8 years. This is in accordance to the findings of Diacono and Montemurro (2010) who observed improvement in soil fertility after long term of using organic amendments.

Using the soil quality indices of Amercher, O' Neill and Perry (2007), the soils are deficient in total N, vegetable farm had moderate P and K level, exchangeable Ca is very high which may later lead to toxicity and exchangeable Mg is also moderate for all plants. Generally, the soil could be rated low in fertility. This could have been due to crop uptake of nutrients.

Agricultural land use with high inputs rates of organic manures could lead to increased risk of soil and water contamination with heavy metals. The result showed general variations among the heavy metals based on land use, soil depth and season though the total concentrations were below the tolerable limit (Kabata-Pendias & Pendias, 2001). There was a considerable difference in the amount of water soluble Cu on the amaranth cropland compared to the Celosia cropland as the latter tends to be significantly lower. There was no significant change in the concentrations of Cu at dry and rainy season.

Changes in Cu concentration at different soil depths and seasons did not follow a particular trend. It was observed that there were no appreciable changes in lead and zinc concentrations with land use, soil depth and season. The low concentrations of these metals could have accounted for this observation. Similarly, there was no considerable accumulation of mobile Cu (ammonium nitrate extractable) Cu, Pb and Zn under the different land use types compared to the semi-natural grassland. The dry season had lower mobile fraction of Zinc compared to the rainy season on the different land uses. Though, below the tolerable limit, topsoil (0-20 cm) accumulated more mobile fractions of Cu, Pb ad Zn. The values obtained were below those reported by Kobierski and Piotrowska (2010). This implied that there was a decrease in mobility of these metals with increasing soil depths. Zhou, Liao, Wu, Zhang and Ren (2008) reported that heavy metals accumulated in the first few centimetres of the topsoil.

The exchangeable fractions (calcium chloride extractable) of heavy metals are those fractions of the metal that could be easily adsorbed on the soil exchange sites. Among the heavy metals, lead had higher concentrations in all the land use types. In order to avoid the risk of future heavy metals contamination or lead poisoning care must be taken in the quality check of organic inputs used in organic farming system. Veeken and Hamelers (2002),

and Nicholson et al. (2003) noted that manures had become an important source of heavy metals applied to agricultural land, accounting for approximately 40% of total annual inputs of Zn and Cu to agricultural land and 11% of Cd inputs.

Plantain plantation showed tendency for increased accumulation of labile fractions (EDTA extractable) of copper and lead. There was a relative increase in the amount of labile Pb in dry season under the vegetable croplands. The variation of these metals appeared to be uniform with soil depth. The amount of these metals were very low (Kabata-Pendias & Pendias, 2001) to pose a threat to both animal and human lives but conscious efforts still need to be made to maintain low levels of lead in the soil.

Furthermore, it was noted that there exist significant positive relationships within and among most of the different fractions of the heavy metals. This implied that increase in one fraction could lead to increased accumulation of the other. It was also observed that there exist poor correlations of water soluble fractions of the heavy metals with other fractions which could be due to the varying degrees of solubility of the metals.

Generally, the arguments on the accumulation of heavy metals in organic systems have not been a conclusive one but most of the scientists are of the opinion that metals found in organic systems are not necessarily due to the additions in the system but aerial depositions from non- point sources (Pandey & Pandey, 2009). However, the use of town refuse in urban agriculture have been reported to contaminate the soil and crops cultivated therein (Pasquini, 2006). It should however, be noted that heavy metal contamination is not necessarily a function of soil loading alone but due to pH, cation exchange capacity and soil nutrient levels are all key factors that determine accumulation of heavy metals in crops. These are myriads of problems the farmer face. Just because people have high expectations form organic farming does not mean they have to be ignored.

Summarily, since the cumulative concentrations of the heavy metals were far below the international tolerable limits, it could be concluded that there is presently no risk of heavy metal contaminations at the organic farm where this research was conducted but attempts should be made to ensure proper quality control of organic inputs used to avoid the risk of future heavy metal contamination which could be harmful to lives. This further demonstrates and confirms organic farming as a safe and sound ecologically friendly system that sustains and improves soil quality, if other likely sources of heavy metals like aerial depositions are kept in check.

CONCLUSION

Manure used in organic farm has liming effect on the soil while soil nutrients are concentrated at surface soil depth. There is the accumulation of soil nutrients in organic farming, irrespective of the land use, cropping seasons and soil depths. Copper, Pb and Zn concentrations in the organic

farm were below the contamination levels. Though, studies on the uptake of heavy metals by organic products is recommended for investigation.

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REFERENCES

Akpa, S. I., & Agbenin, J. O. (2012). Impact of cow dung manure on the solubility of copper, lead and zinc in urban garden soils from Northern Nigeria. *Communication in Soil Science and Plant Analysis*, *43*(21), 2789–2800. doi: 10.1080/00103624.2012.719976

Amacher, M. C., O'Neill, K. P., & Perry, C. H. (2007, May 1). Soil vital signs: A new Soil Quality Index (SQI) for assessing forest soil health. Fort Collins, USA: Rocky Mountain Research Station.

Babajide, P. A., Olabode, O. S., Akanbi, W. B., Olatunji, O. O., & Ewetola, E. A. (2008). Influence of composted Tithonia-biomass and N-mineral fertilizer on soil physico-chemical properties and performance of Tomato (*Lycopersicon lycopersicum*). *Research Journal of Agronomy, 2*(4), 101-106.

Berenguer, P., Cela, S., Santiveri, F., Boixadera, J., & Lloveras, J. (2008). Copper and zinc soil accumulation and plant concentration in irrigated maize fertilized with liquid swine manure. *Agronomy Journal, 100*(4), 1056–1061.

Bindraban, P. S., Stoorvogel, J. J., Jansen, J. M., Vlaming, J., & Groot, J. R. (2000). Land quality indicators for sustainable land management: proposed method for yield gap and soil nutrient balance. *Agriculture Ecosystem and Environment, 81*(2), 103-112. doi: 10.1016/S0167-8809(00)00184-5

Bolan, N. S., Adriano, D. C., & Mahimairaja, S. (2004). Distribution and bioavailability of trace elements in livestock and poultry manure by-products. *Critical Review on Environmental Science and Technology, 34*(3), 291–338. doi/full/10.1080/10643380490434128

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle-size analysis of soils. *Agronomy Journal, 54*(5), 464 – 465.

Bray, R. H., & Kurtz, L. T. (1945). Determination of total organic and available phosphorus in soils. *Soil Science, 59*(1), 39-45.

Bremmer, J. M., & Mulvaney, C. S. (1982). Total nitrogen. In A. L. Page, R. H. Miller & D. R. Keeney (Eds.), *Methods of soil analysis*. Madison, USA: American Society of Agronomy.

Chee-Sanford, J. C., Mackie, R. I., Koike, S., Krapac, I. G., Lin, Y. F., Yannarell, A. C., … Aminov, R. I. (2009). Fate and transport of antibiotic residues and antibiotic resistance genes following land application of manure waste. *Journal of Environmental Quality, 38*(3), 1086–1108. doi: 10.2134/jeq2008.0128

Chen, Y. S., Zhang, H. B., Luo, Y. M., & Song, J. (2012). Occurrence and assessment of veterinary antibiotics in swine manures: a case study in East China. *Chinese Science Bulletin, 57*(6), 606–614. doi: 10.1007/s11434-011-4830-3

Dada, O. A., Togun, A. O., Adediran, J. A., & Nwilene, F. E. (2014). Growth, nutrient uptake efficiency and yield of upland rice as influenced by two

compost types in tropical rainforest- derived savannah transition zone. *Agricultural Science, 5*(05)*,* 383-393. doi: 10.4236/as.2014.55040

Diacono, M., & Montemurro, F. (2010). Long-term effects of organic amendments on soil fertility: A review. *Agronomy and Sustainable Development, 30*, 401–422. doi: 10.1051/agro/2009040

Hossain, M. F., Akhtar, S., & Anwar, M. (2015). Nutritional value and medicinal benefits of pineapple. *International Journal of Nutrition and Food Sciences 4*(1), 84-88. doi: 10.11648/j. ijnfs.20150401.22

Hu, X., Zhou, Q., & Luo, Y. (2010). Occurrence and source analysis of typical veterinary antibiotics in manure, soil, vegetables and groundwater from organic vegetable bases, northern China. *Environmental Pollution, 158*(9), 2992–2998. doi: 10.1016/j.envpol.2010.05.023.

Kabata-Pendias, A., & Pendias, H. (2001). *Trace elements in soils and plants*. Boca Raton, USA: CRC Press.

Kapkiyai, J. J., Karanja, N. K., Qureshi, J. N., Smithson, P. C., & Woomer, P. L. (1999). Soil organic matter and nutrient dynamics in a Kenyan nitisol under long-term fertilizer and organic input management. *Soil Biology and Biochemistry, 31*(13), 1773-1782. doi: 10.1016/ S0038-0717(99)00088-7

Kasa, K., & Yohanis, F. G. (2017). Chemical composition and nutritional effect of pineapple, mango, banana, avocado and orange: A review article. *Chemical and Process Engineering* Research, *54*, 1-6.

Kirchmann, H., & Thorvaldsson, G. (2000). Challenging targets for future agriculture. *European Journal of Agronomy*, *12*(3-4), 145–161. doi: 10.1016/S1161-0301(99)00053-2

Knapp, C. W., Dolfing, J., Ehlert, P. A. I., & Graham, D. W. (2010). Evidence of increasing antibiotic resistance gene abundances in archived soils.

Environmental Science and Technology, *44*(2), 580–587. **doi:** 10.1021/es901221x

Kobierski, M., & Piotrowska, A. (2010). Profile distribution of heavy metals and enzymatic activity in Fluvisols of the Vistula River Valley, Poland. *Fressenius Environmental Bulletin*, *19*(2), 303–311.

Komatsuzaki, M., & Ohta, H. (2007). Soil management practices for sustainable agro-ecosystems. *Sustainability Science, 2*(1), 103-120. doi/10.1007/s11625-006-0014-5

Kumar, K., Gupta, S. C., Baidoo, S. K., Chander, Y., & Rosen, C. J. (2005). Antibiotic uptake by plants from soil fertilized with animal manure. *Journal Environmental Quality*, *34*(6), 2082–2085. doi:10.2134/jeq2005.0026

Lal, R. (2009). Soils and world food security. *Soil and Tillage Research*, *102*, 1–4. doi:10.1016/j. still.2008.08.001

Lemenih, M., Kaltun, E., & Olsson, M. (2006). Assessing soil chemical and physical property responses to deforestation and subsequent cultivation in smallholders farming system in Ethiopia. *Agriculture Ecosystems and Environment, 105*(1-2), 373-386. doi: 10.1016/j. agee.2004.01.046

Lopes, C., Herva, M., Franco-Uria, A., & Roca, E. (2011). Inventory of heavy metal content in organic waste applied as fertilizer in agriculture: evaluating the risk of transfer into the food chain. *Environ Science and Pollution Review*, *18*(6), 918–939. doi: 10.1007/s11356-011-0444-1

Madrid, F., López, R., & Cabrera, F. (2007). Metal accumulation in soil after application of municipal solid waste compost under intensive farming conditions. *Agriculture Ecosystems and Environment*, *119*(3-4), 249–256. doi: 10.1016/j. agee.2006.07.006

Mclean, E. O. (1982). Soil pH and lime requirement. In A. Klute, G. S. Campbell, R. D. Jackson,

M. M. Mortland & D. R. Nielsen (Eds.), *Methods of soil analysis. Part 2. Chemical and microbiological properties* (pp 199-224). Madison, USA: American Society of Agronomy and Soil Science Society of America.

Muller, A., Olesen, J., Davis, J., Smith, L., Dytrtova, K., Gattingr, A., … Niggli, U. (2012). *Reducing global warming and adapting to climate change: The potential of organic agriculture*. Gothenburg, Sweden: University of Gothenburg.

Nicholson, F. A., Smith, S. R., Alloway, B. J., Carlton-Smith, C., & Chambers, B. J. (2003). An inventory of heavy metals inputs to agricultural soils in England and Wales. *Science Total Environment*, *311*(1-3), 205–219. doi: org/10.1016/S0048-9697(03)00139-6

Olowoboko, T. B., Azeez, J. O., Olujimi, O. O., & Babalola, O. A. (2018). Comparative evaluation of animal manures and their ashes on soil pH and electrical conductivity in some Southwestern Nigerian Soils. *Communications in Soil Science and Plant Analysis*, *49*(12), 1442-1454. doi: 10.1080/00103624.2018.1464184

Pandey, J. & Pandey, U. (2009). Accumulation of heavy metals in dietary vegetables and cultivated soil horizon in organic farming system in relation to atmospheric deposition in a seasonally dry tropical region of India. *Environmental Monitoring and Assessment*, *148*(1-4), 61-74. doi: 10.1007/s10661-007-0139-8

Pasquini, M. W., (2006). The use of town refuse ash in urban agriculture around Jos, Nigeria: Health and environmental risks. *Science of The Total Environment*, *15*, *354*(1), 43-59. doi: 10.1016/j.scitotenv.2004.12.025

Rhoades, J. (1982). Cation exchange capacity. In A. L. Page, R. M. Miller & D. R. Keeney. (Eds.), *Methods of soil analysis. Part 2. Chemical and microbiological properties* (pp 149-157). Madison, USA: American Society of Agronomy and Soil Science Society of America.

Sharpley, A. N., & Smith, S. J. (1995). Nitrogen and phosphorus forms in soils receiving manure. *Soil Science*, *159*(4)*, 253-258.

Veeken, A., & Hamelers, B. (2002). Sources of Cd, Cu, Pb and Zn in biowaste. *Science of the Total Environment*, *300*(1-3), 87–98. doi: 10.1016/S0048-9697(01)01103-2

Walkey, A., & Black, I. A. (1934). An estimation of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, *37*(1), 29-38.

Zhou, S. L., Liao, F. Q., Wu, S. H., Zhang, H. F., & Ren, K. (2008). Heavy metals contents in soil profiles of typical agricultural lands in Yixing, Jiangsu Province, China. *Chinese Science Bulletin*, *53*(Supplement 1), 177–187.