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Research Article

Determination of Concentration of Some Heavy Metals in Tissues of Cattle Slaughtered From Southern Agricultural Zone of Nasarawa State, Nigeria

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Abstract: The study was undertaken to determine the presence and concentration of some heavy metals in selected tissues of cattle slaughtered from southern agricultural zone of Nasarawa state using Atomic Absorption Spectrophotometer (AAS). Fifty samples comprising 10 each of liver, kidney, skin, intestine and muscle were collected and analyzed for the presence of Ni, Cr, Pb, Cu and Cd. Male and female cattle of two age categories (Young and Older) were sampled for the study. The mean concentration of Ni, Pb, Cu and Cd in all the sampled tissues were generally low and within the permissible limit. High levels of Cr was detected in all samples with mean concentration of 3.9926 mg/kg, 2.4440 mg/kg, 2.9909 mg/kg, 2.1688 mg/kg and 4.0100 mg/kg in intestine, kidney, liver, muscle and skin respectively. There exist significant difference (P< 0.05) in the mean concentration of Ni and Cu between young and older cattle. Higher levels of Cr, Pb and Cd was detected in the tissues of female animal than male. The result from this study indicates that cattle slaughtered from the study area are free from Cd, Cu, Ni and Pb residues, but contained high levels of Cr. Public and private sector should establish cattle ranches so as to reduce the possibility of grazing cattle in heavy metal contaminated feed and pasture.
Keywords: Abattoir, Agricultural zone, heavy metals, tissues, AAS, cattle, Nasarawa state.

INTRODUCTION

Nigeria is considered the most populous country in Africa (WHO, 2015) and one of the consequences of increased human population is environmental pollution and it is possible to establish relationships between overpopulation, poverty and urban air pollution (Chen B and Kan H, 2008). Heavy metal contamination of food is an issue of global concern that ultimately results in toxicity and diseases in humans and animals through consumption of contaminated soils and food (Michael *et al.,* 2018). These metals are natural components of the environment but high rate of industrialization has been responsible for their wider diffusion and dispersal in the environment (Rajaganapathy *et al.,* 2011). Contaminated food is one of the main sources of exposure to heavy metals and an increased dietary heavy metal intake may contribute to the development of various disorders (Michael *et al.,* 2018). Heavy metals toxicosis in animals occurs when livestock ingest contaminated forage and water or inhalation of contaminated air from their surroundings. This ultimately bio-accumulate in the tissues and organs such as liver, kidney, which are consumed by humans

as a source of animal protein (Okareh OT, 2015). Anthropogenic activities such as mining, use of inorganic agricultural products, unselective dumping of waste on land and water contribute to the existence of toxic metals in the ecosystem (Jayasekara *et al.,* 1992). Other anthropogenic sources of heavy metal contamination include agricultural activities, such as pesticide and herbicide application, contaminated irrigation water, municipal waste used for fertilization of crops (Alloway & Jackson, 1991), mineral fertilizer containing traces of heavy metals and direct waste disposal on farmland (Merian *et al.,* 2004). Somasundaram *et al.,* (2005), in their study conducted in India established that giving animals feeds from areas with elevated content of trace elements results in their bioaccumulation in edible tissues, eggs and milk.

The risk associated with the exposure to heavy metals present in food products had aroused widespread concern in human health (Reilly, 1991). Improvements in the food production and processing technology had increased the chances of contamination of food with various environmental pollutants, especially heavy metals. Ingestion of these contaminants by animals causes deposition of residues in meat (Sabir *et al.,*

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2003). Higher level of trace metals has been recorded in beef and mutton. Presence of substantiates levels of toxic metals including lead and cadmium in meat products has been reported by González Weller *et al.,* 2006.

Some heavy metals are consider as essential metals, they exert biochemical and physiological functions in plants and animals. They are important constituents of several key enzymes and play important roles in various oxidation-reduction reactions (WHO, 1996).

In biological systems, heavy metals have been reported to affect cellular organelles and components such as cell membrane, mitochondrial, lysosome, endoplasmic reticulum, nuclei, and some enzymes involved in metabolism, detoxification and damage repair (Wang S and Shi X, 2011). The fast rate of urbanization and industrialization in the study area informed the necessity of this study. The aim of the study is to determine the concentrations of heavy metals as well as the effect of age and sex in slaughtered cattle from southern agricultural zone of Nasarawa state.

MATERIALS AND METHODS

Study area
The study was conducted in southern agricultural zone of Nasarawa state Nigeria. The zone is among the three agro-ecological region of the state and consist of five local government areas. The area falls within the Guinea Savanna agroecological zone and is found between latitudes 7^o52 N and 8^o56 N and longitudes 7^o25 E and 9^o37 E respectively. The state has a mean monthly temperatures between 20^oC and 34ºC, with annual rainfall ranging between 1100 mm to 2000 mm (Lyam A, 2000).

Sample type
The sample consist of liver, kidney, intestine, muscle and skin

Sample collection

Overall total of 75 tissue samples were collected from slaughtered cattle during the period of study which lasted between April to August 2018. These comprise of 15 samples each of liver, kidney, intestine, muscle and skin. The characteristics (age, sex and breed) of all the sample cattle were recognized and recorded accordingly. About 10 g of sampled tissues were collected, labeled and stored separately in clean polythene bags and transported in an ice pack containing ice block where they were refrigerated at temperature of 2^oc to 8^oc.

Sample Digestion
Conventional Wet Acid Method of Digestion as described by Miranda *et al.,* (2005) was used. 5ml of freshly prepared mixture of concentrated HNO3 (nitric acid) and H2O2 (hydrogen peroxide) in a 4:2 v/v ratio was poured into a Pyrex flask containing 2ml of the blood samples and left for 15 minutes. Watch glass was used to cover the flask prior to digestion. A total of 3 ml of HN03 and few drops of H2O2 were used to treat the digest followed by subsequent heating at 80^oC on a hot plate to obtain a clear digested solution. The excess acid mixture was evaporated to a semi-dry mass and thereafter cooled and diluted with 0.2ml nitric acid. A 100 ml volumetric flask was used to transfer the mixture and diluted with distilled water to obtain a 60 ml volume. The samples were stored in a refrigerator at 4^oC awaiting Atomic Absorption Spectrophotometer (AAS) analysis.

Analysis of samples
Atomic Absorption Spectrophotometer (Manufactured by Shimadzu, Model AA 6800, Japan) was used to evaluate the concentrations of heavy metals in the digested samples at the laboratory of the National Research Institute for Chemical Technology, Zaria, Nigeria. A calibration of the AAS was done with standard solutions after which they were aspirated into the AAS equipment for analysis. Concentration of Pb, Cd, Ni, Cu and Cr were evaluated using descriptive statistic while Student t-test was used to analyzed the effect of age and sex on the concentration of the metals using Statistical Package for Social Sciences (SPSS, 2010) version 20.0 for Windows.

RESULTS AND DISCUSSION

Table 1: Distribution of cattle according to age and sex

Parameters	Number examined	Percentage (%)
Age		
Adult	38	76.00
Old	12	24.00
Total	**50**	**100.00**
Sex		
Male	5	10.00
Female	45	90.00
Total	**50**	**100.00**

Table 1 shows the distribution of sampled cattle according to sex and age. Out of the 50 cattle sampled for the study, 76% (38) were young cattle of age < 5 years. While 24% (12) were older cattle of age > 5 years. Male cattle were 10% (5) while 90% (45) of the sampled cattle were female. This shows that most of the cattle slaughtered in the study area are female, the male are usually reserved for festival and breeding as shown by Sabuwa *et al.,* (2019).

Table 2: Mean concentration of heavy metals in cattle as affected by type of organ

Parameters	Intestine	Kidney	Liver	Muscle	Skin	SEM	SD	LOS
Nickel	0.1090	0.0044	0.0153	0.0430	-0.0815	0.0297	0.2102	ns
Copper	0.0041	0.0029	0.0036	0.0037	0.0009	0.0009	0.0061	ns
Chromium	3.9926	2.4440	2.9909	2.1688	4.0100	0.9718	6.8719	ns
Lead	0.0355	0.0710	0.0691	0.0534	0.0546	0.0083	0.0587	ns
Cadmium	0.0007	0.0007	0.0010	0.0005	-0.0001	0.0003	0.0020	ns

SEM = standard error of mean; LOS = level of significance; ns = not significantly different (P > 0.05).

The mean concentrations (mg/kg) of Ni, Cu, Cr, Pb and Cd of tissues sampled from southern agricultural zone of Nasarawa state are presented in table 2 above. Cr is the most detected metal while Cd is the least detected metal from all tissue samples. Highest mean concentration (mg/kg) of Cr is detected in skin than liver, kidney, intestine and muscle. This findings is not in line with the studies of Bala *et al.,* (2014) and that of Akan *et at.* (2010) who shows that liver bio-accumulate heavy metals more than any organ of the body. A very low concentration of chromium in muscle (0.011 mg/kg), liver (0.022 mg/kg) and kidney (0.025 mg/kg) was reported by Fathy *et al.,* (2011), these values were over 200 times lower than detected in this study. The concentrations (mg/kg) of Cr from all the tissue samples far exceed the maximum permissible limit recommended by codex alimentarious. The high concentrations (mg/kg) of Cr in all the sampled tissues may indicates that the cattle have recently been exposed to either Cr contaminated feed or Cr contaminated environment as a result of anthropogenic activities. This is in line with the findings of Tchounwou *et al.,* (2012) who shows that Chromium enters into various environmental matrices (air, water and soil) from a wide variety of natural and anthropogenic sources with the largest release coming from industrial establishments. Environmental exposure to Cr containing compounds is known to cause multiorgan toxicity such as renal damage, allergy and cancer of the respiratory tract (Goyer RA, 2001). Cr is a toxic industrial pollutant that is classified as human carcinogen by several regulatory and non-regulatory agencies (UEPA, 1992).

The intestine have the highest concentration of Ni when compared with other tissues, with a mean concentration that is 20 times higher than the mean concentration of Kidney (0.0044 mg/kg). Skin recorded the lowest mean concentration of Ni. The mean concentration of Ni in liver (0.0153 mg/kg) is greater than the concentration of kidney (0.0044 mg/kg).

Iwegbue, C. M. A. (2008) in his study conducted in southern Nigeria recorded high levels of Ni in Kidneys (0.20 mg/kg) and Liver (0.12 mg/kg) than concentration recorded in this study conducted in North central Nigeria. Although, Ni plays a vital role in the body by regulating prolactine and stabilization of RNA and DNA structures, excessive amount of Ni produces severe allergic reaction, bronchial asthma, dermatitis and myocardial infection as shown by C.R.K. Murtic and P. Viswanathan (1989).

The liver recorded highest mean concentration (mg/kg) of Cd when compared with the mean concentration (mg/kg) of other tissues. This high relative mean concentration of Cd in the liver indicates that the liver bio-accumulates Cadmium more than any organ in the body. This findings does not agree with the study of Iwegbue AMC (2008) who shows that Kidney accumulates cadmium more than all organs of the body. Generally, the mean concentration (mg/kg) of Cd from cattle tissues recorded from the study area are very low and insignificant. This shows that the environment where these cattle are raised is free from Cd contamination. This is in agreement with the study of Miranda *et al.,* (2009) who reported that cattle and other ruminants are indicators of environmental contamination with heavy metals. Cadmium is toxic to almost every system in the animal body, it is almost absent in the human body at birth but accumulates with age (Mukesh K. R. *et al.,* 2008). Cd compounds are classified as human carcinogens by the International Agency for Research on Cancer (IARC, 1993).

The concentration of Pb is highest in Kidney (0.0710 mg/kg), followed by the liver (0.0691 mg/kg), least concentration was detected in intestine (0.0355 mg/kg). This is in line with the study of Flora, SJS (2006) who showed that the greatest percentage of lead in the body concentrate more in the kidney and the liver. All the sampled tissues recorded concentration that is lower than the recommended daily intake of 0.1

mg/kg (FAO, 2011). The level of Pb in tissues and blood has a significant correlation with the levels and metabolism of essential trace metals (Singh *et al.,* 1994). Ahmed *et al.,* (2007) in India studied the in vivo interaction of Pb with some essential trace elements in the blood of underage children, and their results showed significant association between elevated blood Pb levels and the risk of anemia. This establish that elevated tissues Pb levels will results in a corresponding decrease in the concentration of some essential metals in animal and human body. Bala *et al.,* in their study conducted in Sokoto, north western Nigeria reported an elevated mean concentration of Pb in liver (1.523 mg/kg) and kidney (0.8442 mg/kg) of cattle, values that are extremely higher than the values obtained from this study conducted in north central Nigeria. M. Zahuru *et al.,* (2011) in their study conducted in Bangladesh to determine the levels of Pb in slaughtered cows reported

a high mean Pb concentration (0.7 mg/kg) in liver that is over 10 times the concentration detected in this study.

Highest Cu concentration (mg/kg) is detected in the intestine with least concentration observed in Kidney. This study recorded very low levels of Cu compared to the studies of Oymak *et al.,* (2017), who reported 15.82 mg/kg in Kidney, 280.86 mg/kg in liver and that of Iwegbue, C. M. A, (2008) who reported mean concentration of 1.99 mg/kg and 3.27 mg/kg in liver and kidney respectively from southern Nigeria. Although, Cu is an essential metal that is required for the formation of red blood cells, as well as many oxidation and reduction reactions in humans and animals, elevated levels in the tissues is toxic. The low levels of Cu detected in the tissues of cattle from this study indicates that the environment were these cattle are raised is deficient of some trace metals.

Table 3: Mean concentration of heavy metals in cattle as affected by sex

Parameters	Male	Female	SEM	Standard deviation	LOS
Nickel	0.0271	0.0170	0.0297	0.2102	ns
Copper	0.0031	0.0030	0.0009	0.0061	ns
Chromium	2.6983	3.1682	0.9718	6.8719	ns
Lead	0.0220	0.0606	0.0083	0.0587	ns
Cadmium	-0.0005	0.0007	0.0003	0.0020	ns

SEM = standard error of mean; LOS = level of significance; ns = not significantly different ($P > 0.05$).

The results for mean concentrations (mg/kg) of Ni, Cu, Cr, Pb and Cd as affected by sex is presented in table 3 above. Cr is the most detected metal while Cd is the least detected metals from both male and female cattle. The concentrations (mg/kg) of Ni and Cu are highest in tissues of male cattle than female. Higher levels of Cr, Pb and Cd is detected in female animal then male. The mean concentration (0.0606 mg/kg) of

Pb in female animal is over two times the concentration (0.0220 mg/kg) in male. This is in line with the study of Sabuwa *et al.,* (2019) who shows that female cattle tends to accumulates high levels of Pb and Cd in their tissues than male. No significant difference exist in the concentrations of Ni, Cu, Cr, Pb and Cd between male and female cattle.

Table 4: Mean concentration of heavy metals in cattle as affected by age

Parameters	Young	Old	SEM	Standard Deviation	LOS
Ni	-0.0363	0.1901	0.0297	0.2102	*
Cu	0.0043	-0.0010	0.0009	0.0061	*
Cr	2.8086	4.1114	0.9718	6.8719	ns
Pb	0.0639	0.0338	0.0083	0.0587	ns
Cd	0.0005	0.0008	0.0003	0.0020	ns

ab means on the row having different superscript differ significantly; SEM = standard error of mean; LOS = level of significance; ns = not significantly different ($P > 0.05$)

Table4 represent mean concentrations of Ni, Cu, Cr, Pb and Cd in young and older cattle. Highest mean concentration of Ni, Cr and Cd is detected in the tissues of older cattle than the young age category. Significant ($p < 0.05$) high concentration (0.0043 mg/kg) of Cu was detected in the tissues of young cattle when compared with the older cattle. There exist significant difference ($P<0.05$) in the mean concentration of Ni in older and younger cattle, with high concentration detected in young age category. No significant difference ($P>0.05$) exist in the

concentration of Cr, Pb and Cd between young and older cattle.

CONCLUSION
The study revealed cattle slaughtered from southern agricultural zone of Nasarawa state accumulate some levels of heavy metals in their tissues. The concentrations of Ni, Cd, Cu and Pb are low and within the permissible limits. Cr was found in high concentration in all tissues and above the permissible limit of FAO. Sex have no significant effect on the

concentrations of heavy metals in cattle tissue. Age have significant effect ($p < 0.05$) in the concentrations of some heavy metals in cattle slaughtered from southern agricultural zone of Nasarawa state, north central Nigeria. Although, the concentrations of most of the heavy metals were found to be generally low, it is important for the continuous evaluation of these metals from both animals and the environment of the study area so as to reduce their bioaccumulation in cattle and human tissues. Public awareness on the danger of grazing cattle near industrial and auto-mobile factories should be advocated.

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