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ASSESSMENT OF HEAVY METAL CONCENTRATION OF SOME HEAVY METALS IN THE BLOOD SAMPLES OF LIVESTOCK FROM ABATTOIR IN KADUNA SOUTH LOCAL GOVERNMENT AREA, KADUNA - NIGERIA

Umoru, P.E.[1*], Omale, P. E [2], Mubarak, M.A [3], Akoji, J.N.[4]

[1,2,3]Department of Chemistry, Faculty of Science, Nigerian Defence Academy, Nigeria.
[4]Department of Chemistry, Baze University Abuja, Nigeria.
[1*]Corresponding Author: peumoru@nda.edu.ng

Abstract

This study was conducted to assess the concentrations of heavy metals in blood samples collected from selected livestock (cows) slaughtered at abattoirs within Kaduna South Local Government Area of Kaduna State. The atomic absorption spectrophotometric technique was used for elemental analysis after the wet acid digestion and health risk assessments were also carried out. The heavy metal content (mg/l) in cow blood samples from Zango abattoir were in the range of 0.404 to 0.418, 0.174 to 0.240 and 0.256 to 0.299 for Cd, Cu and Pb respectively. However in the cow blood samples from Makera abattoir, the heavy metal concentration (mg/l) were in the range of 0.392 to 0.428, 0.032 to 0.128 and 0.252 to 0.351 for Cd, Cu and Pb. Non-carcinogenic analysis indicated that the Target Hazard Quotients (THQ) for all examined metals remained below 1, signifying a lower risk for non-carcinogenic health effects. However, the Cumulative Hazard Index (HI) indicated values surpassing 1 for Pb and Cd in the animal species, suggesting potential health risks due to cumulative exposure. The Estimated Daily Intake (EDI) values for all the heavy metals analysed were below the Reference Dose (RfD). The carcinogenic analysis, concentrations of Cd exhibited an incremental lifetime cancer risk exceeding the allowable limit (10^{-6}), although within the moderate risk limit, while Pb remained within the permissible threshold (10^{-6}). Consequently, this study suggests that the examined animals could represent significant sources of heavy metal exposure for humans over extended periods. Hence the need for implementation of enhanced monitoring and control measures to ensure the safety of livestock products.

Keywords: Heavy metals, Blood samples, Hazard, Carcinogenic, Non-carcinogenic.

1. INTRODUCTION

Environmental pollution caused by heavy metals is a worldwide issue. It is brought about by a variety of natural and human activities, including the disposal of garbage, events such as oil spills, volcanic eruptions, and the usage of chemical fertilizers and pesticides in agriculture. These metals get into the food chain and may have adverse effects on both humans and animals (Matthew *et al.,* 2002). As an indirect way of determining human exposure to foreign toxins, the science of implying the environmental characteristics of a place by looking at the organisms that dwell there is quickly gaining popularity throughout the world Srikanth *et al.* (2004), it is a technique that may be used to determine the concentrations of any manufactured or natural compounds that are currently or have previously been present in the environment.

In Nigeria, domestic animals (such as cattle, pigs, goats, sheep, poultry, etc.) and wild animals are both common sources of animal protein. Heavy metal contamination of these species has been attributed to illicit mining operations, indiscriminate home and industrial waste disposal Dioka *et al.* (2004). There is a chance that some of these waste products from homes, industries, and mining sites have heavy metals that are harmful to both human and animal health. These animals are bred or grazed freely in such polluted conditions. These metals may then bioaccumulate in their blood, tissues, and organs as a result (Chen *et al.*, 2022). Heavy metal contamination of animal feed and human food is a risk due to their toxicity as such the amount or degree in which a substance becomes poisonous; bioaccumulation, i.e., the gradual accumulation of substances; and bio-magnification, that is the condition where the chemical concentration exceeds the concentration required in the food chain Demirezen *et al.* (2006).

Certain heavy metals can exert harmful effects on animals even at low concentrations (Jaishankar *et al.* 2014). One of the first effects of heavy metal toxicity is to mess up the metabolism of trace elements (Lopez *et al.* 2002). Large intakes of both toxic and non-toxic heavy metals can result in reduced litter size and weight as well as organ failure in both humans and animals (Blowes, 2002). Lead, mercury, cadmium, and arsenic are a few of the most common environmental pollutants. When the blood concentration of these metals exceeds 10 g/dl, a variety of clinical symptoms may manifest (Miranda *et al.* 2009). There is evidence that some of these metals are more likely than any other material to poison pets accidentally (Casas and Sordo 2006). Some of these heavy metals can move up to a few kilometers by air transport before they are deposited on the surfaces of plants, soil, and water (Nagajyoti *et al.* 2010). According to Bala *et al.* (2020), ruminants and other animals can be used as indicators of heavy metal pollution in the environment.

1.2 Materials and methods

1.2.1 Sampling Area

Kaduna South, a local government area within the Kaduna Metropolis of Kaduna State, Nigeria, has its administrative headquarters in the town of Makera. This local government area is composed of several wards, including SabonGari, Badikko, UnguwarSanusi, KurminMashi, Kakuri, UnguwarMuazu, Television, Tudun Wada, and Barnawa. Covering an area of 46.2 square kilometers (Km^2) the area is served by two prominent abattoirs, namely Zango Abattoir and Makera Abattoir.

The specific address for Zango Abattoir is Zango Road, Tudun Wada, Kaduna, within the Kaduna South Local Government Area of Kaduna State, Nigeria. The geographical coordinates of this study area are approximately 10° 36' 33.5484" N latitude and 7° 25' 46.2144" E longitude. Furthermore, Makera, located in Kakuri within Kaduna South Local Government Area, is positioned at approximately 10° 28' 10.471" N latitude and 7° 24' 7.410" E longitude

1.2.2 Sample collection

The blood collection process was carried out using the venipuncture procedure, as outlined by Charles *et al.* (2017). The animal's neck was left shaven and held in an extended posture. The jugular veins are located 2 to 4 mm lateral to the sternoclavicular joint and have a bluish appearance. A 21-gauge needle was inserted in the caudocephalic direction (back to front). Five milliliters of blood samples was withdrawn slowly and introduced into heparinized tubes in order to prevent coagulation of the blood samples. This was done for 2 cows from Zango abattoir and 2 cows from Makera abattoir based on their breed. The blood samples were then placed on ice and taken to the laboratory for further analysis.

1.2.3 Sample preservation

The preservation of blood for analysis is a critical step in ensuring accurate and reliable results. In this study, the blood samples were carefully preserved by pouring them into heparinized tubes coated with ethylenediaminetetraacetic acid (EDTA). The use of heparin helps prevent coagulation, maintaining the liquid state of the blood and preserving its cellular and biochemical composition for subsequent analyses. Furthermore, the tubes were placed on ice, providing a controlled and cooler environment to slow down any potential biochemical changes in the blood during transportation to the laboratory. This meticulous preservation process is essential to maintain the integrity of the blood samples, ensuring that the subsequent analyses yield meaningful and representative data regarding the levels of heavy metal toxicants, contributing to the reliability of the study's findings by Barabadi *et al.* (2023).

1.2.4 Blood sample preparation

The conventional wet acid method of digestion as described by Miranda *et al.*(2005) was used. Four mililiter (4.0 ml) of the concentrated Nitric acid (HNO_3) and 2.0 ml of the concentrated Hydrogen peroxide (H_2O_2) were poured into a Pyrex flask containing 2.0 ml of the blood sample, which was then allowed to stand for 15 minutes. Watch glass was also used to cover the flask, and the mixture was then digested at 60–70^oC for 1–2 hours until the disappearance of the yellow fumes. 3.0 ml of concentrated HNO_3 and a few drops of concentrated H_2O_2 were used to treat the digest, followed by subsequent heating at about 80 ^oC on a laboratory hot plate to obtain a clear digested solution. The mixture was then evaporated to a semi-dry mass and thereafter allowed to cool and diluted with 0.2 ml of concentrated HNO_3. The Pyrex wall and watch glass were washed with distilled water and the sample was filtered into a 50 ml volumetric flask and diluted with distilled water to obtain a 50 ml volume. The samples were stored in a refrigerator awaiting Atomic Absorption Spectrophotometer (AAS) analysis.

1.2.4 Blood sample analysis

The computerized Buck Scientific PG 990 Model Atomic Absorption Spectrophhotometer was used to analyze the samples and determine the levels of heavy metals present in the digested material. The concentrations of cadmium (Cd), copper (Cu), and lead (Pb) were evaluated using descriptive statistics; all blanks, standards, and samples were analyzed in duplicate. The blood levels of cadmium (Cd), copper (Cu), and lead (Pb) were computed for the estimation of the mean level and the evaluation of the maximum levels in each group Dapul *et al.* (2014).

1.3 Health Risk Assessment

1.3.1 Non-carcinogenic health risk

a. Estimated daily intake

$$EDI = \frac{C \times IR}{BW} \quad (1)$$

The estimated daily intake can be calculated using equation 1 above Okoye *et al.* (2021), where EDI = estimated daily intake, C = heavy metal concentration, and BW = body weight 63.15 kg for adults (average of both males and females) Akinbile *et al.* (2013). The beef ingestion rate (IR) is 120 g/day for adults Kasozi*et al.* (2018).

b. Target hazard quotient

The Target Hazard Quotient (THQ) values were computed (equation 2) in order to assess the non-carcinogenic potential risks to human health associated with the ingestion of animals contaminated with heavy metals. It can be presented using the following equation and was calculated as the ratio of the average daily metal consumption to an oral reference dosage of each metal (USEPA, 2020):

$$THQ = \frac{EDI}{RfD} \quad (2)$$

Where EDI = the population's average daily metal consumption in mg/day/kg body weight and RfD = the oral reference dosage (mg/kg/day) value for each metal of concern.

c. Hazard index

The total of all the THQs determined for individual heavy metals is the hazard index (HI), which measures the overall human danger associated with the metals (equation 3).

$$HI = THQ_1 + THQ_2 + THQ_3 + \ldots\ldots n \quad (3)$$

1.3.2 Carcinogenic Health Risk

The incremental lifetime cancer risk (ILCR) was then calculated from the ingestion of these metals (Cd, ,Cu, and Pb). This was calculated using equation 4 (Kasozi *et al.* 2018).

$$ILCR = EDI \times CsF \quad (4)$$

Where EDI is the population's estimated daily metal intake in milligrammes per day per kilogramme of body weight (mg/day/kg), CSF is the cancer slope factor in milligrammes per kilogramme per day (mg/kg/day), and ILCR is the incremental lifetime cancer risk over the lifetime of individual heavy metal ingestion.

Result and Discussion

Table 1 shows results of heavy metals detected in cows from Zango abattoir.

Table 1: Levels of heavy metals in the cow samples of studied animals from Zango abattoir

Samples	Cd	Cu	Pb
CZ_1	0.404±0.019	0.240±0.410	0.256±0.074
CZ_2	0.418±0.026	0.174±0.041	0.299±0.013
Mean Values	0.411±0.023	0.207±0.225	0.277±0.0435

Key: CZ_1 and CZ_2 = cow from Zango abattoir

The range of cadmium (Cd) concentrations observed in the blood samples, from 0.404 to 0.418 mg/l as shown in Table 1, displayed marked differences compared to previous findings. The value from this study was high when compared to concentration in mg/l range of Cd in blood (0.001 – 0.019) reported by Lucky and Temitayo (2017), but lower to the mean blood Cd levels of 5.67mg/l reported by Okareh and Oladipo (2015) in their study conducted in cows from Southern Nigeria. Tomza-Marciniak *et al.* (2011) detected a mean blood Cd concentration of 0.0007mg/l from inorganically raised Friesian cows in Poland, which was lower than that obtained from this study.

The mean cadmium concentration in the blood of cows, reported as 2.12±1.54 mg/l for those reared and predominantly fed on grasses around Challawa industrial area Kano, and 2.81±0.90 kg/l for cows around Zango area, Zaria Nigeria Ogabiela *et al.* (2011), was higher than the values obtained in the present study. The obtained result was higher than that reported by Nwude *et al.* (2010 and 2011) in their study on blood heavy metal levels in cows slaughtered at Awka abattoir, where values ranged from 0.004 to 0.02 mg/l. Moreover, while remaining lower than the allowable limits established by NESREA (2017) set at 1.00 mg/l, the Cd levels in this study were also below the 0.50 mg/l limit for cadmium in blood set by WHO (2010). The disparities in Cd concentrations could stem from various factors influencing the study's outcomes. These might include regional differences in environmental exposure to cadmium, variations in agricultural practices impacting soil and water quality, differences in animal diets, as well as diverse methodologies used in sample collection and analysis (Lu *et al.* 2015).

Environmental factors play a crucial role; for instance, different regions might have varied industrial or agricultural activities that contribute to cadmium presence in the environment. Furthermore, animal dietary habits and geographical differences in soil composition might lead to variations in cadmium uptake and accumulation (Brekken and Steinnes 2004). Additionally, methodological disparities in sample collection and laboratory techniques, as well as the demographic variations among the studied animal populations, could contribute to the observed differences in the recorded cadmium concentrations in blood samples. These multifaceted influences underscore the complexity of factors that can impact heavy metal concentrations in differen t research studies (Hussain *et al.* 2021).

The copper levels in the blood sample were recorded with in the range of 0.174 to 0.240 mg/l, as depicted in Table 1. These values remained below the maximum limit specified by the WHO (2010), which stands at 0.5 mg/l. They were notably higher than the copper concentrations found in cattle from Jos North 0.003 to 0.033 mg/l and Jos South 0.001 to 0.013 mg/l as reported by Nwidu *et al.* (2017). The obtained result was lower than that reported by Nwude *et al.* (2010) in their study on Blood Heavy Metal Levels in Cows Slaughtered at Awka Abattoir, where values ranged from 0.04 to 2.00 mg/l. The observed values were significantly lower than those obtained by Mohajeri *et al.* (2014) in their study on blood metals, hematology, and hepatic enzyme activities in lactating cows reared in the vicinity of a Lead–Zinc smelter, where the result was 3.35 mg/l. Furthermore, the recorded values remained below the maximum limit set by NESREA (2017), which aligns with the WHO threshold at 0.5 mg/l. Elevated copper levels in the blood samples may be linked to the consumption of particular plants, such as subterranean clover (Trifoliumsubterraneum) as identified by Otter *et al.* (2023). This specific plant is recognized for inducing an increased retention of copper, potentially resulting in elevated copper levels in the bloodstream of the animals.

The observed values were found to be below the maximum permissible limits set by WHO and NESREA, indicating that although the levels were higher compared to certain cattle populations studied in Jos North and Jos South Nwidu *et al.* (2017), they still remained within the safe range established by regulatory bodies.

The lead concentration observed in cow blood ranged from 0.256 to 0.299 mg/l as detailed in Table 1. These figures were lower than the values reported by several studies. For instance, Nwude *et al.* (2011) noted a wider range falling between 0.21 to 10.6 mg/kg in previous studies. Additionally, Miranda *et al.* (2005) reported values of 0.403 g/l and 0.402 mg/l for industrialized and rural areas of Northern Spain. The values were higher than Patra *et al.* (2008) who observed values ranging from 0.17 to 1.22 mg/l. Also the values were in line with the findings of a study conducted by Leonidis *et al.* (2010) on heavy metals from cattle farmed near polluting industries in the province of Thessaloniki who observed value was 0.322 to 0.761 mg/l. The observed values also aligned with those reported by Pourjafar *et al.* (2007) in their study on Lead Profile in Blood and Hair from Cattle Environmentally Exposed to Lead around Isfahan Oil Industry, Iran, where values ranged from 0.62 to 0.741 mg/l. notably, and the values in this study surpassed the limit 0.5 mg/l set by NESREA (2017). However they were also lower compared to various other studies.

The results of the study conducted by Nwude *et al.* (2010) in Awka Southern Nigeria on the blood Pb of cows shows a mean concentration of 0.21 to 10.6 mg/l, a value higher than obtained from this study. Tomza-Marciniak *et al.* (2011) reported a lower mean blood Pb concentration of 0.017mg/kg from inorganic raised cows in Poland. However Ketut *et al.* (2017) recorded a maximum blood Pb value of 23.204mg/kg. Also, they obtained a mean Pb concentration of 7.350mg/kg in the blood of cows. Similarly Ogabiela *et al.* (2011) reported in there study from Northern Nigeria high levels of heavy metals from the blood of cattle grazed in polluted environment than those raised in nonpolluted environment. Their obtained mean blood Pb concentration of 0.79 mg/l from the polluted environment is higher than the values from this study. In this study, most lead levels were below the 0.50 mg/l allowable limit for trace metals in blood as established by FAO (2011), with the exception of one cow, a Red Bororo from Zango abattoir, whose value measured at 0.737 mg/l. The disparities in lead concentrations might be influenced by various factors, including differing environmental conditions, industrial activities, soil compositions, and specific agricultural practices in different regions. Variations in sample collection techniques, animal demographics, and analytical methods across studies can also contribute to the differences in the recorded lead levels Skiba *et al.* (2017). The distinct outliers, such as the higher lead concentration in a specific cow, may result from individual animal variations, diet, or exposure to specific environmental factors.

Tables 2: Levels of heavy metals in the cow samples of studied animals from Makera Abattoir

Samples	Cd	Cu	Pb
CM_1	0.392±0.026	0.128±0.041	0.351±0.074
CM_2	0.428±0.033	0.032±0.034	0.252±0.066
Mean	0.410±0.032	0.079±0.064	0.301±0.082

Key: CM_1 and CM_2 = cow from Makera abattoir

The blood samples showed a concentration of Cd ranging from 0.392 to 0.428 mg/l, as depicted in Table 2. The mean cadmium concentration in the blood of cows, reported as 2.12±1.54 mg/l for those reared and predominantly fed on grasses around Challawa Industrial area Kano, and 2.81±0.90 kg/l for cows around Zango area, Zaria Nigeria Ogabiela *et al.* (2011), was higher than the values obtained in the present study.The disparity in results might be due to various factors beyond solely the impact of cadmium intake Chowdhury *et al.* (2018). The value from this study was high when compared to concentration mg/l range of Cd in blood (0.001 – 0.019) reported by Lucky and Temitayo (2017), but lower to the mean blood Cd levels of 5.67mg/l reported by Okareh and Oladipo (2015) in there study conducted in cows from Southern Nigeria. Tomza-Marciniak *et al.* (2011) detected a mean blood Cd concentration of 0.0007mg/l from inorganically raised Friesian cows in Poland, which was lower than that obtained from this study. The reported values align closely with those obtained in a study conducted by Leonidis*et al.* (2010), which investigated heavy metal levels in cattle raised near polluting industries in the province of Thessaloniki. In that study, the concentration of the heavy metal was recorded as 0.379 mg/l. The obtained result was also lower than that reported by Nwude *et al.* (2010) in their study on Blood Heavy Metal Levels in Cows Slaughtered at Awka Abattoir, where values ranged from 0.004 to 0.02 mg/l.

These could include differences in the geographical locations where the samples were collected, variations in the health and diet of the studied animals, or potential changes in industrial activities affecting cadmium exposure in the environment. It's crucial to conduct further research to pinpoint the specific reasons for the differences observed Karar*et al.* (2006). Additionally, the Cd levels identified in this study were below the allowable limit established by NESREA (2017) 1.00 mg/l. Furthermore, these levels were lower than the 0.50 mg/l limit set by the World Health Organization/Food and Agriculture Organization WHO/FAO (2004) but higher than the 0.01 mg/kg reported in the literature by Nwude *et al.* (2011). These differences could also stem from variations in testing methodologies, regional influences, or the characteristics of the animal population under study Karar *et al.* (2006).

The range of copper (Cu) levels in the blood, as presented in Table 2, was found to be between the ranges of 0.032 and 0.128 mg/l. These values were below the maximum limit set by the World Health Organization WHO (2014), which is 0.5 mg/l. However, they differed from previous research conducted by Nwidu *et al.* (2017), who reported Cu levels of 0.003 to 0.033 mg/l in cattle from Jos North and 0.001 to 0.013 mg/l in cattle from Jos South. The obtained result was lower than that reported by Nwude *et al.* (2010) in their study on Blood Heavy Metal Levels in Cows Slaughtered at Awka Abattoir, where values ranged from 0.04 to 2.00 mg/l. values were also lower than the allowable limit set by NESREA (2017) 0.5 mg/l. However the The observed values were significantly lower than those obtained by Mohajeri *et al.* (2014) in their study on blood metals, hematology, and hepatic enzyme activities in lactating cows reared in the vicinity of a Lead–Zinc smelter, where the result was 3.35 mg/l. The difference in results could be attributed to various factors. One possible reason for the disparity in Cu levels could be variations in geographical location and environmental conditions. Copper concentrations in soil and water can vary depending on the region, which can subsequently affect the uptake of copper by plants and animals. It is possible that the areas where the previous study was conducted had lower copper content in their soil and water sources compared to the current study area Laven *et al.* (2007).

Another factor that could contribute to the difference in results is dietary variation among the cattle populations. Cattle may consume different types of forage and plants depending on their grazing habits and availability of vegetation in their respective regions Spolders *et al.* (2010). Furthermore, differences in breed or genetic factors among the cattle populations could also play a role in varying Cu levels. Different breeds may have different abilities to metabolize and excrete copper, leading to variations in blood Cu concentrations. It is possible that the cattle populations in the current study had a higher genetic predisposition for copper retention or absorption.

The lead concentration observed in cow blood ranged from 0.252 to 0.351 mg/l, as detailed in Table 2. Interestingly, these figures differed from the values reported by Nwude *et al.* (2010), which ranged from 0.21–10.6 mg/kg in prior studies. Tomza *et al.* (2011) reported a lower mean blood Pb concentration of 0.017mg/kg from inorganic raised cows in Poland. However, Ketut *et al.* (2017) recorded a maximum blood Pb value of 23.204mg/kg. Also, they obtained a mean Pb concentration of 7.350mg/kg in the blood of cows. Similarly Ogabiela *et al.* (2011) reported in there study from Northern Nigeria high levels of heavy metals from the blood of cattle grazed in polluted environment than those raised in nonpolluted environment. Their obtained mean blood Pb concentration of 0.79mg/kg from the polluted environment is higher than the value from this study. The reported values were found to be lower than the findings of a study conducted by Leonidis *et al.* (2010), which investigated heavy metals in cattle farmed near polluting industries in the province of Thessaloniki. In that study, the recorded concentration of the heavy metal was 0.322 mg/l. The variations in lead concentrations among these studies might be attributed to factors beyond solely lead exposure, including differences in sampling techniques, animal breed and health, variations in laboratory methodologies, or regional disparities in lead levels due to environmental influences or other unknown variables Sanders *et al.* (2009). The observed values were also lower than those reported by Pourjafar *et al.* (2007) in their study on Lead Profile in Blood and Hair from Cattle Environmentally Exposed to Lead around Isfahan Oil Industry, Iran, where values ranged from 0.62 to 0.741 mg/l. Furthermore, the reported values from other studies showed a range of lead concentrations. Miranda *et al.* (2005) reported values of 0.403 g/l and 0.402 g/l for industrialized and rural areas of Northern Spain. Additionally, Patra *et al.* (2008) observed values ranging from 0.17 to 1.22 mg/l. These discrepancies could arise from diverse geographical locations, industrial activities, or different methodologies used in the studies Miranda *et al.* (2009). Moreover, the lead levels in this study were generally lower and below the allowable limit for trace metals in blood, set by the Food and Agriculture Organization (FAO, 2002), which is 0.50 mg/l.

Health Risk Assessment

The findings extracted from Table 3, indicated that all recorded Total Hazard Quotient (THQ) values remained below the threshold of 1 (< 1). This suggests that the consumption of animals sourced from these specific abattoirs does not pose a significant risk for non-carcinogenic effects. The data implies an absence of potential adverse health effects upon consuming these animals, as the THQ values falling below 1 indicate a negligible level of exposure to non-carcinogenic health risks, as reported by Antoine *et al.* (2017).

Table 3: Samples, chronic daily intake and total hazard quotients

SAMPLES	METALS	CDI	THQ
Cz	Cd	0.00082	0.82
Cm		0.00078	0.78
Cz	Cu	0.00051	0.013
Cm		0.00015	0.004
Cz	Pb	0.00074	0.21
Cm		0.00057	0.16

Keys
Cz = Cows from Zango Abattoir
Cm = Cows from makera Abattoir

The Hazard Index (HI) values calculated from the heavy metals present in the blood samples (as detailed in Table 4 exhibit varying levels of potential risk. The Hazard Index (HI) for Cadmium (Cd), the calculated HI is notably high at 3.190, suggesting a higher potential risk level. This could be associated with agricultural practices involving the use of cadmium-based fertilizers or potential soil contamination, contributing to increased Cd levels in the blood samples Khatun *et al.* (2022). The Hazard Index level for Copper (Cu) is determined as 0.0098, representing a relatively low potential risk level. In contrast the Hazard Index (HI) for lead which was calculated at 1.390 surpassing the threshold of one, signifying a moderate level of potential risk. Reasons for this include potential contamination from anthropogenic sources that impact the environment, leading to increased lead exposure Khatun *et al.* (2022). These differences in potential risk levels among the metals might be due to varying exposure levels, likely stemming from different anthropogenic sources or specific agricultural practices related to each metal.

Table 4: Hazard index of metals calculated

Metals	HI
Cd	3.190
Cu	0.0098
Pb	1.390

The values listed in Table 5 represent the standard reference dose and cancer risk factor for various metals, respectively USEPA. (2020).

Table 5: Oral reference dose and cancer risk factor of various metals respectively

Metals	CSF	RFD
Cd	0.38	0.001
Cu	……	0.04
Pb	0.0085	0.0035

Table 6 provides data on the Incremental Lifetime Cancer Risk (ILCR) associated with various metals for different samples. The ILCR values are presented in terms of their magnitude (in 10^{-6} or 10^{-3}) and indicate the potential risk of cancer over a person's lifetime due to exposure to these metals.

For cadmium (Cd), the ILCR values for the samples are consistently within (10^{-4}), reflecting a moderate incremental lifetime cancer risk across these sources for exposure to cadmium (Pepper *et al.*, 2012). Lead (Pb), the ILCR values for the samples are all within the allowable limit (10^{-6}) set by the United States environmental agency USEPA. (2020), indicating a relatively low incremental lifetime cancer risk for exposure to lead in the samples from these sources. The values for lead are noticeably lower compared to the ILCR values of other metals in the same samples.

Overall, the ILCR values in this table provide insights into the potential cancer risks associated with exposure to these metals. Lead (Pb) generally represents a lower risk, while cadmium (Cd) suggest slightly higher to moderate risks.

Table 11: The Incremental Lifetime Cancer Risk of metals (ILCR)

SAMPLES	METALS	ILCR	SAFE LIMIT	MODERATE RISK
Cz		3.1×10^{-4}	10^{-6}	10^{-3}
Cm	Cd	3.0×10^{-4}	10^{-6}	10^{-3}
Cz	Pb	6.2×10^{-6}	10^{-6}	10^{-3}
Cm		4.8×10^{-6}	10^{-6}	10^{-3}

Conclusion

The study of heavy metal concentration in blood samples of livestock from Abattoirs within Kaduna south local government area of Kaduna state, Nigeria provided insightful information regarding the concentrations of certain heavy metals in the blood of cows slaughtered at Abattoirs in Kaduna South Nigeria. The study revealed elevated concentrations of specific heavy metals Cd, Cu and Pb in the blood of cows. Notably, mean concentrations of all investigated element were below the tolerable thresholds recommended by FAO/WHO. Despite lower levels of Cd and Pb indicating seemingly safe meat consumption, continuous exposure and consumption of these metals may lead to bioaccumulation, posing substantial health risks to both animals and humans.

Throughout this research, the Target Hazard Quotients (THQs) were consistently below 1.0 in all the examined samples. However, the Hazard Index (HI) surpassed 1.0 for Pb and Cd in these samples. Additionally, Cadmium (Cd) displayed the highest Incremental Lifetime Cancer Risk (ILCR) among the samples, with a cancer risk greater than 10^{-4}, while Lead (Pb) exhibited the lowest concentration, with a cancer risk higher than 10^{-6}.

Conflicts of interest

The authors declare no conflicts of interest.

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