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Detection of Heavy Metals in Selected Organs of Slaughtered Cattle from the Northern Agricultural Zone Of Nasarawa State, Nigeria

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Abstract:
Background: *Contamination by Heavy metals has been a major source of concern especially in the fast growing industrialized countries. Nigeria, with an estimated population of 200 million is becoming industrialized and agricultural activities are massively at an increasing rate thereby increasing anthropogenic source heavy metals contamination of the environment. This study was undertaken to detect the levels of heavy in selected organs of slaughtered cattle from the Northern Agricultural zone of Nasarawa state Nigeria.*
Materials and method: *Fifty samples of kidney, muscle, liver, intestine and skin were collected from cattle of different age and sex across randomly selected abattoirs in the zone. The samples were analyzed for the presence of Cd, Cr, Cu, Ni and Pb using Atomic Absorption Spectrophotometer.*
Results: *The mean concentration of Ni, Cd, Pb and Cu in all the tissues sampled were generally low and within the permissible limit. The mean concentration of Cr in kidney, liver and muscle were 1.0599, 4.0485 and 1.1254 respectively. These values are generally high and far exceed the recommended permissible limit of FAO. The mean concentration of Ni in male and female cattle were 0.2952 and 0.0312 respectively. There exist a significant difference in the concentration of Ni between male and female cattle. The concentrations of Ni, Cu, and Cd is higher in older cattle than detected in the young age category.*
Conclusion and recommendation: *The concentration of Ni, Cd, Cu and Pb were generally low. However, Cr constitute a major health concern for the population. Extensive grazing of cattle near industrial areas, automobile workshop and any other potential source of heavy metals contaminants should be discouraged while cattle ranching and colony is advised.*
Key words: *AAS, Chromium, heavy metals, cattle, Nasarawa state.*

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I. Introduction

A heavy metal is any relatively dense metal or metalloid that is noted for its potential toxicity (Bánfalvi, 2011). Heavy metals such as iron, copper, zinc and manganese are considered as essential elements, because they are required by the body in trace amount where they play important role in biological systems; however these essential heavy metals can also produce toxic effects when consumed at high concentrations. . Toxic heavy metals on the other hand are harmful even in trace amounts; they are entirely excluded from human food and have been included in the regulations of the European Union for hazardous metals (European Commission, 2001). Rogival *et al.,* (2007) showed that these toxic, non-essential elements are transferred through the food chain than the essential, non-toxic metals. These elements are highly resistant to decomposition in natural conditions and can also bioaccumulate and biomagnify in the food chains (Rzymski *et al.*, 2014).

In Nigeria, cattle are free grazing and drink water from ditches, streams, rivers and other water sources. They also graze along runways and other sites that might have been contaminated with toxic substances hence the risk of exposure to high levels of contaminant. Livestock production has been a source of supply of animal protein worldwide and meat from slaughtered cattle at various abattoirs constitutes the largest source of animal protein for Nigerians (Idahor *et al.*, 2009). Industrial activities are the major sources of environmental heavy metal pollution and elevated levels of heavy metals in tissues of animals in a polluted environment may be ascribed to livestock grazing on contaminated pastures (Okada *et al.*, 1997).

The sources of toxic metals in the environment are the fossil fuels, mining industries, waste disposals and municipal sewage (He, *et. al*., 2005). Farming and forestry also contribute on the level of heavy metals in the environment due to the uses of inorganic fertilizers, pesticides and herbicides. These metals become concentrated as a result of anthropological activities and can enter plant, animal and human tissues through air, food and manual handling. Then, they can bind to and interfere with the functioning of vital organs in animal and human system. Non-essential heavy metals can also interfere with the availability and functions of some essential elements, this was reported by Jarup *et al.*, (1998) where they showed that Cd can affected Ca, P and bone metabolism in both industrial and people exposed to Cd in the environment.

Because of their high degree of toxicity, arsenic, cadmium, chromium, lead and mercury rank among the priority metals that are of public health significance. Emission of heavy metals into the environment occurs through various processes, including to the air, to surface water and to the soil. (Reeder *et al.*, 2006).

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 repair (Wang and Shi, 2001).

Many metals show a positive correlation between their content in soil and post-harvest grains (Grytsyuk N., 2006), it is estimated that 80–90% of all heavy metals enter the human body via food chain. Farm animals (especially ruminants) are very useful indicators of environmental pollution (Koréneková B., 2002). Giving animals feeds from areas with high content of trace elements results in bioaccumulation in edible tissues, eggs and milk (Somasundaram J., 2005). López Alonso *et al.*, (2004) observed that domestic animals are an important source of food for humans, thereby providing direct indicator of pollutant transfer to humans through food chain.

The aim of this study therefore is to detect the concentration of heavy metals in selected organs of slaughtered cattle from the Northern Agricultural Zone of Nasarawa state, Nigeria.

II. Materials and Methods

Study design: Observational study with laboratory analysis.

Study location: The study was conducted in the Northern Agricultural Zone of Nasarawa State. The zone falls within the guinea savannah agro-ecological zone. Nasarawa State is found between latitudes $7^o52'$N and $8^o56'$N and longitudes $7^o25'$E and $9^o37'$E respectively. Annual rainfall figures range from 1100 to 2000 mm with mean monthly temperatures ranging between 20^oC and 34^oC (Lyam, 2000). The state has a total human population of about 1, 207, 876 (NPC, 2006) and the vegetation is Guinea Savannah which is conducive for farming and rearing of livestock. The state consists of 13 local government areas within three agricultural zones. The Northern agricultural zone comprises of 3 local government area.

The Sample population: The sample population consist of slaughtered cattle across different abattoir and slaughter houses within the agricultural zone.

Sample size: A total of 50 samples were used for the study. The characteristics of the sampled cattle was considered before slaughtered.

Sample Collection: Samples collected include muscle, kidney, liver, intestine and hide from randomly selected bulls and cows of different ages from central abattoirs of Northern Agricultural Zone of Nasarawa state. The samples were labeled and put in a polyethylene bags, preserved in an ice pack and transported to the research laboratory of National Research Institute for Chemical Technology, Zaria, Nigeria.

Sample Preparation: The frozen samples collected were placed in a watch glass and allowed to thaw at room temperature before the digestion process.

Samples Digestion: The samples of intestine, muscle, liver, hide and kidney from cattle were analyzed using Atomic Absorption Spectrophotometer (Manufactured by Shimadzu, Model AA 6800, Japan) in the laboratory of the National Research Institute for Chemical Technology, Zaria, Nigeria. The tissues were weighed and decomposed by wet digestion method for the determination of lead, chromium, nickel, copper and cadmium residues as described by Clark (1989).

Analysis of samples: VGP Model AA 6800 Atomic Absorption Spectrophotometer was used to analyze the concentrations of heavy metals in the digested samples. A calibration of the AAS was done with standard solutions after which they were aspirated into the AAS apparatus for analysis.

Data Analysis: Concentration of Pb, Cd, Ni, Cu and Fe 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.

III. Results

The distribution of samples is presented in table no 1. From the total number of tissues examined, 38 (76%) were from young cattle while 12 (24%) were older cattle. Male were 5 while female were 45. It was therefore observed that most of the cattle slaughtered in the abattoir female, the male are usually reserved for festival as shown by the study of Sabuwa *et al.* (2019).

Table no 1: Shows Distribution of cattle examined according to age and sex

Parameters	Number examined	Percentage (%)
Age		
Young	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 no 2 present the mean concentration (mg/kg) of heavy metals as affected by organs. All the tissue samples had concentrations of heavy metals detected above 0.00 mg/kg with the exception of intestine and skin which had Cr concentration below 0.00 mg/kg.

Table no 2: Shows mean concentration (mg/kg) of heavy metals in cattle as affected by type of organ

Parameters	Intestine	Kidney	Liver	Muscle	Skin	SD	SEM	LOS
Nickel	0.3361	0.1783	0.2297	0.2228	0.1131	0.3376	0.0478	Ns
Copper	0.0044	0.0024	0.0010	0.0015	0.0013	0.0056	0.0008	Ns
Chromium	-0.5288	1.0599	4.0485	1.1254	-1.3235	5.2198	0.7382	Ns
Lead	0.0601	0.0107	0.0616	0.0114	0.0513	0.0704	0.0010	Ns
Cadmium	0.0015	0.0017	0.0019	0.0027	0.0029	0.0021	0.0003	Ns

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

The mean concentration of Ni, Cu, Cr, Pb and Cd from tissues of slaughtered cattle from Northern agricultural zone of Nasarawa state according to sex is presented in Table 3 below. Standard deviation, level of significant and standard error of means are also presented. All the samples were detected above concentration of 0.00mg/kg from both male and female cattle.

Table no 3: Shows mean concentration (mg/kg) of heavy metals in cattle as affected by sex

Parameters	Male	Female	Standard deviation	Standard error of mean	LOS
Nickel	0.2952^{a}	0.0312^{b}	0.3376	0.0477	*
Copper	0.0019	0.0027	0.0056	0.0008	Ns
Chromium	0.5955	1.5314	5.2198	0.7382	Ns
Lead	0.0492	0.0152	0.0704	0.0100	Ns
Cadmium	0.0021	0.0022	0.0021	0.0003	Ns

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

The mean concentration of heavy metals as affected by age is represented by table no 4. Although, high concentrations of Ni, Cu, and Cd was detected in older cattle than in young cattle, there exist no significant difference (P > 0.05) in the concentration of heavy metals in both young and adult cattle.

Table no 4: Shows mean concentration (mg/kg) of heavy metals in cattle as affected by age

Parameters	Young	Old	SD	SEM
Ni	0.1435	0.2885	0.3376	0.0477
Cu	0.0015	0.0028	0.0056	0.0008
Cr	1.2749	0.4777	5.2198	0.7382
Pb	0.0506	0.0274	0.0704	0.0100
Cd	0.0014	0.0029	0.0021	0.0003

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)

IV. Discussion

The distribution of cattle slaughtered in Northern Agricultural Zone of Nasarawa state, North Central Nigeria indicates that cattle slaughtered from the study area were mostly female, this is in contrast with the study of Okareh and Oladipo (2015) conducted in Southern Nigeria who showed that majority of cattle slaughtered in the abattoir were male. Our findings further revealed that most of the male cattle were kept and reserve for festivals, mostly is the unproductive female that were presented to the abattoir for slaughter in the study area.

The highest concentration of heavy metal detected was Cr from female cattle while Cd was lowest. The mean concentration of Ni in male and female cattle is 0.2952 and 0.0312 respectively. Significant high concentration of Ni was obtained in male cattle when compared with the levels from female cattle. The concentration of Cd, Pb and Cr are within the permissible limit recommended by WHO/AO when compared with the study of Masoumeh Ariyaee *et al.* (2015) conducted in the Republic of Iran where they reported mean concentration (mg/kg) of Cd, Pb and Cr above the permissible recommended limit. Generally, they recorded significantly higher concentrations of Cd, Pb and Cr in tissues of both male and female cattle when compared with this study conducted in North Central Nigeria. The concentration of Pb is higher in male than in female cattle, this finding is at variance with that of Masoumeh Ariyaee *et al.* (2015) who showed that female cattle bio-accumulate Pb in their tissues more than male cattle. However, our study is in agreement with their findings that female cattle accumulate Cr and Cd in their tissues than male cattle. Male cattle have significantly higher mean concentration (mg/kg) of Ni than female cattle, this could be due to the large body mass of male cattle compared to the body mass of female cattle. The concentration of Cu in female cattle is almost two times higher than the male cattle. This is contrary to the study of Milam *et al.* (2015) where high concentration of Cu in bulls was observed than in cows. The high levels of heavy metals in the tissues of female cattle may be due to the fact that female cattle have higher age and tends to stay longer thereby accumulating more heavy metals in their tissues (Rahimi and Rokni 2008). The mean concentration (0.0152 mg/kg) of Pb in female animal is over three times lower than the mean concentration (0.0492 mg/kg) in male. This is in contrast with the study of Sabuwa *et al.* (2019) who reported that female cattle tend to accumulate high levels of Pb in their tissues than male. No significant difference exist in the concentrations of Ni, Cu, Cr, Pb and Cd between male and female cattle.

Liver bio-accumulate more heavy metal (Cr) while least concentration (mg/kg) of heavy metals is detected in the skin. The findings from our study is not in pact with the studies of Milam *et al.* (2015) and Akan *et al.* (2010) who showed that the Kidney bio-accumulate heavy metals more than any organs of the body. The mean concentrations (mg/kg) of Cr in Kidney, liver and muscle is 1.0599, 4.0485 and 1.1254 respectively. These values far exceed the statutory recommended limit by WHO/FAO. This is similar to the findings of Masoumeh *et al.* (2015) where high concentrations (mg/kg) of Cr was detected in tissues of slaughtered cattle above the permissible limit. 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 significant high concentrations (mg/kg) of Cr in all the sampled tissues may indicate that the cattle were recently exposed to Cr contaminated feed and/or Cr contaminated environment as a result of anthropogenic activities. This is in line with the findings of Tchounwou *et al.* (2012) who show that Chromium enters into various environmental matrices (air, water and soil) from a wide variety of natural and anthropogenic sources with the largest discharge coming from industrial source. Environmental exposure to Cr containing compounds has shown by Goyer (2001) to cause renal damage, allergy and cancer of the respiratory tract. Chromium is highly toxic with mainly pollute the environment through industrial source. It has been classified as carcinogen by several regulatory agencies (UEPA, 1992).

The concentration of Cd is highest in skin and muscle when compared with the concentration (mg/kg) observed in livers and kidneys, this study differ with the findings of Massanyi *et al.* (2001) who confirmed that Cd have lower ability to accumulation in ruminants muscles in comparison with kidneys and livers.

The concentration of Pb is highest in Liver (0.0616 mg/kg), followed by the intestine (0.0601 mg/kg), least concentration was detected in Kidney (0.0107 mg/kg). This is in line with the study of Flora, (2006) who showed that the greatest percentage of lead in the body concentrate more in the liver. The high mean concentration (0.0616 mg/kg) of Pb in the liver than kidney does not tally with the findings of Milam *et al.* (2015) that show that kidney tends to accumulate higher Pb concentration than the liver. All the sampled tissues recorded concentration that is lower than the FAO recommended daily intake of 0.1 mg/kg. 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 were extremely higher than the values obtained from this study conducted in North Central Nigeria. 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.

The high mean concentration of Ni, Cr and Cd was detected in the tissues of older cattle than the young ones is in agreement with the study of Masoumeh (2015) who also observed high Cd concentration in the tissues of older cattle than the young age category. However, our findings about Pb as it relates with age variation does not agree with their study that shows higher concentration of Pb in tissues of older cattle as compared with young cattle. 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 a 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 ($P > 0.05$) exists in the concentration of Cr, Pb and Cd between young and older cattle.

V. Conclusion

With the exception of Cr, it is apparent that the concentrations of Pb, Cd, Cu and Ni from Northern Agricultural Zone of Nasarawa state were generally lower than the minimum toxic level and the populace is not exposed to health risk associated with ingestion of cattle meat. This result is similar to the findings of Sabuwa *et al*. (2019) and the study of Ihedioha JN and Okoye COB (2013) conducted in Enugu state, Southern Nigeria when the dietary intake of lead and cadmium and health risk from consumption of various parts of cattle tissues by the urban population was studied. The values indicate that humans are not exposed to any significant health risk that may be associated with the consumption of tissues from slaughtered cattle in the study area.

VI. Recommendation

There should be continuous advocacy on the need to avoid the grazing of cattle near industrial areas, automobile workshops and any potential heavy metal contaminated areas. Intensive management system should be encouraged through the establishment of cattle ranches and cattle colonies across the country. There is need for the continuous monitoring of the study environment on the levels of heavy metals especially Cr which is highly toxic and has no any known biological significance.

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Sabuwa A.M, et. al. "Detection of Heavy Metals in Selected Organs of Slaughtered Cattle from the Northern Agricultural Zone Of Nasarawa State, Nigeria." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 14(5), 2021, pp. 13-18.