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# Hematotoxicity status of lead and three other heavy metals in cow slaughtered for human consumption in Jos, Nigeria.

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Heavy metals are of public health concern worldwide due to their damaging effects on human and animal health, the environment and life in general. This study assessed concentration levels of some toxic heavy metals: Cadmium (Cd), lead (Pb), copper (Cu) and magnesium (Mg) in blood samples of ten (10) cattle slaughtered in two areas (Jos North and South) of Plateau State, Northern Nigeria. The results were compared with World Health Organization (WHO) standard for heavy metals allowable content in food. The samples were analyzed for Cd, Pb, Cu and Mg in triplicates by Shimadzu Atomic Absorption Spectrophotometer (AA 6800) after wet digestion. The results of the analysis indicated that the levels in parts per million (ppm) range from 0.4169 to 3.0302 for Pb; 0.0067 to 0.0204 for Cd; 0.1112 to 0.9845 for Mg and 0.0027 to 0.0326 for Cu. The mean concentration of Pb was found to be higher than the WHO acceptable limit, while Cd, Cu and Mg were within the WHO acceptable limit. The high value of Pb might be attributed to impact of environmental pollution from diverse mineral resource base of Jos metropolitan city and this has health implication on consumers.

**Key words:** Toxicological status, health implication, heavy metals, blood, abattoir.

## INTRODUCTION

Heavy metals are of global concerns due to their destructive effects on animal and environment health (Sanayei et al., 2009; Jaishankar et al., 2014; Shalini et al., 2017). The term heavy metal refers to any metallic chemical element that has a relatively high density, considered to be of sufficient distribution in the environment and is toxic or poisonous at low concentrations (Shirkhanloo et al., 2011). These metals

are highly toxic and can cause damaging effects even at very low concentrations; with chronic exposure, it poses serious health consequences (Choudhary, 2012; Shalini et al., 2017). Health issues such as brain damage, anaemia and kidney malfunctioning have been reported (Zheng et al., 2003; Ogamba et al., 2016). Based on health importance, Raikwar et al. (2008), classified heavy metals as essential (Cu, Zn, CO, Cr, Mn and Fe); non-

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essential (Ba, Al, Li and Zr), less toxic (Sn and Al) and highly toxic (Pb, Hg, Cd and As). Industrialization, urbanization and socio-economic activities have increased the levels of heavy metals; technological advances in medicine have increased the level of heavy metals used therapeutically in medicine (Al, Bi, Au, Ga, Li and Ag) including the alloy of silver-mercury used as tooth amalgam (Abulude et al., 2006; Ekpo et al., 2008; Choudhary, 2012; Ogamba et al., 2016; Shalini et al., 2017).

Assessment of ground water heavy metal levels in various states of Nigeria have been reported (Ibe et al., 2005; Okonko et al., 2008; Shittu et al., 2008; Agbabiaka et al., 2010; Oparaocha et al., 2010; Nkamare et al., 2012). In Nigeria, heavy metals such as lead, mercury and arsenic exposure is a public health concern as evidence abounds on its effect on the cognitive development of children (Abulude et al., 2006). Sources of heavy metals are many and varied (Sanayei et al., 2009; Shir Khanloo et al., 2011; Adegbola et al., 2015). The food chain is an important source of heavy metals accumulation (Jolly et al., 2013), especially for plants grown on polluted soils (Pilarczyk et al., 2013). Sometimes, they become concentrated in soil, water or in air and they are taken up by plants (Ogabiela et al., 2011; Orisakwe et al., 2012) and ingested by humans when they eat animals grazed in areas of increased industrial activities or contaminated pastures (Okada et al., 1997; Salem et al., 2000). Significant amounts of heavy metals (Cd and Pb) can be transferred from contaminated soil to plants and grass, causing accumulation of these potentially toxic metals in grazing ruminants, particularly in cattle (López et al., 2003; Miranda et al., 2005). Since heavy metals are readily transferred through food chains into humans or from domesticated animals to humans through contaminated pastures with potential health risk (Tabari et al., 2010), heavy metals contents in biological fluids could be used as important indicator of environmental pollution (Abulude et al., 2006). The residual concentrations of heavy metals in cow blood could be an important "direct indicator" of the safety status of cow meat consumed, as well as an "indirect indicator" of the degree of pollution of the environment in which the cow was bred. One of the main problems with metals is their ability to bio-accumulate in plant (Bhatti et al., 2016) and animals (Akbar-Jan et al., 2011; Chowdhury et al., 2011; Lotfy et al., 2013; Abd El-Salam et al., 2013; Li et al., 2015; Ogamba et al., 2016).

Lead is the most commonly reported heavy metal poisoning in livestock and cattle is the most susceptible. Lead levels above the maximum acceptable concentrations in meat (0.11 mg/kg), milk (0.020 mg/kg) and other products from cattle make these products unsafe and unfit for human consumption. The lead maximum limit for blood is 0.05 mg/kg and animal at this limit or above is unfit for human consumption and animal below this limit should be observed for a year before

human consumption. Cattle are exposed to sources of lead by ingestion. Likely sources of exposure include: discarded lead acid batteries, lead based paints, ashes from burnt objects painted with lead based paints, mine tailings, sump oil, posts painted with sump oil, linoleum, grease, lead weights, lead shots, oil filters, lead light windows and lead fittings used in water pipes. Cattle can have elevated levels of lead in their blood without showing any outward signs of clinical disease. The blood lead levels in these cattle can remain elevated above the maximum acceptable concentration of 0.11 ppm for an extended period of time. All age groups of cattle can be affected; however young calves are more vulnerable because they absorb more as compared to older cattle and their brain is still developing. Lead is a very stable metal and will remain in soil indefinitely. Cattle and especially calves find the metal tasty and will actively lick and consume it. Therefore, lead is a toxic to animals which have access to areas where it has been inappropriately disposed. The toxicokinetics of lead in cattle indicate that oral absorption of lead salts and metallic lead is sluggish and incomplete. Of the ingested lead, only 2 to 10% is absorbed and insoluble lead complexes are excreted in the feces. Lead is rapidly distributed to soft tissues by the blood once absorbed by the gut. Lead is deposited in the kidneys, liver and bone. It can cross the placenta and enter the fetus. Accumulation may occur in the central nervous system of the neonate because of immaturity of the blood-brain barrier. Lead is excreted by active transport into bile and is eliminated in the urine. Secretion into milk and redistribution into bone may also be significant. Bone is the tissue that serves as the long-term storage site for lead. In other species, the initial deposition of lead in bone is at areas of active bone growth, such as the epiphyseal plate. The lead is deposited in cancellous bone and can account for 60% of the total body burden. Tissue distribution and metabolism in the case of field exposures have not been well documented in cattle (Waldner et al., 2002); (Zadnik, 2007).

In the United States, the average blood lead concentration reported is 0.03 mg/L (3 µg/dL) in children aged 1 year and 0.11 mg/L (11 µg/dL) in children aged 5 years. The percentage of lead absorption through the gastrointestinal (GI) tract is variable. Children are at greater risk because they absorbed more lead than adults and their brain is undergoing developmental changes. (United Nation Environment Programme, 1997). Lead absorption is dependent on several factors, including the physical form of lead, the particle size ingested, the GI transit time, and the nutritional status of the person ingesting. Lead absorption is inversely proportional to the particle size; the smaller the particle, the more completely the lead is absorbed. Thus, exposure to lead dust results in higher absorption than exposure to the equivalent amount of lead from chips of lead paint. Lead absorption is augmented in the presence

of iron, zinc, and calcium deficiency. Lead absorption is also augmented by malnutrition, with lead absorption decrease if phosphorus, riboflavin, vitamin C, and vitamin E are in the diet. Low-energy (calorie) intake and high-fat intake have been associated with enhanced lead absorption. Pb has a threshold value of 130.6 mg/kg (of whole soil) for low birth weight (Hong et al., 2016). Lead has several adverse mechanisms of toxicity deleterious to man. Lead has a high affinity for sulfhydryl groups thereby enhancing its toxicity to multiple enzyme systems and its inhibition of cellular function requiring calcium. Lead affinity for calcium-activated proteins is 105 times higher than that of calcium. At cellular sites, the interaction of lead and calcium depends on the concentration of  $Pb^{2+}$  and  $Ca^{2+}$  present. Both ions compete at the plasma membrane for transport systems affecting the integrity of  $Ca^{2+}$  channels and the  $Ca^{2+}$  pump but lead disturbs intracellular  $Ca^{2+}$  homeostasis and possible interaction of both ions ( $Ca^{2+}$  and  $Pb^{2+}$ ) interaction at the mitochondria;  $Pb^{2+}$  interacts with a number of  $Ca^{2+}$ -dependent effector mechanisms, such as calmodulin, enzymes, e.g. phosphodiesterase, protein kinases, protein kinase C,  $Ca^{2+}$ -dependent  $K^+$  channels in the plasma membrane and neurotransmitter release (Tsai and Hatfield, 2011).

Encephalopathy, neuropathy, nephropathy, compromised enzymes functions, increase in blood pressure (a 2-fold increase in blood lead concentration was associated with a 1 mm Hg rise in the systolic pressure and 0.6 mm Hg increase in the diastolic pressure), altered reproductive function, bone abnormalities and disruption of the function of endothelial cells in the blood-brain barrier leading to hemorrhagic encephalopathy, characterized by seizures and coma are some of the burden of lead intoxication (Tsai and Hatfield, 2011; Van der Kuijp et al., 2013). Lead poisoning hampers the pliability and sustainability of communities because of its linkages with several life-long childhood-to-adulthood human health and behavioral disorders (Juarez et al., 2014; Bellinger, 2017).

A total of 70% of protein intake in Africa is from meat consumption (Olatunji and Adeyokunnu, 1973) and Nigeria's per-capita meat consumption is estimated to approximate 6.4 kg (Osho and Asghar, 2005). In a study in South West Nigeria by Okunlola (2012), meat preferences for poultry is 20.66%, beef is 17.96% and fish is 7.07%, but meat consumption pattern for beef is 25.00%, poultry is 20.09% and fish is 62%, and for suya is 40.77%. This reflects the important contribution of meat to human development.

The aim of this investigation is to evaluate heavy metals in blood samples of cows grazed in Jos North and South areas of metropolitan Jos, capital of Plateau state. The evaluation of heavy metals levels of toxicological significance in blood could be an indicator of quality of meat or levels of contamination of animals slaughtered for human consumption.

## MATERIALS AND METHODS

### Study area

Jos in Plateau State Nigeria is located on a plateau that lies between latitudes  $8^{\circ} 22'$  and  $10^{\circ} 24'$  north and longitudes  $8^{\circ} 32'$  and  $10^{\circ} 38'$  east. Thus, Plateau State which derives its name from the Jos Plateau is located right in the center of Nigeria-North central zone. The state's capital is Jos. It covers 8600 km<sup>2</sup> and bounded by 300 to 600 m escarpment around much of its circumference. Jos average altitude is 1280 m with the highest point on Shere Hills about 1829 m above sea level. The state shares common boundaries with the following states: Benue and Nasarawa, in the South West and west, Kaduna in the North West, Bauchi, Gombe and Adamawa in the North East and Taraba in the South East (Wikipedia, Plateau State, [https://en.wikipedia.org/wiki/Plateau\\_State](https://en.wikipedia.org/wiki/Plateau_State)).

Plateau State has a predictable cattle population of 1.07 million within the confines of the Fulani nomads. Transhumance activities occur. A slight less than half of the cattle, graze continually on the cool tsetse-fly free Jos Plateau, while the rest expend the dry season on the rangelands of Benue grasslands and move up to the Plateau in the wet season. The large number of cattle on the Jos Plateau reinvigorated the early formation of a veterinary research center and a dairy factory in Vom. The dairy factory was to provide the short fall in imported dairy products throughout the Second World War. The Vom dairy factory proved so successful that another one was opened soon after at Kumbul in Pankshin. The rapid growth of cattle population on the Jos Plateau has resulted in over-grazing and very stiff competition for land between sedentary farmers and nomadic Fulanis which is often articulated in ferocious clashes between the two groups. These and the grazing-induced soil erosion problems are being tackled through the establishment of game reserves in Wase and twelve other LGAs for settling of the nomads in some form of mixed farming. Olowolafe and Dung (2000) reported that gullies on the Jos Plateau have in many places, been predicated by over grazing of livestock, cultivation, mining activities, etc.

Agriculture is the main stay of the economy, with about 80% of the population engaged in farming in almost all the rural areas. Plateau state has 2,714,700 ha of land (National Bureau of Statistics, 2015). About 1.5 million ha is under cultivation and over two third of the land is arable. The soils are suitable (fertile) for crop production. In view of the favorable conditions, the following major crops are grown: Irish potatoes (of which the State produces over 300,000 metric tons per annum Sweet potatoes, Maize, Rice, Acha (Hungary rice), guinea corn and millet. The state is also known for the production of soya beans, groundnuts, bambaranuts, cowpea and sesame (beniseed). Furthermore, a variety of vegetable crops are grown on the plateau. These include, cabbage, onions, radish, carrots, lettuce, cucumber, tomatoes, sweet melon, green pepper, sweet pepper, green beans, parsley, green peas and garlic. Root crops such as yam, cocoyam and cassava are grown. Also, there are tree crops like, coffee, apple, strawberries, citrus (oranges and lemon) mangoes, guava, bush candle tree (olive tree) and gum arabic.

Plateau State Industrial Development commenced with the formation of a British company known as Amalgamated Tin Mining Company of Nigeria (ATMN) to mine tin, columbite, iron ore and other associated minerals. However, decline in the importance of tin in the world market, led to the collapse of the company. In spite of the decline of tin mining companies, Plateau State government has been trying to lay a solid foundation to facilitate sustainable industrial development in the state. Plateau state is associated with mining which started as far back as 1902. Tin, columbite and associated minerals have been exploited for over a century. Thus, the Jos city is nicknamed "TIN CITY" (Ministry for Special Duties

**Table 1.** The concentration levels (ppm) of heavy metals in cow blood.

Elements (ppm)	Jos North	Range in Jos North	Jos South	Range in Jos South
Lead (Pb)	1.686 ± 1.19	0.417 - 3.032	1.961 ± 0.281	1.762 - 2.160
Cadmium (Cd)	0.013 ± 0.005	0.007 - 0.020	0.013 ± 0.007	0.007 - 0.020
Magnesium (Mg)	0.697 ± 0.505	0.111 - 0.949	0.505 ± 0.162	0.337 - 0.661
Copper (Cu)	0.016 ± 0.013	0.003 - 0.033	0.019 ± 0.012	0.001 - 0.013

Concentration of heavy metals is in this order: Pb > Mg > Cu > Cd. The mean concentration of Cd, Mg and Cu are below maximum acceptable limits, while lead is above maximum acceptable limits. PPM: part per million.

and Mineral Development, 2008). Apart from tin and associated minerals, the state is richly endowed with a large number of other valuable mineral resources. For example: Kaolin, Feldspars, Barytes, Galena, Tantalite and Sphalerites. These have continued to arouse and attract local and international attention (Plateau State Government, 1991).

The industries includes: blacksmithing, pottery, bakeries and leatherworks at Naraguta Village. Manufacturing industries include: Jos International Breweries-(JIB), Zalaki Flour Mills, NASCO Group of companies, West African Milk Company (WAMCO) located at Vom, Nigerian Electric Supply Company (NESCO), Europharm Company Limited-Anglo-Jos, Grand Cereals, Standard Biscuits and Spring Waters of Nigeria (SWAN). Others are the Nigerian Associated Best Feeds, Vita foam, Nigerian Bottling Company, Nigerian Standard and Plateau Bottling Company.

### Reagents and solutions

Nitric acid (HNO<sub>3</sub>), distilled water, deionized water was used. The chemicals and reagents used for the analysis were of high grade and deionized water was used in preparation and dilution of all the solutions. All working solutions were prepared by de-ionized water.

### Sample collection

Samples were evaluated between August to September, 2012. Blood was collected randomly from beef cattle (age between 4 and 5 years) breed on grasses grown in the area of study. Blood samples were collected from the cow slaughtered routinely in Abattoir in Jos North and Jos South both in Plateau state for human consumption. Fresh blood samples (10 mm) were collected via jugular venepuncture using sterilised 10 mm syringe into sterilized 20 mm commercially available plain lithium heparin labelled polyethylene blood tubes immediately as the cattle were slaughtered. Ten (10) cows were sampled: seven (7) males and three (3) females from Jos North Abattoir, and two (2) females and one (1) male from Jos South abattoir, respectively in Plateau state. The samples were then preserved in ice and transported to the laboratory for analysis.

### Sample preparation

The collected samples were decomposed by wet digestion method for the determination of various metals. First of all, the glass wares used in the experiment were washed with distilled water, followed by rinsing with deionized water and nitric acid and then allowed to dry. The method of Nwude et al. (2010) was utilised with modification of procedures of digestion as follows: ten (10) gram of each blood sample was introduced into a 50 mm conical flask.

Thereafter, 5 ml of nitric acid was added to the sample, and

digested by heating on a hot plate, until dryness at 100°C for about 2 h. Deionized water (50 ml) was added, then thoroughly shaken and filtered with Whatman filter paper, into a 100 ml volumetric flask. A clear filtrate was obtained; this filtrate was then made up to mark with deionized water.

### Metal analysis using AAS

The Atomic Absorption Spectrophotometer (AAS), Model AA 6800 (Shimadzu, Japan) equipment with graphite furnace and background corrections (SR-BDG) was used for metal analysis. The flame condition was optimized for maximum performance and linear response while aspirating known standard. The calibration standard solution was prepared from individual 1000 ppm stock solution (Scharlab S.L, Spain). A suitable hollow cathode lamp for each of the element was mounted after the instrument was allowed to warm for thirty minutes and the current adjusted to the recommended value at a specific wavelength at the National Research Institute for Chemical Technology (NARICT) Zaria, Kaduna State. All the spectroscopic measurements of the standard metal solutions as well as the sample solutions were done at their respective wavelength of maximum absorptions  $\lambda$  max. The accuracy of the instrumental methods and analytical procedures were checked by running the samples in triplicates. The sample was aspirated to the flame and the absorbance noted. The absorbencies obtained were compared with the calibration standard from where the concentration of the element was computed and compared with standard guideline values as shown in Appendix Table 1. The following elements were determined in the samples: Cadmium, lead, copper and magnesium.

### Statistical analysis

The data obtained from the chemical parameters were statistically analysed by Graphpad Prism 5 (GraphPad Software Inc., San Diego, California USA). Results are expressed as means ± standard error of mean (SEM). A *p* value of < 0.05 was considered significant. Comparison of levels of heavy metals obtained in this experiment with WHO standards is shown in Appendix Table 1.

## RESULTS

The mean concentration (ppm) of heavy metals in blood samples (n=3) of 10 cattle analysed for the presence of lead (Pb), cadmium (Cd), copper (Cu) and magnesium (Mg) is shown in Table 1. The level of Pb in the blood range from 0.4169 to 3.0320 ppm for cattle from Jos North and 1.762 to 2.160 in cattle from Jos South. Both blood samples exceeded WHO maximum limits for Pb in

**Table 2.** Concentration of heavy metals (PPM) in per cow blood from Jos North and Jos South Abattoir, Plateau State.

Location	Sex	Samples	Pb	Cd	Mg	Cu
Jos North	Male	Ab	0.5306 ± 0.4358	0.0108 ± 0.0006	0.8982 ± 0.0447	0.0083 ± 0.0035
	Male	Bb	0.4737 ± 0.4283	0.0129 ± 0.0024	0.7270 ± 0.0063	0.0040 ± 0.0024
	Male	Cb	0.4169 ± 0.4130	0.0110 ± 0.0004	0.7770 ± 0.0052	0.0332 ± 0.0027
	Male	Db	2.4820 ± 0.3600	0.0199 ± 0.0036	0.1112 ± 0.0108	0.0027 ± 0.0033
	Male	Eb	1.9520 ± 0.2942	0.0179 ± 0.0034	0.9485 ± 0.0176	0.0252 ± 0.0065
	Male	Fb	3.0320 ± 0.6350	0.0110 ± 0.0026	0.7919 ± 0.0117	0.0279 ± 0.0058
	Male	Gb	2.9180 ± 1.0350	0.0067 ± 0.0046	0.6236 ± 0.0022	0.0085 ± 0.0081
Jos south	Female	Hb	2.1600 ± 0.9535	0.0204 ± 0.0039	0.3367 ± 0.0008	0.0326 ± 0.0046
	Female	Ib	1.7620 ± 0.5158	0.0101 ± 0.0036	0.5189 ± 0.2032	0.0118 ± 0.0011
	Male	Jb	ND	0.0074 ± 0.0036	0.6606 ± 0.0098	0.0126 ± 0.0031

Values above are presented as mean ± SEM, n=3; ppm, concentration in parts per million; ND, not detectable. Sample code of blood samples collected from the animals: Ab, Bb, Cb, Db, Eb, Fb, Gb, Hb, Ib and Jb.

food which is 0.10 ppm. The mean concentration of Cd in the blood range from 0.007 to 0.0204 ppm for cattle from Jos North and 0.007 to 0.020 ppm for cattle from Jos South. The mean concentrations of Cd in the blood samples are below the WHO maximum limits of Cd in food, 0.05 ppm. The mean concentration of Mg in the blood samples of cow ranges from 0.111 to 0.949 ppm in cattle from Jos North and 0.337 to 0.661 in Jos South. The mean concentrations of Mg are below the WHO maximum acceptable limits for Mg which is 50 ppm. The level of Cu in the blood range from 0.003 to 0.033 ppm in the cattle from Jos North and 0.001 to 0.013 in cattle from Jos South; the values are below the WHO maximum limit for Cu in food which is 0.5 ppm. The results of heavy metals per cattle is summarize in Table 2.

## DISCUSSION

The purpose of this investigation is to evaluate routinely, the heavy metals status of blood samples of cows grazed and butchered for human consumption in metropolitan Jos (North and South areas), capital of Plateau State. Random sampling of blood collected from cow slaughtered in Jos North and South abattoirs for toxicological analysis following standard procedure was done. The study is of toxicological significance as it could serve as an indicator of quality of meat and or levels of heavy metals contamination of animals slaughtered for human consumption.

Haematotoxicity profile of heavy metals level depends on the bio-accessibility rate (Khan et al., 2008) and is an index reflecting extent of environmental exposure in a population and a significant factor in public health assessment (Fergusson, 1990). Lead concentration was found to be high in all the cattle blood analysed. Other studies quantifying levels of heavy metals in cattle revealed high levels of Pb in cow blood (Nwude et al.,

2011; Ogabiela et al., 2011). Determining likely sources of these high exposure levels will have significant implications for future public health and risk reduction measures. Jos in Plateau state is rich in mineral resources (MSDMD, 2008; Plateau State Government, 1991) hence mining activities are common practice. Exploitation and exploration of mineral resources might in part underpin high Pb content in the environment, and long-term accumulation of Pb in soils, grasses and other forage consumed by animals. Animals, particularly cattle are most commonly exposed to lead through ingestion of contaminated feed and plants along roadsides and highways which may in part explain the high Pb levels in cattle blood. Another route of possible source of exposure to Pb is industrial waste contamination; automobile emission of organic lead sources (organoleads) such as tetramethyl and tetraethyl lead found in leaded petroleum products. Cattle are most commonly exposed to Pb through ingestion of discarded automotive batteries, farm machinery grease or oil, roofing felt or lead-based agricultural paints, and chalks or putties (Gwaltney-Brant, 2004).

The problem of lead poisoning in animals has widely been recognized. Lead is known to bioaccumulate in different organs such as bones, liver, kidney and brain. Direct ingestion of Pb contaminated meat will no doubt increase blood Pb levels; a significant correlation between elevated blood Pb levels and the risk of anemia have been reported (Singh et al., 1994; Ahmed et al., 2007). In addition, accumulation of Pb in the body is a significant source of blood Pb burden (Swarup et al., 2005) with associated health risks such as nausea, vomiting, diarrhoea, sweating, convulsions, coma and death (Shirkhanloo et al., 2011); cancers of stomach, small intestine, large intestine, ovary, kidney, lungs, myeloma, all lymphoma and all leukaemia (Reddy et al., 2004). Lead is commonly distributed to sites where calcium plays an important role, most conspicuously in

the teeth of developing children and in bone at all ages (Choudhary, 2012) and it inhibits the protein biosynthesis and is also known to affect the kidneys, brain cells, central nervous system, kidneys, liver and the reproductive system (Ademoroti, 1996).

Accumulation of Pb and Cd in ruminants are reported to causes toxic effects in cattle, but also in humans when toxic metals contaminated meat and milk are consumed (González-Weller et al., 2006; Cai et al., 2009). Blood lead levels reared around polluted localities is increased in lactating cows (Swarup et al., 2004). Lead and Cd are amongst the elements that have caused the most concern in terms of adverse effects on human health (Cai et al., 2009; Fowler, 2009; Jarup and Akesson, 2009). This is because they are readily transferred through food chains and are not known to serve any essential biological function. Lead is a pervasive and widely distributed environmental pollutant with no beneficial biological roles. The poisoning is more common in farm ruminants, which are considered most susceptible to the toxic effects of lead (Swarup et al., 2005). For that reason, the concentration of Pb and Cd in cow's blood should be monitored to ensure protection of consumers' health (Jen et al., 1994).

These metals are stable elements, hence bioaccumulate (Akbar-Jan et al., 2011) easily because they cannot be metabolized by the body, making it easy for them to pass through the food chain to humans. Heavy metals become toxic when they accumulate beyond the permissible levels and can cause profound biochemical changes in the body. Children are at more risk than young ones and older adult, because of high sensitivity to heavy metals (Akbar-Jan et al., 2011). The mean concentrations of Cd, Cu and Mg in the blood samples of all the cattle were lower than the maximum acceptable level for each.

Cadmium is reported to be toxic to virtually every system in the animal body. It is almost absent in the human body at birth, however it accumulates with age (Akan et al., 2010). Daily dietary intake of Cd ranges from 40 to 50 µg per day (WHO, 1987). Cadmium does accumulate within the kidney and liver for a long period of time (McLaughlin et al., 1999). Health implications of high cadmium intake are lung damage, reduction in sperm count and renal tubular damage (Ibeto and Okoye, 2009). Copper occurs in food in many chemical forms and combinations, which affects its availability to the animal. It is known to be essential at low concentrations for both human and animals but it is toxic at high levels. The lethal dose of copper for humans is 100 ppm, but when its concentration in food is above 5-7 ppm, it becomes repulsive for human consumption. Thus, there is no danger to humans for copper poisoning (Iwegbue, 2008).

Magnesium is required for energy production, oxidative phosphorylation and glycolysis. It contributes to the structural development of bone and is required for the synthesis of DNA, RNA, and the antioxidant glutathione. Magnesium also plays a role in the active transport of

calcium and potassium ions across cell membranes, a process that is important for nerve impulse conduction, muscle contraction and normal heart rhythm. Assessing magnesium status is difficult because most magnesium is inside cells or bone. Habitually, low intakes of magnesium induce changes in biochemical pathways that can increase the risk of illness over time. Four diseases and disorders in which magnesium might be involved include: hypertension, cardiovascular disease, type 2 diabetes, osteoporosis and migraine headaches (Rude, 2012).

It is important to note at this point that even though Cd, Cu and Mg fell within acceptable limits, a continuous bioaccumulation might be a problem later, hence the need for their consistent monitoring to forestall heavy metal intoxication.

## Conclusion

This study indicated that consumption of cattle and cattle product within Jos metropolis is not completely safe, particularly with the high level of Pb in all the blood samples of cattle screened in both Jos North and South areas. A period of quarantine for heavily leaded animals should be prescribed, they should be feed on clean rations and such animals should be slaughtered for human consumption when the lead level or any incriminated heavy metal status normalises.

The low levels of Cd, Cu and Mg observed do not justify safety of meat consumed as continuous exposure and ingestion of these heavy metals by animal and human, may eventually bioaccumulate, resulting in serious public health hazards. Enforcement of regulations governing mining and industrial activities need revision; establishment of grazing reserves and aggressive public enlightenment of the burden of heavy metals consumption and their health implications are sine qua non if the society is to benefit from this investigation. This way, public health can be guaranteed in Jos metropolitan city, Nigeria.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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## APPENDIX

**Table 1.** Maximum acceptable levels of some heavy metals in food.

Heavy metals	Maximum acceptable levels for food	
	mg/kg	ppm
Cadmium (Cd)	0.05 <sup>a</sup>	0.05
Lead (Pb)	0.10 <sup>a</sup>	0.10
Mercury (Hg)	0.50 <sup>a</sup>	0.50
Arsenic (As)	0.05 <sup>b</sup>	0.05
Copper (Cu)	0.5 <sup>b</sup>	0.5
Magnesium (Mg)	50 <sup>c</sup>	50

Source: (a) Commission regulation (EC) No. 1881/2006 of 19 December 2006. Setting maximum levels for certain contaminants in food stuff. (b) Specification for the identity and purity of food additive and their toxicological evaluation: some emulsifiers, stabilizers and certain other substances. Tenth report of the joint FAO/WHO Expert Committee on Food Additive. Geneva, 11-18 Oct 1966; (c) Drinking water quality standards (Royal Government Gazette, Vol. 95, part 68).