An Evaluation of the Concentration of Heavy Metals in the Feed and Faecal Samples of Layer Birds from Selected Farms in Ikenne Nigeria

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Abstract: This study was carried out to determine the concentration of heavy metals present in the feed and faecal samples of layer birds from commercial poultry farms at Ikenne Local Government area of Ogun State, Nigeria. Feed and faecal samples were collected by random sampling from bags of feed and farm dumpsite respectively at seven commercial poultry farms with bird population of 2,000 and above. Collected samples were analysed for heavy metal concentration with atomic absorption spectrometer AAS model 210GP after wet digestion. Data analysed by descriptive statistics showed that both feed and faecal samples contained varying levels of Copper (Cu), Zinc (Zn), lead (Pb), Chromium (Cr) and Arsenic (As). The mean concentration (ppm) values of heavy metals obtained in poultry feed from all the farms falls within the National Research Council and European Union reference values. However, the concentration of Cr in all feed samples was below the NRC recommended value. In all the faecal samples collected, the concentrations (ppm) of Cu and As were lower than the concentrations obtained in feed samples. This could either mean that birds absorbed some of the metals in their diets or some of the metals in the faeces had been eroded off because the faeces were dumped in the open. Adequate incorporation not exceeding the maximum required value of metals into poultry diet is therefore recommended so that birds will not be deficient in having access to minerals required for their optimum growth, development and productivity. Also, chickens are nourished by the feed they consume and if the feed is excessive in heavy metal concentration, there will be a deposition of the metals in their body tissues. This will pose a poisonous and detrimental effect to the health of the human population that consumes such birds. Furthermore, it is recommended that faecal wastes should be properly dumped or recycled to avoid accumulation of heavy metals in soils or run off.
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Introduction

Global demand for livestock products has been on the increase (Jones and Thornton, 2008), and the increased demand is largely based in the developing countries. In Nigeria, the poultry industry is expanding rapidly and this growth has brought about an increasing concern on the proper way of disposing the poultry faecal wastes (Owen *et al*., 2009). According to Oluyemi and Roberts, (1979) a laying bird produces between 63 and 70kg droppings per year. Therefore, the Nigeria livestock industry with an estimation of over 153million poultry (Adeoye, 2014) will be producing about 9.64-10.71 million tons of poultry litter annually. Poultry manure generation record in Nigeria appears to be unknown but likely to be in multiples of 932.5 metric tons (Musa *et al.,* 2012). The magnitude of this generated poultry wastes have given rise to its improper disposal which include over application to land and improper timing of application, thereby creating pollution problem to soil, water and air environment.

It is a common practice to enhance livestock feed particularly poultry with minerals such as Zinc (Zn), Copper (Cu) and Arsenic (As) in form of mineral additives or mineral premix. This is because of their antimicrobial and growth stimulating effects (NRC 2005). However, all mineral elements, whether considered to be essential or potentially toxic, can have adverse effect upon humans, animals and the environment if included in the diet at excessively high concentrations (Okoye *et al.,* 2011) as these metals are often excreted in the faeces. Several organisms within a given ecosystem are contaminated along their cycles of food chain (Henry and Milesciência, 2001) with heavy metals and there are several factors that led to concern about the possibility of excessive mineral intakes by poultry birds.

Poultry birds are nourished by the feed they consume. If there feed therefore contains high level of heavy metals, it will bring about the production of unsafe and unwholesome poultry products which are poisonous and detrimental to the health of the human population that consume such birds (Okoye *et al.,* 2011). There are various sources of heavy metal contamination in poultry diet. Natural water ways/supplies can contain high concentrations of magnesium and iron. Also, various hazardous elements, especially heavy metals, can be added to ground water from toxic waste sites, industrial pollution, and municipal waste systems. Furthermore, heavy metal contamination could occur as a result of human error during transport and mixing of ingredients and final delivery of a finished feed to the poultry house (Henry and Milesciência, 2001). The unsustainable applications of manures can increase heavy metal content in soil. According to Brock *et al*., (2006) the continuous long-term application of animal manure may cause accumulation of metals in soil that will reach toxic levels for some crops and organisms to survive.

In countries like Nigeria where regulations on animal waste disposal are not in place or where there are no enactions of the existing regulations, this practice can result in serious environmental problems. In view of the potential risks to public health issues associated with heavy metal pollution, this study aimed at determining the mean concentration of heavy metal contents in a range of faecal wastes from poultry farms. Since the metals inherent in poultry faeces are largely derived from feeds, this study also sought to study the mean concentration of heavy metals present in poultry feeds used on the farms visited.

Materials and Method

Experimental Site

This study was carried out on commercial layers farms within Ikenne Local Government Area, (6° 52' N 3°43'E) of Ogun State, Nigeria. Seven Commercial poultry farms in Ikenne local government with layer birds population above 2000 (>2000) were sampled. A brief interview was employed to capture all information required aside sample collection.

Sample Collection

Feed samples (layer mash) were collected from individual farms by taking random samples from bags of feed available using a corer. The feed samples were bulked together to provide one sample of 5-10kg for each farm. These samples were transferred to clean polythene bags and stored in the freezer at -18°C until required for analysis. Faecal samples were collected from individual farm dump sites by taking samples randomly at the top and up to 2-3cm depth of the heap. Faecal samples from each farm were bulked in polythene bags and stored in the freezer at -18°c until required for analysis.

Sample Treatment

Feed and faecal samples were oven dried at 60-65°C and ground. The ground samples were passed through 0.25mm mesh sieve. Sub-samples of 0.1g of feed and faecal waste were digested with 10ml of nitric and perchloric acid. Digests were analysed on an Atomic Absorption Spectrophotometer (AAS) model 210GP from Buck Scientific (USA) after calibrating the equipment for each element using relevant standard solutions.

Statistical analysis

Data obtained were analysed using descriptive statistics. Data obtained were also subjected to analysis of variance (ANOVA); and Duncan's Multiple Range Test was used to compare significant means using SPSS (2007).

Results and Discussion

Results of the heavy metal concentration and their range value in feed samples from the different farms visited are presented in tables 1 and 2. All the feed samples contained detectable concentrations of Cu, Zn, Cr, Pb and As indicating that these metals were present in feed ingredients or in the additives used to formulate feed for birds on the farms.

Table 1: Mean Concentration of Heavy Metals (ppm) in Feed Samples of Layers from Selected Farms

Parameters	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F	Farm G	SEM
Cu	8.50^{ab}	83.00^{c}	16.25^{ab}	2.25^{a}	13.50^{ab}	22.75^{b}	19.50^{b}	2.10
Zn	70.25^{ab}	80.25^{cd}	71.00^{ab}	19.75^{a}	118.75^{d}	101.50^{cd}	94.00^{cd}	9.60
Pb	7.75	8.50	8.00	5.00	7.75	7.50	5.50	2.60
Cr	18.25^{b}	6.25^{a}	4.50^{a}	3.75^{a}	5.50^{a}	5.25^{a}	4.00^{a}	1.40
As	1.23	1.08	0.96	0.68	0.91	0.56	0.38	1.21

Cu-copper, Zn-zinc, Pb-lead, Cr-chromium and As-arsenic. Means bearing different superscripts within the same row are statistically different ($p<0.05$). SEM- Standard Error of Means

The concentration of Zn in the feed was high in all the farms except farm D and there were significant differences ($p<0.05$) between farms in the level of Cu and Zn in feed samples. The mean concentrations of Zn and Cu in feed of birds for most of the farms were higher than the mean concentration of Zn and Cu in poultry feed samples reported by Rohma *et al.,* (2014). Although the concentration values obtained in this study fell below the maximum NRC (2005) and EU (2003a; 2003b) recommended values, it is still within the permissible limits. However, farm B has a Cu content higher than the reference value of EU (2003b). Values obtained for Zn (19.75-118.75 ppm) concentration is still within the range of 21.15-241.10 ppm obtained by Mahesar *et al.,* (2010) in their analysis of poultry feed, though comparably lower.

The concentration of Cr in the feed of birds obtained from different farms under study were below the reference value 500ppm of NRC (2005) although no value was given by the EU (2003). However, the values of the concentration of Cr in poultry feeds reported in this study were higher than that of Rohma *et al.,* (2014). This could be as a result of difference in countries where experiments were carried out, difference in feed types studied, differences in feed ingredients and additives used for formulation of feeds, methods of feed production and the exposure of feed ingredients to pollutants/contaminants.

There was no significant difference in the concentrations of Pb and As ($P>0.05$) across the farms. The concentration of As obtained in feed of birds from farms A and B were close to the permissible limit 2ppm of the EU (2003) however all the farms had As concentration that is below 30 ppm recommended value of NRC (2005). For Pb concentration, only farm D had a value that is in accordance with the EU (2003) maximum value of 5ppm, all other farms had higher concentration of Pb. However, the concentration of Pb in poultry feeds from all the farms were close to the NRC (2005) maximum requirement value of 10ppm. The concentration of Pb reported in this study is higher than the values, 5.96-7.80ppm reported by Okoye *et al.,* (2011) on Pb concentration obtained from different brands of layer mash. When high concentration of Pb and As metals are used in poultry diets, it is considered toxic and harmful. For example, if there is high deposit/accumulation of As in the body system, it could substitute for phosphorus, disrupting cellular oxidative processes and result in capillary injury and tissue hypoxia (Henry and Miles, 2001).

Table 2: Range of Heavy Metal Concentration (ppm) in Feed Samples of Laying Birds from Selected Farms

Flock size	No of Farms	Metals	Cu	Zn	Pb	Cr	As
≥2000	7	Range	2.25-83.00	19.78-118.75	5.00-8.50	3.75-18.25	0.38-1.23
		Mean	23.67	79.35	7.142	5.35	0.82
		Median	16.25	80.25	7.75	5.25	0.91

Cu- copper, Zn- zinc, Pb- lead, Cr- chromium and As- arsenic.

From the range of values obtained, Cu and Zn varied widely from 2.25-83.00ppm and 19.78-118.75ppm respectively indicating possible differences in their inclusion levels. Both metals are used as additives in feed for growth and development as well as reproduction. Cu is used as growth promoter in poultry farms while Zn is needed in poultry for growth, feather and skeletal problem and reproduction (Bolton and Blair 1974). The range reported for Cu in this study is higher than the 6.53-12.60 ppm reported for different brands of layer mash by Okoye *et al.,* (2011). However, the range of Cu concentration in feeds obtained in this study is within the limits set by the EU (2003), 25ppm and the NRC (2005), 250ppm.

The mean concentration and range values reported for Zn is higher than the mean 40.54ppm and range values 23.60-50.20ppm reported by Imran *et al*., (2014) who studied heavy metals concentration in different types of feeds for broiler birds. This could be as a result of differences in feed type studied as different animal class has different nutrient requirements. However, the values obtained in this study are within the NRC (2005) and the EU (2003) maximum permissible values.

The values reported for mean concentration and range of Cr in layers feed is low compared to the maximum requirement level of 500ppm (NRC, 2005). Imran *et al*., (2014) also reported mean concentration value 1.93 ppm and range values 0.288-7.71ppm which is lower than the NRC (2005) reference value although values reported in this study are higher. The Cr content in feed samples could be sourced back to the tanneries as it is present in its effluent in the concentration of 3956 mg/l and also in its solid waste (Tariq, 2009).

The As concentration range in feed of layers has a slight deviation from the EU (2003) 2ppm recommended value although the range of concentration obtained is low to the NRC (2005) 30ppm reference value. As metal is sometimes used as a growth promoter for poultry. This is because of its antibiotic and anti coccidial properties, (Li *et. al.,* 2005; Nicholson *et. al.,* 1999).

Pb mean concentration value and range values differ slightly from the maximum Pb concentration requirements by the NRC (2005), 10ppm and the EU (2003), 5ppm. The presence of lead can be attributed to its presence in the effluent from tanneries which generally emit lead at the concentration of 4.362 mg/l (Tariq, 2009) and anthropogenic sources of lead pollution in the environment especially fossils fuels combustion (Okoye *et al.,* 2011).

Mean Concentration of Heavy Metals in Faeces of Laying Birds

Results of the concentration of heavy metals and their range value in the droppings of layers across the selected farms are shown in tables 3 and 4. Unlike the feed samples, the heavy metals in the faecal samples were all significantly different ($p<0.05$) across the farms.

Table 3: Mean Concentration of Heavy Metals (ppm) in Faecal Samples of Layers from Selected Farms

Parameters	Farm A	Farm B	Farm c	Farm D	Farm E	Farm F	Farm G	SEM
Cu	12.35^{cd}	12.60^{cd}	3.59^{ab}	8.37^{bc}	14.50^{d}	0.60^{a}	3.58^{ab}	1.45
Zn	121.63^{c}	37.24^{b}	33.50^{ab}	51.99^{b}	112.57^{c}	3.11^{a}	47.46^{b}	11.89
Pb	15.98^{d}	3.35^{bc}	1.26^{a}	2.19^{abc}	3.82^{c}	1.53^{ab}	1.28^{a}	1.36
Cr	4.79^{ab}	3.70^{ab}	2.08^{a}	5.38^{b}	5.53^{b}	1.48^{a}	1.44^{a}	0.53
As	0.39^{b}	0.21^{ab}	0.26^{ab}	0.17^{ab}	0.24^{ab}	0.11^{a}	0.13^{a}	0.03

Cu- copper, Zn- zinc, Pb- lead, Cr- chromium and As- arsenic. Means bearing different superscripts within the same row are statistically different ($p<0.05$). SEM- Standard Error of Mean

Table 4: Range of Heavy Metal Concentration (ppm) in Faecal Samples of Layers from Selected Farms

Flock size	No of Farms	Metals	Cu	Zn	Pb	Cr	As
≥2000	7	Range	0.60-14.50	3.11-121.63	1.26-15.98	1.44-5.53	0.11-0.39
		Mean	7.94	58.21	4.20	3.49	0.22
		Median	8.37	47.46	2.19	3.70	0.21

Cu- copper, Zn- zinc, Pb- lead, Cr- chromium and As- arsenic

With the exception of Zn in farm A, all other metals were below 100ppm in the faecal samples. While there were differences in the concentration of all the metals in the faeces across the 7 farms, it was observed that Zn varied more widely than all the others in concentration among the farms. Contrary to the observation by Kunle *et al.,* (1981) and Morrison (1969) that Cu and As were more concentrated in the faeces than in feed, this study showed that the concentration of metals, were numerically higher in the feed than in the faeces. The reason for this could be that birds absorbed some of the minerals in their feed to facilitate their development and productivity or the metals were loss from the faeces through run off since the manure was largely dumped in the open where they are exposed to rain.

Conclusion

Generally, both the layers feed and faecal waste sampled contained varying levels of Cu, Zn, Pb, Cr, and As. Zn and Cu were higher than the other heavy metals in both feed and faecal samples. This may be because they were widely supplied as micro nutrients in feed. In all the farms, the level of Cr in feed was low when compared to the maximum recommended value of NRC. It is therefore recommended that feed mills should follow recommended standards set for poultry birds in terms of permissible heavy metals content in birds' diets. This is to avoid bioaccumulation of these heavy metals in the poultry tissues, a situation that can pose serious risks to consumer of poultry products. Furthermore excessive application of poultry droppings as source of manure should be dissuaded to avoid excessive accumulation of heavy metals in the soil thereby affecting soil fertility and product quality. This is because the indiscriminate use of poultry droppings as manure may promote metal migration through leaching and runoff from dump sites and farms. To facilitate proper disposal of poultry droppings, the faecal samples could be recycled to produce biogas.

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