DETERMINATION OF POTENTIALLY TOXIC METALS IN POULTRY LITTER FROM SELECTED POULTRY FARMS IN WURUKUM AND WADATA AREAS IN MAKURDI BENUE STATE

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Abstract: This study was aimed at determination of potentially toxic metals in poultry litter from selected poultry farms in Wurukum and Wadata areas in Makurdi Local Government. Samples of poultry litter were collected from seven poultry farms; Zoe Livestock Farm (ZLF), James Farm (JAF), Divine Favour Farmland (DFF), Johnson Poultry Farm (JPF) from the Wurukum axis and God's Own Farm (GOF), Mr. Tersoo Farm (MTF), Aondofa Integrated Farm (AIF) from Wadata and were analysed for Cd, Cu, Cr, Fe, Mn, Pb and Zn by Atomic absorption spectrophotometer. The concentration of the metals in the various samples indicated that Cd was only present in ZLF (2.10 mg/kg) from Wurukum. The concentrations of Cu, Cr, Fe Mn, Pb and Zn in all the samples (ZLF, JAF, DFF, JPE, GOF, MTF and AIF) were 24.0 ± 5.0, 19.0 ± 1.0, 37.0 ± 0.8, 62.0 ± 0.7, 164 ± 4.0, 44.0 ± 1.0 and 43.0 ± 3.0 mg/kg, respectively. The level of Fe in (ZLF, JAF, DFF, JPF, GOF, MTF and AIF) were 399 ± 5, 671 ± 2, 771 ± 12, 1810 ± 20, 6630 ± 25, 1130 ± 3 and 1050 ± 15 mg/kg, respectively. Manganese concentration were of Mn in the samples (ZLF, JAF, DFF, JPE, GOF, MTF and AIF) were 238 ± 4, 167 ± 7, 244 ± 9, 281 ± 8, 257 ± 7, 273 ± 2 and 45.0 ± 4, respectively. Lead was not present in all the samples while Zn gave the following results in the samples (ZLF, JAF, DFF, JPF, GOF, MTF and AIF); 256 ± 6, 261 ± 1, 200 ± 2, 246 ± 6, 5630 ± 10, 260 ± 8 and 218 ± 1 mg/kg, respectively. The results gave the following sequence in all the samples; Fe > Zn > Mn > Cu > Cd > Cr or Pb. The result indicates high levels of PTM and there is need for continuous examination of poultry litter for safer environment.

Keywords: Atomic absorption spectrophotometer, contamination, environment, toxic metals, poultry litter

Introduction

Rapid growth in the poultry farm has resulted in significant poultry litter generation. In 1996, more than 11.4 million tons of poultry litter was generated by chickens alone in the USA (Cabrera and Sims, 2000). The application of poultry litter to the land is one of the typical ways of disposing of animal waste. It solves the problem of animal waste disposal and also improves agricultural productivity (Obasi *et al.*, 2008). The litter (after drying) can be mixed with animal feed but is primarily disposed of by land application as a fertilizer (Stephenson *et al*., 1990). Poultry litter contains considerable amounts of nutrients such as nitrogen, phosphorus, and other excreted substances such as hormones, antibiotics, pathogens and heavy metals which are introduced through feed (Steinfeld *et al*., 2006). The litters contain appreciable quantities of PTM such as As, Cu and Zn (Bolan *et al*., 2004).

Trace elements are introduced into poultry diets either involuntarily through contaminated feedstuffs or voluntarily, as feed additives used to supply animals' requirements or – in much greater proportions – as veterinary medicines or growth promoters (NRC, 1994). With increasing use of metals not only as growth promoters, but also as feed additives to combat diseases in intensive poultry production, poultry litter application has emerged as an important source of environmental contamination with some of these metals. Metals such as arsenic, cobalt, copper, iron, manganese, selenium, chromium and zinc are added to feeds as a means to prevent disease, improve weight gain and feed conversion, and increase egg production (Bolan *et al.*, 2004). Since a major portion of the trace elements ingested is excreted in faeces and urine, the concentrations of trace elements in manure by-products depend primarily on their concentrations in the diet (VanRyssen, 2008).

Therefore, it's important to assess the level of PTM in poultry litter from poultry farms as they are sometimes used as manure, fertilizer or amendments in order to ascertain their potential for environmental contamination.

Materials and Methods

All reagents and chemicals used were of analytical grade (> 98%). Distilled water was used for the analysis. The apparatus used are volumetric flask, Whatman No. 1 filter paper, conical flask, HI 9024 microcomputer pH meter (pH 4 and 7 buffer solutions), electronic weighing balance, mortar and pestle, analytical weighing balance, spatula, beaker, sample bottles, hot plate, centrifuge tube, 2 mm sieve, Flame atomic absorption spectrophotometer (Varian SpectrAA 600 model).

Sample collection and pre-treatment

Samples of the poultry litter were obtained from seven different farms in Makurdi. Poultry litter samples were collected from four (4) different farms in Wurukum and three (3) different poultry farms in Wadata as shown in Table 1. The samples were placed into polyethylene bags and transported to the laboratory. Then the samples were air-dried for 3 weeks at room temperature in a storage room. The samples were gently grounded using mortar and pestle which was then passed through a 2 mm sieve after removing stones and other unwanted materials. The grounded samples were stored in clean labelled plastic containers and covered tightly prior to digestion.

Table 1: Sampling location/sample codes

S/N	Name of farm	Location	Sample code
1.	Zoe livestock farm	Wurukum	ZLF
2.	James farm	Wurukum	JAF
3.	Divine favour farmland	Wurukum	DFF
4.	Johnson poultry farm	Wurukum	JPF
5.	God's own farm	Wadata	GOF
6.	Mr Tersoo farm	Wadata	MTF
7.	Aondofa integrated farm	Wadata	AIF

Analytical procedure

The analytical procedures followed in this work are described below:

The pH measurement

The pH determination was performed according to BSI (2005); About 5.0 g of each air-dried sieved sample into the 50 mL conical flask, after which 25 mL of distilled water was added. The conical flasks were closed firmly and place on the mechanical shaker for 1 h, then removes and allowed to stand for 2 h. The pH was then measured in the suspension after calibrating the pH meter with the buffer solutions.

Sample digestion with aqua regia

The digestion method according to Omaku *et al*. (2015) with modification was used in this work. The samples were digested using *aqua regia* which is the mixture of nitric acid (HNO_3) and hydrochloric acid (HCl) in the ratio 1:3. Each of the sieved samples (0.50 g) was weighed into a conical flask. The 20 mL of *aqua regia* was then added. The flask was heated gently on a hot plate in a fume chamber. Brown fumes evolved as the heating continued until a clear solution was obtained. The flask was removed from the hot plate. The mixture was allowed to cool and then filtered using Whatman No. 1 filter paper into 50 mL volumetric flasks and made up to mark with distilled water. The sample solutions were then transferred into pre-washed sample bottles. Procedural blank which includes the reagents without the sample were also digested, filtered and brought to volume with distilled water and stored. The digests were analysed for the presence of seven metals; Cd, Cr, Cu, Fe, Mn, Pb and Zn using Atomic Absorption Spectrophotometer (Flame atomic absorption spectrophotometer Varian SpectrAA 600 Model).

Results and Discussion

Table 2 shows the result of analysis of the pH measurement of the poultry litter samples. Table 3 shows the concentration (mg/kg) of the potentially toxic metals in Wurukum poultry litter samples (ZLF, JAF, DFF and JPE). Table 4 shows the concentration (mg/kg) of the potentially toxic metals in Wadata poultry litter samples (GOF, MTF and AIF).

As shown in Table 2, the pH value for sample ZLF, JAF, DFF, JPE, GOF, MTF and AIF were 7.14, 7.20, 6.95, 7.90, 7.50, 7.10, and 7.77, respectively. The highest pH (7.90) was recorded in sample JPE while the least value (6.95) was obtained in sample DFF. From the analysis above, it is clear that majority of the poultry litter samples are alkaline in nature.

Table 2: The pH values of the poultry litter samples

Sample Code	ZLF	JAF	DFF	JPF	GOF	MTF	AIF
pH	7.14	7.20	6.95	7.90	7.50	7.10	7.40

ZFL = Poultry Litter Sample from Zoe Livestock**,** JAF = Poultry Litter Sample from James poultry Farm, DFF = Poultry Litter Sample from Divine Favour Farmland**,** JPF = Poultry Litter from Johnson Poultry Farm,GOF = Poultry Litter Sample from God's own farm**,** MTF = Poultry Litter Sample from Mr Tersoo Farm, AIF = Poultry Litter Sample from Aondofa Integrated Farm

Cadmium was not detected in any of the poultry litter samples obtained both in the Wurukum and Wadata, except in Zoe Livestock Farm (2.10 ± 0.4 mg/kg) from Wurukum. The value obtained in this study was however comparably lower than the concentration range of 39.50 - 11379 mg/kg reported by Wang *et al*. (2013) but higher than 0.50 mg/kg obtained by Zhang *et al*. (2016) in their analysis of poultry wastes. Chromium was not detected in any of the samples analysed in this study. However, Wang *et al*. (2013) reported a concentration of Cr in animal waste which ranged from 1.0 - 1602 mg/kg in their study. Copper was present in all the samples collected from the two areas as shown in Tables 3 and 4.

Table 3: Concentration (mg/kg) of the potentially toxic metals in poultry litter samples obtained frompoultry farms Wurukum

Sample code	Cd	Cr	Cu	Fe	Mn	Pb	Zn
ZLF	2.10 ± 0.4	ND	24.0 ± 0.5	399 ± 5.0	238 ± 4.0	ND	256 ± 6.0
JAF	ND	ND	19.0 ± 1.0	671 ± 2.0	167 ± 7.0	ND	261 ± 1.0
DFF	ND	ND	37.0 ± 0.8	771 ± 12	244 ± 9.0	ND	200 ± 2.0
JPF	ND	ND	62.0 ± 0.7	1810 ± 20	281 ± 8.0	ND	246 ± 6.0

ND = Not Detected,ZLF = Poultry Litter Sample from Zoe Livestock Farm**,** JAF = Poultry Litter Sample from James Farm, DFF = Poultry Litter Sample from Divine Favour Farmland**,** JPF = Poultry Litter from Johnson Poultry Farm

Table 4: Concentration (mg/kg) of the potentially toxic metals in poultry litter samples obtained from poultry farms Wadata

Sample code	Cd	Cr	Cu	Fe	Mn	Pb	Zn
GOF	ND	ND	164 ± 4.0	6630 ± 25	257 ± 7	ND	5630 ± 10
MTF	ND	ND	44.0 ± 1.0	1130 ± 13	273 ± 2	ND	260 ± 8
AIF	ND	ND	43.0 ± 3.0	1050 ± 15	45.0 ± 4.0	ND	218 ± 1

ND means not detected, GOF = Poultry Waste Sample from God's own farm, MTF = Poultry Waste Sample from Mr Tersoo Farm, Sample AIF = Poultry Waste Sample from Aondofa Integrated Farm

The concentrations of Cu in the various samples (ZLF, JAF, DFF, JPF, GOF, MTF and AIF) were 24.0 ± 0.4, 19.0 ± 1.0, 37.0 ± 0.8 , 62.0 ± 0.7, 164 ± 4.0, 44.0 ± 1.0 and 43.0 ± 3.0 mg/kg, respectively with JAF which was obtained from Wurukum gave the lowest concentration of Cu and God's Own Farm from Wadata indicated the highest Cr concentration. The concentrations of Cr recorded in each of the samples analysed in this study were less than the values of 1196, 718, 743 and 2040, and mg/kg earlier reported by Vander watt *et al*. (1994), Moore *et al*. (1998), Jackson *et al*. (1999) and Wang *et al*. (2013) respectively but within the mean concentration of 55.0, 97.0 and 31.1 mg/kg obtained by Edward *et al*. (1997), Nicholson *et al*. (1999) and Zhang *et al.* (2016) respectively in a similar study. Iron was present in all the samples obtained both from the Wurukum and Wadata axes of Makurdi (Tables 3 and 4). The concentrations of Fe in the various samples (ZLF, JAF, DFF, JPE, GOF, MTF and AIF) were 399 ± 5.0, 671 ± 5.0, 771 ± 2.0, 1810 ± 20.0, 6630 ± 25.0, 1130 ± 13 and 1050 ± 15 mg/kg, respectively with Zoe Livestock Farm indicating the lowest level of Fe from Wurukum and sample God's Own Farm from Wadata gave the highest concentration of Fe. Manganese was present and relatively high in all the samples obtained from Wurukum and Wadata.

The concentrations of Mn in the samples (ZLF, JAF, DFF, JPE, GOF, MTF and AIF) were 238 ± 4.0, 167 ± 7.0, 244 ±

9.0, 281 ± 8.0, 257 ± 7.0, 273 ± 2.0 and 45.0 ± 4.0 mg/kg, respectively. The highest concentration of Mn was recorded in poultry litter obtained from Johnson Poultry Farm from Wurukum area of Makurdi while the lowest amount of the metal was reported in poultry litter sample obtained from the Wadata axis. Lead was not detected in any of the samples obtained from Wurukum or Wadata probably due to its low detection limit. Zinc was detected in all the samples obtained from Wurukum and Wadata as shown in Tables 3 and 4. The concentrations of Zn in the samples (ZLF, JAF, DFF, JPF, GOF, MTF and AIF) were 256 ± 6.0, 261± 1.0, 200 ± 2.0 , 246 ± 6.0, 5630 ± 10, 260 ± 8.0 and 218 ± 1.0 mg/kg respectively with sample Zoe Livestock Farm from Wurukum having the lowest concentration and sample God's Own Farmfrom Wadata having the highest concentration. However, the concentrations of Zn in each of the samples were comparably lower than the values of 631, 647, 378 and 501 mg/kg reported by Vander watt *et al*. (1994), Edwards *et al*. (1997), Nicholson *et al*. (1999) and Jackson *et al*., (1999), respectively with the exception of the sample obtained at God'sOwn Farm from Wadata which gave a very high value (5630 mg/kg) of Zn compared to the concentrations obtained from other samples in the study.

Conclusion

The study was aimed at the determination of potentially toxic metals in poultry litter from selected poultry farms in Wurukum and Wadata areas of Makurdi Benue State. Generally the concentration of Cu, Fe, Mn and Zn measured in the poultry litter samples obtained from Wadata were consistently higher than in the samples obtained from the Wurukum axis of Makurdi. The following sequence of the concentration of the metals in all the sample was as follows: Fe > Zn >Mn > Cu > Cd > Cr or Pb. Therefore, there is need for relevant agencies to monitor closely the kinds/sources of raw materials used particularly in formulating different animal feeds and standards for toxic metals in animal wastes should be established in order to minimise possible environmental contamination due to animal waste.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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