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Risk of Heavy Metals from Using Broiler Litter as an Alternative Animal Feedstuff or Organic Fertilizer

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ABSTRACT

Potential risk of heavy metal residues in poultry litter is considered as one of the environmental concerns of litter applications on agricultural land or as animal feedstuff. Therefore, a total of 136 litter samples were collected from broiler farms and examined for the presence of cadmium (Cd), lead (Pb), aluminum (Al) and nickel (Ni) using ZEEnit 700P Atomic Absorption Spectrophotometer with Graphite Furness. The results showed that all litter samples contained notable concentrations of the analyzed metals and their order was Ni > Al > Pb > Cd. Standard limit for heavy metals in litter differs greatly if it is applied to pasture or as feed for animals. It was found that Pb content in litter was 8-10 times as FAO limit when used as fish feed. Meanwhile, Pb level was higher than the European Communities standard in 24% of litter samples when used as complete feedstuff for animals. However, Pb level was much lower than the Spanish legislation for fertilizers. Additionally, Al, Ni and Cd content did not exceed the legally permitted guideline limits when used as feedstuff or fertilizer. It was concluded that, poultry litter contained high Pb level, which may accumulate in the body and can pose health risk when used as an alternative feedstuff for fish and animals.

Introduction

The poultry industry is one of the largest and fastest growing agro-based industries in the world. In Egypt, poultry meat is the most important source of animal protein for the majority of Egyptians representing over 45% of total animal protein consumption (Taha, 2003). The livestock population statistics in Egypt indicate that poultry are the most prolific species of farm animal and the number of birds increased substantially with an annual growth rate of around 9 % (Al Azzouny, 2014). In 2005, poultry production was amounted to be about 459 million birds.

The recycling of large quantities of poultry litter generated as byproducts should be hygienically and economically feasible approach in intensive poultry production. Poultry litter is a mixture of bedding material, manure, feathers and spilled feed that accumulates from the production of each flock of birds. Most broiler production operations generate between 1.1 and 1.5 tonnes of litter per 1000 birds (UACES, 2002). A major problem facing the poultry industry is the large-scale accumulation of wastes, including manure and litter, which may cause problems unless environmentally and economically sustainable management technologies are evolved. The fact that poultry manure contains many feed components that pass through the diges-

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tive tract without being digested and numerous by-products from metabolism, such as non-protein nitrogen, suggests that it should have nutritional value if recycled through other animals, including poultry (Bell and Weaver, 2002). According to Infonet-Biovision (2010), the average composition of chicken litter; dry matter %, nitrogen, phosphorus, potassium and calcium are 50, 1-2, 2, 1 and 3, respectively. In recent years, poultry manure has been used, directly or after transformation by chemical (acidification) or physical (heating) processes, in feed formulations for fish or animal feed (Rankins *et al*., 1993; Bagley *et al*., 1996). In addition, land application of poultry litter to pastures is the predominant form of litter disposal in many broiler production regions after composting or anaerobic digestion. The third alternative disposal route is direct combustion of poultry litter with the potential to provide for both space heating of poultry house and large-scale schemes involving power generation or combined heat and power. The later consider environmentally acceptable, disposal routes, with potential financial benefits (Kelleher *et al*., 2002).

Egypt is currently expanding its domestic livestock sectors to meet rising demands for consumption to face the chronic shortages of feedstuffs. Meanwhile, feed production contends with limited amounts of suitable pasture- land, arable land, and water. Moreover, Egypt relies likely on imports for nearly all of its soybeans and 48 percent of its corn requirements (Taha, 2003). As one of the principal constraints for the development of the poultry industry in Egypt relates to feed resources and aspects of feed, which contribute, to poor Feed Conversion Ratio (FCR). Feed costs usually represent 70-75 percent of the economic inputs in the Egyptian poultry industry (Hosny, 2006). Therefore, there will be a great need to replace expensive ingredients with other feed resources that is available with relatively low price and huge amounts. Furthermore, in the conventional fish culture system, fish feed and fertilizer play the key role in fish production. In most cases, farmers cannot afford to purchase feed and fertilizer round the year. As a result, improper feed and fertilizer management do not contribute to achieve the target production. But these feed and fertilizer could easily be supplemented by poultry droppings (Alam *et al*., 2009).

Total chemical fertilizer consumption was estimated at 170.7 million tons in 2010 with a successive increase of 2.0% per year (FAO, 2011). Chemical fertilizer use in Egypt has increased significantly since the construction of the Aswan High Dam in 1968. According to FAO (2009) chemical fertilizer used per hectare in Egypt is 624.8 kg/ha/year. The consecutive use of fertilizers disturbs the equilibrium of agro-systems and pollutes the environment. Over application of chemical fertilizers can result in negative effects such as leaching, pollution of water resources, destruction of micro-organism, crop susceptibility to diseases attack, acidification or alkalization of the soil or reduction in soil fertility (Anonymous, 2009). Bremner (1996) reported the adverse effects of urea fertilizers on seed germination and seedling growth in soil that are due to NH_3 produced through hydrolysis of urea by soil urease. In addition, toxic concentrations of nitrogen fertilizers cause characteristic symptoms of nitrite or nitrate toxicity in plants, particularly in the leaves. Furthermore, the dry matter reduced under application of chemical fertilizer because injured roots (Rahmani *et al*., 2011). Nitrate is relatively non-toxic, but its metabolites and reaction products e.g., nitrite, nitric oxide and N-nitroso compounds, have raised concern because of the implications for adverse health effects such as methaemoglobinaemia and carcinogenesis (EFSA, 2008).

The majority of nitrogenous fertilizers aren't absorbed products and they interfere with both underground and surface water. About 12.7% to 25.4% of applied N was remained in the soil (Han *et al*., 2003). It reaches the depth of soil and converted to nitrate through nitrification by microorganisms then nitrate can reach ground water. Also the amount of phosphate may increase in drinking water and rivers as a result of high levels of fertilizer use. Shamrukh *et al*. (2001) reported the contamination of ground water at shallow depths (30 m) due to the high rate of chemical fertilizer applications and the use of hand pumps, in zones close to croplands (15 m depth) must be avoided.

In addition to plant macronutrients, poultry litter also contains notable amounts of heavy metals like copper (Cu), cadmium (Cd), lead (Pb), manganese (Mn), iron (Fe), selenium (Se), zinc (Zn) and arsenic (As) (Kunkle *et al*., 1981; Kpomblekou-A *et al*., 2002). The application of poultry litter for soil leads to accumulation of these metals in soil and plants. Residues of heavy metals in manures can be accumulated in surface soils as a result of long-term agricultural use (He *et al*., 2009; Shi *et al*., 2011) and promote metal migration through leaching and runoff (Azeez *et al*., 2009; Wang *et al*., 2011). According to Maule *et al*. (2007) and Indrajit *et al*. (2011) feeds contain significant concentrations of contaminants including heavy metals; many of which can bio-accumulate and bio-concentrate in the body. Toxicity with heavy metals is due to their ability to disrupt the function of essential biological molecules such as protein, enzymes and DNA, as well as, displacement of certain metals essential for cell which proven to be carcinogenic to animals and humans. In addition, digestive, renal, nervous, endocrine, reproductive and respiratory system defect were also, confirmed as a result of heavy metal exposure (NIEHS, 2009). In Egypt, environmental problems of using chemical fertilizers as well as high cost of animal feedstuff have a negative impact on expanding plant and animal production. However, poultry litter can play an important role in solving those problems; the potential risks of heavy metal residues should be monitored. The potential health risks of heavy metals for the Egyptian population through consumption of poultry edibles have been estimated by many studies (Ismail and Abolghait, 2013; Mahmoud and Abdel-Mohsein 2015), however, there is limited available data about the metal levels in poultry litter. Therefore, the aim of this study was to evaluate the hygienic quality of broiler litter concerning its heavy metal contents before its use as a feedstuff for animals or fertilizer.

Materials and methods

Sample collection and preparation

A total of 136 litter samples were collected from broiler poultry farms; forty samples and ninety six samples from farms using sawdust and wheat straw as a bedding material, respectively. Litter samples were collected as recommended by Peters *et al*. (2003). Eight to ten samples from throughout the house to the depth of the litter were collected. Approximately 500 g of poultry litter samples were collected with a clean spoon and placed in poly bag and marked with permanent marker pen and then the samples were kept at -20 °C until analysis.

Before digestion to analyze heavy metals, each litter sample was dried at 65 °C until reach a constant weight. Samples were homogenized and grinded to a powder. Nitric acid digestion was done according to the method of Hseu (2004). All laboratory equipments and containers were washed with 10% HNO_3 solution prior to each use. One gram of dried sample was placed in a 250 ml digestion tube and 10 ml of concentrated HNO3 (68%) (Merck KGaA, 64271 Darmstadt, Germany) was added. The sample was heated for 45 min at 90°C, and then the temperature was increased to 150 °C at which the sample was boiled for at least 8 h until a clear solution was obtained. Concentrated HNO_3 was added to the sample (5 ml was added at least three times) and digestion occurred until the volume was reduced to about 1 ml. The interior walls of the tube were washed down with a little distilled water and the tube was swirled throughout the digestion to keep the wall clean and prevent the loss of the sample. After cooling, 5 ml of 1% HNO3 was added to the sample. The solution was filtered with Whatman No. 42 filter paper. It was then transferred to a 25 ml volumetric flask and made up to mark with deionized water.

Analysis of heavy metals and quality control

Metal analysis (Cd, Pb, Al and Ni) was carried out in the Central Laboratory of the Faculty of Veterinary Medicine, Assiut University, Egypt using a ZEEnit 700P Atomic Absorption Spectrophotometer with Graphite Furness Unite (AASG).

Aqueous standard stock solutions were prepared for Pb, Al, Cd and Ni using appropriate salts. Four working standards were prepared in triplicate for each metal by serial dilution of the stock solution. These standards and blank solution were aspirated into AASG as described by the manufacturers to obtain the absorbance of each of the samples and standard solutions for each of the metals. A calibration curve for the absorbance versus concentration of the standard metal concentrations was prepared for each metal from which calibration graph for each of the metals in the sample was determined as described by Nnaji *et al*. (2007). The metal concentrations of the litter samples were determined from these calibration graphs.

The digestion method and the atomic AASG analysis were validated by preparation of a multi-element standard solution containing 1000 mg/ l of each metal. One gram of randomly selected litter sample powder was spiked with four different concentrations 1, 5, 25 and 50 ppb of each heavy metal, and each adjusted to run in triplicate. This was followed by the digestion of the spiked samples and determination of metal concentration using AASG. Unspiked samples (considered as blank) were carried through the whole procedure described above. The amount of spiked metal recovered after the digestion of the spiked samples was used to calculate percentage recovery, which was ranged from 80-98% for Cd and Ni and 95-125% for Pb and Al. Blank samples were run in duplicate in each analysis batch in a randomized order and were used to calculate the method detection limit (MDL). Heavy metal concentrations were determined and given as µg/g dry weight (µg/g d wt).

Statistical analysis

The obtained data was statistically analyzed using IBM SPSS version 19. A one- way analysis of variance (ANOVA) was performed. Differences in mean values were accepted as being statistically significant if $P < 0.05$. When the effect was significant ($P<0.05$), means were separated using Tukey's test. The statistical significance of the correlation was reported at both $P \leq 0.01$ and $P \leq 0.05$levels.

Results

Heavy metals were estimated in poultry litter collected from broiler poultry farms with sawdust and straw bedding. The levels of Ni, Al, Pb and Cd in poultry litter were summarized in Fig.1. It was clear that there were highly significant differences ($P<0.01$) between the contents of the analyzed metals in the litter samples. On a dry matter basis the mean values of Ni, Al, Pb and Cd collected from different farms regardless the type of bedding material were 19.5±0.5, 7.4±2.5, 3.9± 1.5 and 0.2±0.5 µg/g dwt, respectively. It was clear that Ni had the highest content ($p \leq 0.001$) in the examined litter, while the lowest value was recorded for Cd.

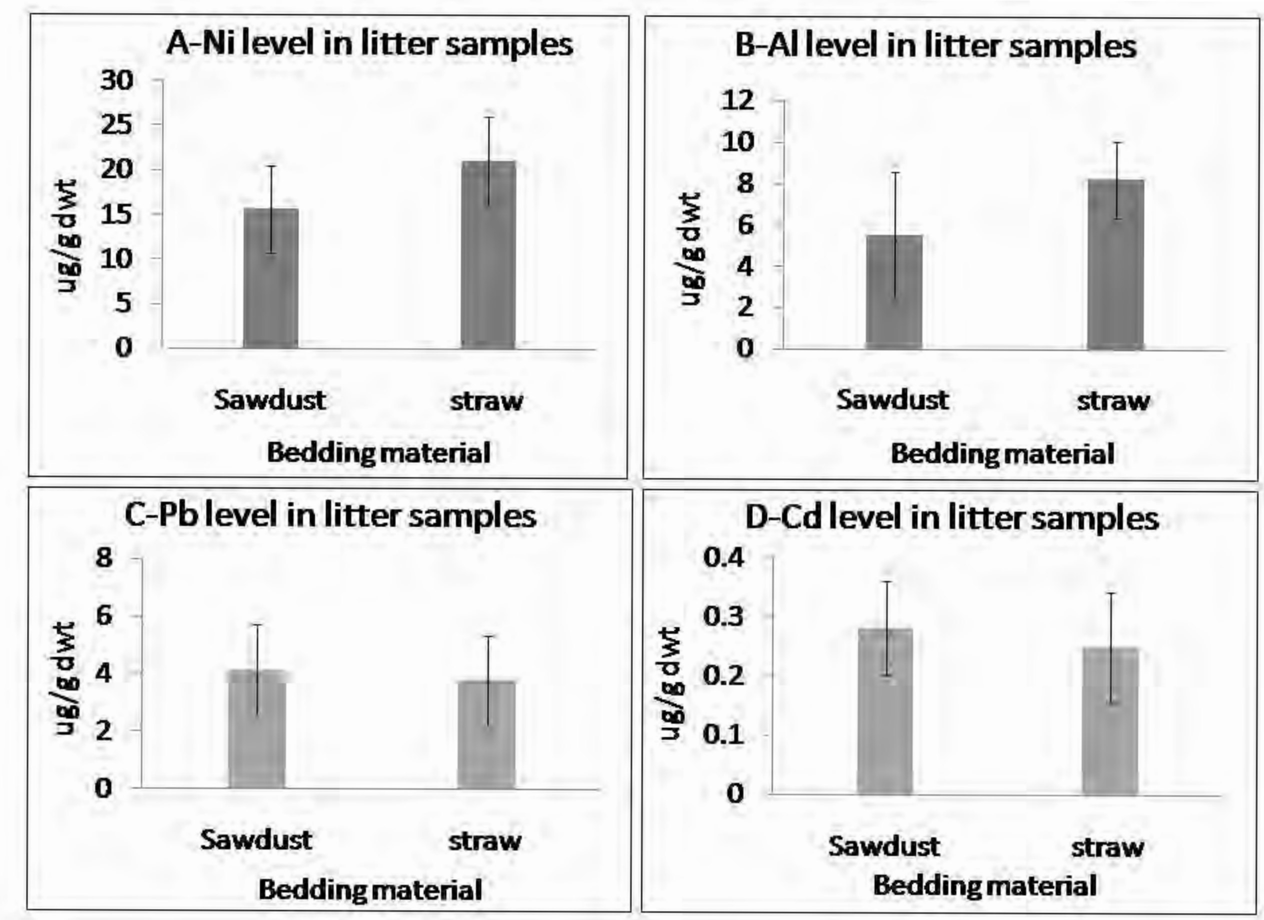

Fig. 1. Mean concentrations of heavy metals (Cd, Pb, Al and Ni) expressed as µg/gm dry weight (µg/g d wt) from broiler farms with sawdust or straw bedding material.
Means with different letters are significantly different (P<0.05).
The obtained heavy metals levels in poultry litter were compared with the fish feed limit (FAO, 1983), ruminant feed limit (EC, 2002) and organic fertilizer limit (BOE. 1998; WSDA, 2009).

Ni and Al showed a significant increase in straw litter compared with sawdust one. The Ni content in straw litter was the highest ($P \leq 0.001$) with a mean value of 21.1 µg/g dwt, followed by Al (8.2 µg/g dwt). Pb and Cd levels were however statistically similar in litter either with straw or sawdust. Pb levels were 3.8 and 4.1 µg/g dwt in straw and sawdust litter, respectively. Cd content in straw litter (0.25 µg/g dwt) was significantly similar to that of the sawdust litter (0.28 µg/g dwt), which had the lowest value among the analyzed metals.

Discussion

Metal concentration may differ according to manure or bedding type (sawdust and straw). Ritz *et al*. (2005) and Kunkle *et al*. (1981) reported wide variations in poultry litter nutrient contents; they concluded that storage and handling or management resulted in the nutrient variation. In addition, the heavy metal contents of animal manures are largely a reflection of their content in the feeds consumed and the efficiency of feed conversion by the animals (Zhang *et al*., 2012).

Nickel was the highest metals content in the examined poultry litter. According to reports of Kpomblekou-A *et al*. (2002); Brye and Pirani (2006) and Jaja *et al*. (2013), in the USA, Jeon *et al*. (2013) in Korea, Lo´pez-Mosquera *et al*. (2008) in Spain and Long *et al*. (2004) in China, the mean Ni level in this study was much higher than these results.

Mean concentration of Al was higher than 1.4 mg/kg that reported by Kpomblekou-A *et al*. (2002) in Alabama (USA) and much lower than 267 mg/kg, which reported by Brye and Pirani (2006) for poultry litter in Arkansas (USA).

Lead content in the examined litter was comparable with its content in litter identified by Kunkle *et al*. (1981) and lower than 9.2 mg/kg obtained by Jaja *et al*. (2013) from Alabama (USA). Our results were in disagreement with studies obtained by Jeon *et al*. (2013) from Korea, Lo´pez-Mosquera *et al*. (2008) from Spain and Kpomblekou-A *et al*. (2002) from Alabama (USA) who could not detect Pb from poultry litter.

Compared with our study, higher Cd content was recorded from litter in Spain (1.5 mg/kg) by Lo´pez-Mosquera *et al*. (2008), USA (0.6 mg/kg) by Brye and Pirani (2006) and China (1.8 mg/kg) by Long *et al*. (2004).

The digestive tract of a chicken is very short, only six times its body length. Therefore, some of the eaten foodstuffs are excreted by the chicken before being fully digested (Adewumi *et al*., 2011). Research has shown that about 80% (dry weight) of feedstuff is utilized and digested by the poultry. Furthermore, while picking the feedstuffs, the chicken scatters 10% of their food on litter (Tuleun, 1992). Therefore, as poultry feed contain heavy metals; manure could be polluted with metal proportion to its value in feed. This was supported by Zhang *et al*. (2012), who reported that the heavy metal contents of animal manures are largely a reflection of their content in the feed consumed and the efficiency of feed conversion by the animals. Experiment of Jiang *et al*. (2011) concluded that only a small amount of added metals in feed is absorbed, most of metals are in feces. Pb, Cd Cr, As and Hg concentrations in poultry litter and livestock manures were higher than that in feeds. Manure included as 1-3 and 2-4 times higher Pb and Cd as in feed, respectively (Zhang *et al*., 2012). Some other elements, including Ni was also found to accumulate in poultry manure obviously (Long *et al*., 2004). Metal content in litter is related to the metal in both manure and bedding material used in the farm, which confirmed by the study of Jeon *et al*. (2013) that identified higher concentrations of trace elements in the final litter than that of the rice hulls.

Risk of poultry litter used as fish feed

Recently, fish farms especially in the integrated farming system have been encouraged to recycle wastes from animal dung (especially poultry) as food for fish (Obasa *et al*., 2009). Chicken manure when added into a pond, undergoes microbial decomposition releasing nutrients for the growth of microscopic green plants (algae or phytoplankton) which is the base of the trophic level (food chain) in aquatic systems (Aquaculture South Africa, 1999). Phytoplankton are eaten by zooplankton (microscopic animals) while zooplankton serves as food for small fish and aquatic insects. Research verified that poultry manure is not only used as organic manure in the production of plankton, but also directly consumed by fish in the culture system (Gavina, 1994; Ugwumba and Abumoye, 1998). Advantages of poultry manure/ litter have been addressed by many researchers. EI-Ebiary (1998) reported that poultry manure ponds with supplementary feeding possessed the highest growth performance and production parameters as well as survival rate compared with those using supplementary feeding with or without cow manure. The superior growth and nutrient utilization resulting from the use of dried poultry manure in place of soybean meal has economic significance considering that the latter has become expensive (Obasa *et al*., 2009). This is important in aquaculture particularly as the cost of fish feed currently accounts for 40% to 70% of the variable costs of fish farming ventures (Gallagher, 1994).

Compared with FAO (1983) standard of lead (0.5 mg/kg) and cadmium (0.5 mg/kg) in fish feed, Pb was as 8-10 times as the standard limit. However, Cd did not exceed the allowance value in any examined litter samples. Lead causes decreases in survival, growth rates development, behavior, learning, and metabolism, as well as increased mucus formation in fish (Eisler, 1988). Ekpo *et al*. (2008) reported that lead is known to cause the disease called plumbism and it is also known to damage the brain, the central nervous system, kidneys, liver and the reproductive system. According to Maule *et al*. (2007) and Indrajit *et al*. (2011) feeds contain significant concentrations of contaminants including heavy metals; many of which can bio-accumulate and bio-concentrate in fish. In addition, concerns have been raised about food safety from using poultry litter as feed in fish farms. Knud-Hansen *et al*. (1993) indicated that chicken manure is neither a preferred source of particulate organic matter for Nile tilapia, nor an economically wise choice of fertilizer to provide nitrogen (N) and phosphorus (P) for production of natural foods.

Contamination of fish feeds will greatly affect both the fish and the vulnerable population that depends on it as a source of proteins and as a staple food (Anhwange *et al*., 2012). So, it is suggested that much attention should be paid from Pb toxicity, when use poultry litter as feed in fish farms.

Risk of poultry litter used as ruminant feed supplement

Poultry litter has been used as a very safe source of protein, mineral and energy for cattle, goat and sheep (Abdel-Baset and Abbas, 2010; Adegbola *et al*., 2010). Uric acid which is a major content of poultry waste can be utilized by rumen microbes for protein production (Abdel-Baset and Abbas, 2010). Also, poultry litter is high in urea, a source of nitrogen, which improves the rumen environment making feed more efficiently utilized and the animal better nourished with whatever feed that is made available (Anonymous, 2006; Adegbola *et al*., 2010). In addition to nutritional benefits, poultry litter reduces production costs (Jackson *et al*., 2006). For example, poultry manure has been reported to be best economically used in the ruminant feeding as a forage substitute during drought and when there is forage shortage (Chauhan 1993; Anonymous, 2006). Additionally, feed costs were lower for cows fed diets supplemented with poultry manure than for those fed diets supplemented with soybean meal (Rossi *et al*., 1999).

Pb and Cd concentrations in feed are limited to 5 and 0.5-1 mg/kg (according to animal species) in European Communities (EC) standard, respectively (EC, 2002). It was found that 24% of litter samples were higher than the EC standard for Pb when used as complete feedstuff for animals. However, Cd concentration was satisfied with the EC requirements. High Pb content in litter suggested possible health hazard from feeding poultry litter to animals. Toxicity from heavy metal pollution resulted from poultry manure/ litter utilization as animal feed could not be identified in vivo studies. Heavy metals have not been found to be sufficiently high in poultry litter to present a problem (Westing *et al*., 1985). The metals did not accumulate in fattening cattle fed broiler litter. Feeding a diet containing dried poultry waste to dairy cows did not significantly affect cadmium, copper, lead and zinc in milk (Bruhn *et al*., 1977). However, according to Fontenot and Webb (1975) cadmium in liver, kidney, muscle and fat of lambs was related to dietary levels. Feeding 15 to 60 ppm cadmium lowered performance in lambs, but 5 ppm had no effect (Mills and Dalgarno, 1972; Doyle *et al*., 1974). High concentrations of dietary cadmium have been shown to be antagonistic to copper, iron, selenium and zinc metabolism in both animals and humans, (Abdulla and Chmielnicka, 1990). Moreover, increasing the level of dietary cadmium from 0.7 to 12.3 ppm resulted in decreased levels of liver copper of sheep (Mills and Dalgamo, 1972).

Risk of poultry litter used as organic fertilizer

Excessive application of chemical fertilizer in agricultural soil caused serious environmental problems, deterioration of soil physical structures and nutrients unbalance of soil and water eutrophication (Arroyo *et al*., 2014). Livestock and poultry manure can be an alternative source of fertilizer in organic farming, where the use of anthropogenic chemicals is prohibited (Wong *et al*., 1999). The large quantities of animal waste generated as byproducts of intensive animal production are reused by application to agricultural land (Ihnat and Fernandes, 1996). The utilization of poultry manure as an organic fertilizer is essential for improving soil productivity and crop production (Cooperband *et al*., 2002, Dikinya and Mufwanzala, 2010). Application of poultry litter to pasture provide beneficial plant nutrients including nitrogen (N) and phosphorus (P) (Stephenson *et al*., 1990).

The permitted values for Cd, Pb and Ni under current Spanish legislation for fertilizers (BOE, 1998) were 3, 150 and 120 mg/kg, respectively. However, for raw, composted, and processed manure used as fertilizer under the WSDA International Organic Program their limits were 10, 150 and 210 mg/kg, respectively (WSDA, 2009). It can be observed that heavy metal contents in the examined poultry litter were much lower than the legally permitted maximum values for organic fertilizers. Litter generated from the examined broiler houses had low heavy metal content, which satisfies the legal standards and consequently suggested not to pose environmental threat when it is applied to pastures.

Although, the wastes possess substantial nutritional value, it must be handled in a manner which will cause minimum risk to human health and comfort (Fontenot and Webb, 1975). Composting is a controlled decomposing natural breakdown process of organic material that render poultry litter unable to damage crops and surface water (Anne, 2007; Musa *et al*., 2012). The danger lies in accumulation of manure borne metals, since they are not biodegradable and eventually become phytotoxic (Bolan *et al*., 2004). Such accumulation of heavy metals in composts has the potential of restricting soil functions, contaminating the food chain, and causing toxicity to plants, animals and humans (He *et al*., 2005; Guerra-Rodrı´guez *et al*., 2006). Long-term application of livestock and poultry manures for soil leads to accumulation of elements in soil and plants and arise significant migration in soil with depth (Jiang *et al*., 2011). The fate and transport of trace elements from poultry litter are controlled by their leaching rate from litter, adsorption, uptake in vegetation and dilution (Oyewumi and Schreiber, 2012). While it is assumed that these metals are immobile in managed agricultural soils (McBride, 1995), some factors that enhance their mobility include the properties of the metals, soil texture, soil pH and competing cations in the soil (Dowdy and Volk, 1984).

Recently, a study by Azeez *et al*. (2009) showed that the content of organic carbon is related to the concentration of heavy metals in the soil, which confirms the study of Robertson *et al*. (1982) and Udom *et al*. (2004) that as the organic matter decreased, there was an increase in heavy metal content. There is however an increase in the mobility of these metals and their ability to concentrate to phytotoxic level in the soil, thereby polluting ground water. The accumulation of these metals can also affect the microbial biomass and some enzyme activities causing a reduction in the quality of the soil. Luo *et al*. (2009) confirmed that animal manure was an important source of soil pollution caused by heavy metals in China. Toxicity of heavy metals to plant from contaminated soil has been reported by many studies. The plants grown on soils with elevated level of lead are generally contaminated with this toxic metal, which pose a major health risk (Arora *et al*., 2008). The plants differ widely in their ability to accumulate the metal (Elfadeli *et al*., 2014), the uptake of soil metals by plants depends on their bioavailable amount rather than the total concentrations and plants physiological processes (Wang *et al*., 2005).Results demonstrated that the food crops grown on contaminated soil threatened health for the local inhabitants (Lim *et al*., 2008; Zhuang *et al*., 2009). The heavy metals inputs (Pb and Cd) to agricultural soils in England and Wales were: 48 t/yr of Pb (16 % poultry) and 4.2 t/yr of Cd (26% poultry) (Nicholson *et al*., 2003). Also, Luo *et al*. (2009) analyzed heavy metals inputs to agricultural soils in China where livestock manures accounted for approximately 55 %, of the total Cd inputs.

Thus, heavy metal accumulation is one of the limiting factors to long term disposal of animal waste and this does not enhance the sustainable use of land for agriculture (Azeez *et al*., 2009). Although, the heavy metal content was far from the standard guideline limit of poultry litter used as organic fertilizer, repeated annual additions of poultry litter may accumulate metals in soil and consequently pollute groundwater and plants that may pose a health risk when humans or livestock consume them.

Conclusion

Using poultry litter as alternative feedstuff could expose fish or animal to health risk from lead toxicity. So, it is suggested that much attention should be paid for Pb exposure sources to poultry farms. Although, heavy metal levels in poultry litter was lower than the permitted limit for organic fertilizer, repeated application to agricultural land may lead to environmental and health problems. Regulate the metal contents in poultry litter is important in recycling poultry wastes as food for fish or animals, for safely meat production and guaranteeing environmental security.

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