Qualitative Assessment of Six-Animal Dungs in University Teaching and Research Farm

*Bada, B. S., Towolawi, A. T., Akinsola, O. E.,
Arowolo, M. N., Odufuye, A. O., Adeleke, O. S. and Oguntade, M. A.
Department of Environmental Management and Toxicology, College of Environmental Resources Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.
*Correspondence email: badabs@funaab.edu.ng

Abstract

Animal dungs constitute environmental nuisance. This made the daily generated dungs of animals (poultry, rabbit, sheep, goat, pig and cattle) from university teaching and research farms to be comparatively studied for essential elements (N, P, K, Zn and Cu) and heavy metals (Cd and Pb) for their qualities. Animal dungs were sampled four times in 1st, 6th and 12th month interval from May 2018 to May 2019, bucked and analysed for N, P, K, Zn, Cu, Cd and Pb using standardized methods. The data obtained were subjected to descriptive and inferential statistics. Level of N was highest: 1.23 ± 0.17 mg/ kg in poultry dungs in the 12th month. Order of levels of P in all the dungs was observed to be rabbit > cattle > sheep > goat > poultry > pig while order of the determined K was poultry > rabbit > cattle > goat > sheep > pig and were significantly ($p < 0.05$) different from the 1st to the 12th month. Level of Zn increased in rabbit, sheep and cattle dungs across the months. Levels (mg/ kg) of Cu: 3.27 ± 1.02 and Pb: 0.53 ± 0.26 were highest in pig dungs in the 1st month. Order of presence of the elements was Zn > Cu > Pb > Cd with no possibility of detrimental effects because of their low contents. Elemental contents of the animal dungs differ with potential for sustainable utilization in quality.

Keywords: Animal dungs, Essential elements, Heavy metals, Detrimental effects, Nigeria

INTRODUCTION

Inappropriate disposal of animal dungs has been with adverse environmental effects (Nicholson *et al.*, 2002). This is distressful and alarming because of the potential for the risks of groundwater pollution (Goody *et al.*, 2001), odour (Pain, 1994), ammonia emissions (Phillips *et al.*, 1997), greenhouse gas emissions and survival of microorganisms (Ostling and Lindgren, 1991). Animal dungs have tendencies to create public health and environmental distresses being the major source of noxious gases, harmful pathogens and odour (Sorathiya *et al.*, 2014). Environmental distresses are evidenced in water body acidification and nitrogen enrichment contributing to eutrophication after the dungs are eroded from deposition or escape from the storage (Roeloffs and Houdijk, 1991). Average incidences of water pollution for 12 years from animal dungs had been computed (Environment Agency, 1999). Amount of the emissions from agriculture that contributes to the human driving forces of climate change had been asserted to be enormous (Steeg and Tibbo, 2012). Nearly 40 % of the emission is from livestock production (McMichael *et al.*, 2007). Aerial pollution which could worsen health risks from breathing route in association with dust, pathogenic, microbial and gaseous causal agents can be attributed to animal dungs (Okoli *et al.*, 2006). Of concern is the nausea which is possibly influenced by animal dungs odour (Chavez *et al.,* 2004).

Handling and care of animals is risky because animal wastes such as dungs harbour pathogens. Serious epidemic disease could loom from mismanagement of animal dungs and get transmitted to humans (Korner *et al.,* 2003). Overfilling of available storage structures can hardly be controlled while corrosion of panel joints due to weakening is common (Sangarapillai *et al.,* 1994). This indicated that poor management of animal dungs is a detrimental and serve as route for spread of diseases. The inherent disease-vectors are liable to contaminate human consumptions or enter their bodies directly through inhalation, skin lesions, and other routes susceptible to their entries (Rachel and David, 2016). The aggregate associated problems of animal dungs show inevitability for diverse management approaches that make dungs feasibly and eco-friendly handling to ensure sustainable use and recycling of the inherent nutrients as mitigation to environmental impacts (Sorathiya *et al.,* 2014).

Feed-mills, supplements, medications and water consumed by the animals determine quality of available nutrients in animal dungs. Animal dungs are advantageously enriched in soil organic matter, which does not only modify soil physico-chemical properties but also release nutrients for a longer period of time than chemical fertilizer. Animal dungs as organic fertilizers have spectrum of high quality nutrients (FAO, 2000). Cheaply availability and the keen for sustainable environment bestow beneficial considerations on animal dungs to be integrated to solve problems of decline in soil productivity. This is as a result of continuous cultivation in sub-Saharan Africa identified as the most important background issues to food insecurity, poverty as well as crop yields that continued to reduce with a huge difference between the envisioned and actual crop yields (Yeboah *et al.,* 2009). If dungs and related-animal waste are properly managed, they can protect soil from chemicals and fertilizers thereby improving soil fertility (Vijay, 2011).

Animal dungs have a potential for organic input sources and could significantly increase soil nitrogen (N) (Asawalam and Onwudike 2011). Organic phosphate mineralization owing to both the harboured microbes and production of organic acids in animal dungs contribute to the soil Phosphorus availability (Virekanandan and Fixen 1990). Prompt mineral-releasing of the organic matter in animal dungs when explored as organic fertilizers to provide nutritive elements (Oehl *et al.,* 2004). However, continuous usage of animal dungs as organic fertilizers may not do without significantly affect quality and productivity of soil when contribute to the availability of essential elements to plants and soil-microbes (Acton and Gregorich, 1995). The dungs can regulate crop production and change soil chemical, physical and biological properties (Belay *et al.,* 2002). Thus, this made the research to assess six different animal dungs being generated in a university teaching and research farm for their quality with respect to both the N, P, K contents and Zn, Cu, Cd and Pb concentrations.

MATERIALS AND METHODS

The study area

Federal University of Agriculture, Abeokuta (FUNAAB), Ogun state is located centrally in Odeda Local Government Area of Ogun State on the latitude 7.1475° N and longitude 3.3619° E.

Temperature of the area varies between 21-32 ^{O}C, and relative humidity ranging from 37–54 % (dry season) to 78 – 85 % (rainy season) (Wikipedia, 2019). The FUNAAB has Directorate of University Farms (DUFARMS) established to oversee and manage the research and training facilities for undergraduate and postgraduate students as well as staff of the University. The DUFARM keeps livestock unit to maintain animals for researches.

Sample collection, preparation and laboratory analyses

Animal dungs were scrapped weekly for four weeks in the first, sixth and twelfth month (May 2018 to May 2019) using rake and packed in labeled polythene bags which were pre-cleaned with distilled water. The labeled polythene bags of various animal dung samples were carried in ice chest to the laboratory of the Department of Environmental Management and Toxicology, FUNAAB for preparation (Bada *et al.,* 2014). The samples were air-dried under shade for seven days, pulverized and sieved through 2 mm mesh for homogeneity (Towolawi *et al.,* 2017). About 1 g of each sample was measured in conical flask and digested with nitric, sulphuric and perchloric acids in ratio 5:1:2 (Nurunnahar *et al.,* 2012). The digested samples were made to the mark in 50 mL plastic containers and transported to the Central Laboratory of the University of Ibadan for the metals analyses using Atomic Absorption Spectrometer (Buck Scientific, Model 210VGP, CT, US). Both nitrogen (N) and phosphorus (P) in the six animal dung samples were also analysed according to the previous methods. The samples were digested using salicylic acid–sulfuric acid–hydrogen peroxide (Ohyama *et al.,* 1991). Soil incubation method as described by Sahrawat (1983) was then adopted for mineralizable N analysis while indophenol method (Cataldo *et al.,* 1974) was used for the total N analysis. Available P was tested by the ascorbic acid method (Murphy and Riley, 1962) and analysed using the method of Truog (1930).The data obtained were subjected to descriptive and inferential statistics.

RESULTS AND DISCUSSION

Levels of NPK in animal dungs

Animal dung derivable from FUNAAB Teaching and Research farm are becoming enormous. Observation from the daily generated animal dung in quantity and quality indicated environmental threats. From the six different animal dung assessed, nearly 71, 36 and 280 kg was quantified from sheep, pig and cattle rearing houses on the farm respectively. These could in turn yield 497, 252 and 1,960 kg weekly from sheep, pig and cattle respectively in quantity (Table 1). Levels of total N (mg/ kg) were detected to be 0.04 ± 00 to 0.79 ± 07, 0.09 ± 05 to 0.74 ± 15, and 0.07 ± 04 to 1.23 ± 17 in the 1st, 6th and 12th month of the research respectively and were significantly ($p < 0.05$) different (Table 2). The presence of N in animal dung samples might be as a result of the presence of organic nitrogen which is usually derived from microorganisms in animal gut, intestinal wall secretions and undigested plant cell components (Catelo *et al.,* 2001), reflecting the digestion efficiency of crude protein (Delaune *et al.,* 2004).

Table 1: Quantity of animal dung generated in kg.

Day	Poultry	Rabbit	Goat	Sheep	Pig	Cow
1	7	5	5	71	36	280
7	50	35	35	497	252	1,960

Nitrogen is a macronutrient needed by plants in large quantity which depends on the plant. Animals take in their nitrogen by eating the plants. Decomposition of plants or animals and the release of waste dungs create ammonia in the soil. The difference in the nitrogen contents of the released waste could be as a result of variation in the type of animal feed ration, amount of litter, bedding or soil included, amount of urine concentrated with the dung and handling methods. Nitrogen is one of the most essential nutrients needed, even though the limits vary, its presence is essential. It is a naturally occurring element found in amino acids that make up proteins. Four forms of N identified in poultry dung to include complex organic N, Labile organic N, Ammonium and Nitrate (Sharpley *et al.,* 2004). N-application of manure (which could be one of the dungs under the research) based on crop Nitrogen requirement is likely to provide more of other nutrients (especially P and K) than is required by the crops (Diaz *et al.*, 2008).

Table 2: Levels of NPK (mg/ kg) across animal dungs categorized by mean and standard deviation.

		N		P		K	
Month	Animal	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1st	Poultry	0.23^{b}	0.15	15.50^{b}	4.80	57.5^{a}	2.92
	Rabbit	0.36^{c}	0.36	175.41^{de}	80.06	163.33^{b}	50.33
	Goat	0.31^{c}	0.38	60.98^{c}	8.72	4583.33^{d}	629.15
	Sheep	0.79^{d}	0.07	72.59^{c}	31.55	5833.33^{e}	629.15
	Pig	0.04^{a}	0.00	1.27^{a}	0.03	9666.67^{f}	577.35
	Cow	0.40^{c}	0.23	118.01^{d}	10.51	3600.00^{c}	264.58
6th	Poultry	0.67^{c}	0.14	18.20^{b}	4.05	57.75^{a}	6.81
	Rabbit	0.59^{b}	0.25	186.93^{de}	71.75	223.33^{b}	15.23
	Goat	0.74^{d}	0.15	68.29^{c}	16.30	3666.67^{c}	629.15
	Sheep	0.66^{c}	0.43	86.95^{c}	31.16	5833.33^{d}	144.34
	Pig	0.09^{a}	0.05	1.25^{a}	0.04	9000.00^{e}	1732.05
	Cow	0.65^{c}	0.32	112.50^{d}	19.92	3400.00^{c}	360.58
12th	Poultry	1.23^{d}	0.17	31.10^{b}	1.99	58.46^{a}	11.70
	Rabbit	0.53^{b}	0.27	133.99^{de}	81.48	233.33^{b}	85.05
	Goat	0.85^{c}	0.12	59.96^{c}	1.02	4000.00^{d}	433.01
	Sheep	0.76^{c}	0.22	67.54^{c}	33.93	6250.00^{e}	661.44
	Pig	0.07^{a}	0.04	1.61^{a}	0.02	8666.67^{f}	2081.67
	Cow	0.55^{b}	0.25	104.40^{d}	10.25	3000.00^{c}	482.18

Mean with the same superscripts down the column were not significantly different ($p < 0.05$).

Available P across the assessed animal dungs was quantified to be least in pig dung and highest in rabbit dung. The quantities of available P (mg/ kg) were observed to be highly ($p < 0.05$) different throughout the months of animal dung assessment. Levels of Phosphorus (P) determined might be linked to its quantity in the diet as an important mineral fortified the feed mill with. Phosphorus is a vital plant nutrient primarily used for growth and repairs of body cells and tissues, and considered one of the most important nutrients for plant growth. Excess P can lead to damages in plants and kidney disease in animals and human beings (Hou *et al.,* 2012). It is used as fertilizer either commercially available in the form of manure, or plays a key role in the growth of livestock. Animal dung is one of the sources of phosphorus, where the concentration may vary with age of livestock, diet and bedding type, livestock species.

High levels of phosphorus observed in the assessed animal dungs could be as a result of the variability of feed, rearing technologies and feeding practice (Hussein and Sawan, 2010). Phosphorus in poultry dung is about two-third as solid–phase organic P and one-third as inorganic P. Inorganic Phosphate species in poultry dung for an example include Dibasic Calcium Phosphate, Amorphous Calcium Phosphate and weakly bound water-soluble Phosphorus (Sharpley *et al.*, 2004). Phosphorus occurs in animal dung in a combination of inorganic and organic forms, 45 to 70 % of manure P is inorganic while the rest of constitute organic P. Essentially, all inorganic P is in the orthophosphate form, which is the form taken up by growing plants and much of the organic Phosphorus is easily decomposable by soil microorganisms to the inorganic form. Factors such as temperature, soil moisture, and soil pH affect P mineralization rate. P-manure, like other nutrients, is normally not uniform even in the same storage facility as dictated by various factors that are not limited to the amount of bedding, the amount of moisture entering the system, and how the manure is handled and stored (Moore *et al.,* 2006).

Potassium quantity was significantly ($p < 0.05$) least (57.50 ± 2.92 to 58.46 ± 11.70 mg/ kg) in Poultry while highest (8666.67 ± 2081.67 to 9666.67 ± 577.35 mg/ kg) in Pig (Table 2). Levels of the obtained K in dungs of the various assessed animal under the study might be linked to factors that include rations of feed, type of bedding materials and amount of water used by animals. Some dried fruits like prunes, raisins, dates, potatoes, mushrooms and peas that are sometimes fed to animals have high K-content and can be as a reason for its presence in the dung of animal under research (Othman *et al.,* 2013). Potassium functions as a regulator of metabolic activities and is the only nutrient which remains in the plant fluids in a soluble state, and is highly mobile in the soil but its leaching is minimized by cation exchange and trapping within clay crystals. Potassium which is required for numerous plant growths is not only increasing crop yield and improving quality but also contribute to enzyme activation, photosynthesis, protein synthesis and starch synthesis (Osorio, 2005).

Availability of N, P and K was not directly related to one another unless the pool of generated animal dung is considered for beneficially sustainable utilization to meet the required quality; pig dung had the least N-quantity but highest K-quantity. Prospective utilization of these animal dungs as soil amendments except poultry and rabbit dung would directly introduce high quantities of K. Pig dung was identified as the least source of N and P, but main K-source. Pig dung could thus be a source of K in amendment formulations. This indicated that animal dung is a source of high yielding and sources of NPK in quality, which if not explored could elicit residual effects on the spheres of the environment in quantity. Both N and P have tendency to facilitate cell division in all the important growth parameters, and amplify N nutrition to increase photosynthetic capacity of the crop resulting in more assimilates being apportioned into different parts of the growing plant for proper developments (Kling and Edmeades, 1997). Both P and K on a dry matter basis (or the concentrations of P_2O_5 and K_2O) could be varied significantly by the dungs moisture contents (Clemson, 2019). Exploration of poultry and cattle dungs as organic fertilizers had been observed not to only considerably increase soil cation exchange capacity and bases saturation contents but also indicate substantial effect on the soil edaphic factors (Bakayoko *et al.,* 2009).

Levels of metals in animal dungs

Considering associated heavy metals to explore beneficial quality of the generated animal dung for sustainable utilization, levels of the four metals assessed indicated that Zn was highly available (3.00 to 5.5 mg/ kg) in rabbit, goat and sheep dungs while highest quantity (> 1.00 mg/ kg) of Cu was observed in pig throughout the periods of animal dungs' assessment (figure 1). Poultry dung had the least quantity of Zn, followed by pig dung. The order of metal bio-availability for possible bioaccumulation was Zn > Cu > Pb > Cd. There was inference that rabbit, relatively followed by poultry dung could best be explored for sustainable utilization unlike other animal dungs. The detected values of Cd contents across the animal dungs could have resulted from variations in feed content, water consumed and activities carried out around the location of the piggery unit. Levels of the Cd in most of the cattle dung were lower than values penned by Iwegbue *et al.*, (2013) but agreed with the findings of Njoku and Ayoka (2007).

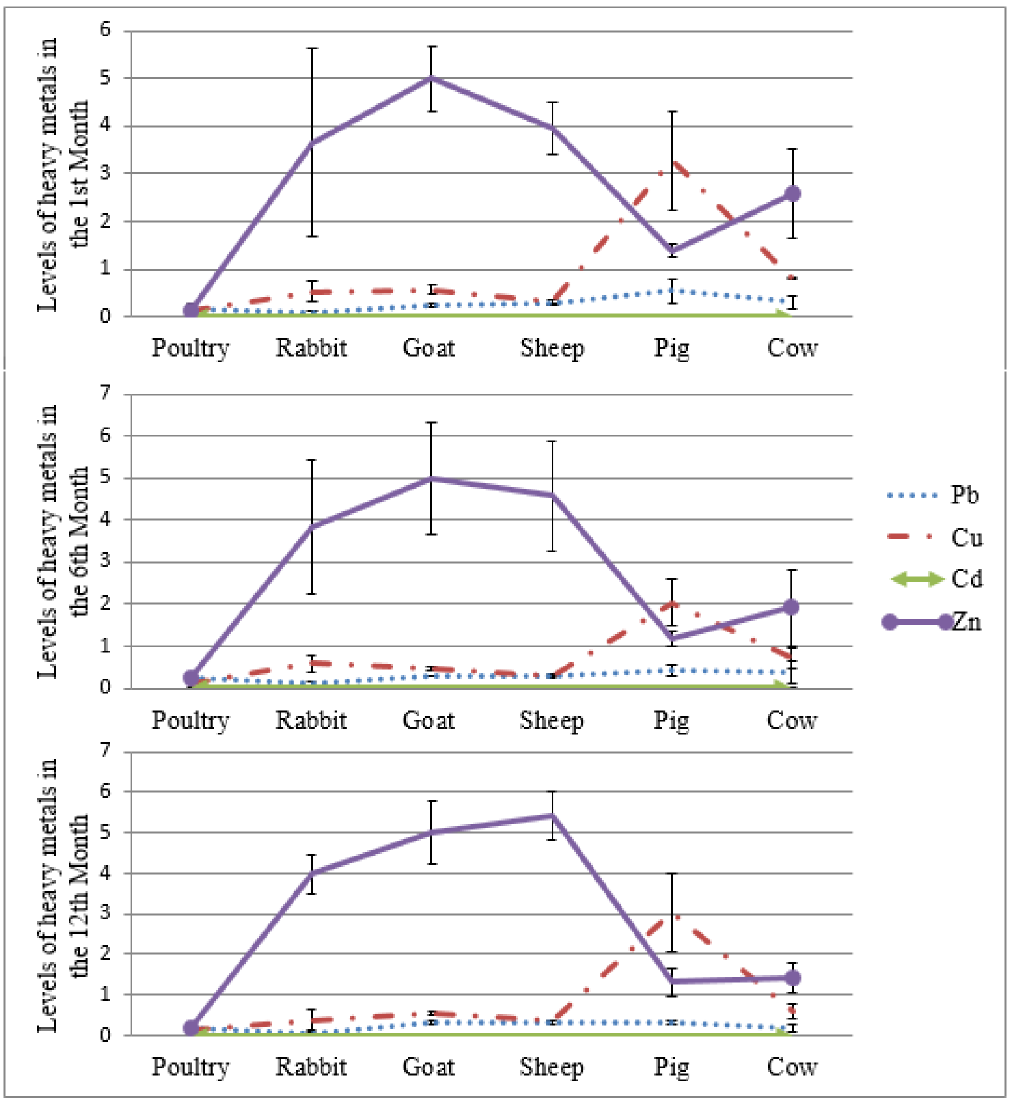

Figure 1: Levels (mg/ kg) of heavy metals across the sampling periods and animal dungs. Top panel: 1st month, middle panel: 6th month and bottom panel: 12th month.

Applications of cattle and poultry dungs as manures represent an important source of Cd to arable soils (Powers and Dick, 2000). Though land application of manure is conventionally based on N- and P- requirements, Cd is typically added via atmospheric deposition or P-fertilizer, and a non-essential element classified as an extremely toxic metal even at low concentrations. Cadmium has a long biological half-life of about 30 years in human, elicits damage to the proximal tubules of nephron, and leads to leakages of low molecular weight proteins and some essential ions like Ca into urine with progression over time to kidney failure (Dawaki *et al.*, 2013).

Low levels of Cu in the assessed dungs except in pig dung might be linked to the feed Cu content owing to feed types as some feeds contain Cu in an amount that is beneficial to the animal for proper growth. Copper is an essential mineral for livestock diets and added to concentrate feeds as well as availability in the farm surroundings; this could denote that there was no exposure of the 6-assessed animal to Cu-sources: burning of metallic objects from cars or electrical wirings (Conway and Pretty, 1991). Feeding ingredients are formulated and fortified with trace elements in earlier nutrition to prevent deficiencies, diseases, improve weight gains and feed conversion as well as increase egg production to meet up with the intensity of production. Essential elements participate in a wide range of enzymatic processes for many aspects of physiological functions and intermediary metabolism of the organism to act as catalyst or co-factor in enzyme systems with their role ranging from relatively weak, non-specific ion effects (metal ion activated enzymes) to highly specific association (metallo- enzymes) whereby the metal could firmly be attached to the protein in a fixed number of atoms per molecule.

Copper occurs generally in the soil, sediments and air, and partakes in plant growth necessary for many enzymes that aid normal growth and development, though high concentration of Cu is sufficient to elicit metal fumes fever, air and skin discoloration, dermatitis and respiratory tract diseases (Lopez *et al.*, 2000). Only 5 to 15 mg/ kg of metal additive is absorbed by animals while the rest is excreted. Soils on which pig and poultry manures are continuously applied at high rates accumulate heavy metals jeopardizing the optimal functioning of the soil, contaminating crops and posing human health risk. Addition of trace elements to feed mill does not only serve as a supplement to improve health and feed efficiency but also as essential nutrients (Miller and Semmens, 2002; Burel and Valat, 2009).

Levels of Pb were observed to be relatively low across the assessed animal dungs. Lead is a non-essential heavy metal that causes oxidative stress and contributes to the pathogenesis of Pb poisoning by disrupting the delicate antioxidant of mammalian cells. Detection of P in animal dung had previously been reported: Bhat and Krishnamachari (1980) reported 4.7 to 38 mg/ kg Pb in cattle dung samples; Sidhu *et al.* (1994) reported 48.7 to 146.1 mg/ kg Pb in the dung of ruminants; and Gowda *et al.* (2003) reported 0.55 mg/ kg Pb in dairy cattle dung samples in the industrial areas and was higher than the values in the samples from the control areas. High Pb-content in the 1st month assessed pig dung could be traced to activities such as exhaust from both mobile and stationary equipment in the farming area where the piggery unit was located.

Concentration of Pb-content greater than 1.0 mg/ kg was being used as an indication of a local source of pollution, the low Pb-concentration observed might not only be as a result of less industrial and domestic activities within the cattle pen but could also be due to gradual decrease from the metal leaching out of the assessed waste dung (Ayodele and Modupe, 2008). High level accumulation of Pb in the body could elicit anaemia, headache, brain damage and central nervous system disorder (Sharma *et al.,* 2014).

High Zn-levels may be a result of the presence of its dietary contents; Zn-supplementation has various beneficial effects on body functions that include acid-base balance, nutrient metabolism and immunity protection (Banerjee, 1988). Zinc acts as activator for many enzymes and hormones; as a basic component of number of diverse enzymes, Zn plays key roles in structural, regulatory and catalytic functions (Riordan and Vallee, 1976); crucial roles of Zn include DNA synthesis, normal growth, brain development, bone formation and wound healing, though elicits neurotoxin in high level (Al-Trabulsy *et al.,* 2013).

Cadmium and Zn are strongly bound to organic matter and land application of organic matter–rich poultry manure is likely to result in their soil accumulation (Schomberg *et al.,* 2009). Though over supplementation of animal feeds with Cu and Zn hardly have direct environmental effects, it is potential to elicit phytotoxic via bioaccumulation if generated dungs from such animal is applied as manure (Alva *et al.,* 2000; Novak *et al.,* 2008). The observed high concentrations could have been from the presence of additives (such as zinc dithiophosphates) with metals in various proposition in the ration fed or consumed by the cattle (Akpoveta *et al.,* 2010). Levels of Zn obtained in this study were similar to the report of Eddy *et al.* (2006), but were relatively higher than level obtained elsewhere (Jung, 2008; Qishlaqi *et al.,* 2009; Al-Trabulsy *et al.,* 2013; Iwegbue *et al.,* 2013). Increased Zn-level may elicit many health disorders with well documented health implications.

Possible implication of amendments containing high Zn-levels includes interruption of microorganisms and earthworms activity thereby retarding breakdown of organic matter (Ubwa *et al.,* 2013). Presence of heavy metals in Pig dung had been attributed to metal-dietary contents. This could have resulted from the technologies used, the water given to the pigs, the type of and variation in feed because some feeds contain Zn in an amount that is beneficial for proper growth (Godfrey *et al.,* 2014).

CONCLUSION AND RECOMMENDATIONS

Exploration of the six assessed animal except poultry and rabbit dungs as amendments would directly introduce high quantities of K. Pig dung was identified as the least sources of N and P, but main K-source, followed by poultry dung, which had the least quantity of Zn. The order of metal bio-availability for prospective bioaccumulation was Zn > Cu > Pb > Cd.

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