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Health Risk Assessment of Heavy Metals (Pb, Cd, Ni,) Consumed in Goat Meat Organs within Kaduna Metropolis, Kaduna State, Nigeria

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Abstract:
Background: *This study was carried out to investigate the level of heavy metals using Atomic Absorption Spectrophotometer (AAS) and to also carry out health risk posed to adult men by heavy metals such as lead (Pb), cadmium (Cd) and nickel (Ni) in goat meat organs sold within Kaduna Metropolis. The concentrations of these heavy meals were assessed on the basis of variation of heavy metals localization in different organs of goat (heart, liver, kidney and muscles) and the calculation of risk assessment parameters such as estimated daily intake of heavy metals (EDI), target hazard quotient (THQ) and target cancer risk (TCR).*
Material and Methods: *Fresh samples of (heart, liver, kidney and muscles) of 20 different slaughtered goats were collected from Zango Abattoir within Kaduna Metropolis. A total number of 81 samples were randomly collected within 3months. These samples were kept in a labelled plastic bag and stored in cooler boxes containing ice blocks before been transferred to the laboratory for preparation and analysis. The collected samples were washed, dried, ashed and digested using HNO_3 and $HClO_4$ and then analysed using atomic absorption spectrophotomer (AAS). Risk assessment of heavy metals was also carried out for the goat meat organs using EDI, THQ and TCR for adult men within Kaduna Metropolis.*
Conclusion: *The concentrations of heavy metals (Pb, Cd, and Ni) obtained in most of the goat meat samples were higher than the safety limits recommended by world health organization (WHO). A health risk analysis based on the Estimated Daily Intake (EDI), Total Hazard Quotient (THQ) and Target Cancer Risk (TCR) revealed that the dietary intake of (Pb, Cd, and Ni) was high as compared to the permissible tolerable daily intake (PTDI) recommended by (WHO). This revealed that adult men in Kaduna Metropolis consuming these organs would not experience significant risk associated with heavy metal poisoning through the consumption of these organs.*

Keywords: *Health Risk Assessment, Heavy Metal, Goat, AAS, THQ, EDI, TCR*

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I. Introduction

The consumption of meat is of immense benefit as it provides a substantially large amount of essential micronutrients to man [1]. Meat is most important source of protein to millions of people worldwide. It is known to be one of the cheapest sources of protein and other essential nutrients required in human diets [2]. Because of its distinctive taste and desirable chemical composition, goat meat is increasingly consumed in Nigeria. As animal foods, it is rich in protein, vitamins and minerals, but contains very little fat, especially cholesterol. This type of meat is no opposing religious and cultural aspects of consumption. Goats have not been eliminated as a kind of animal, but their production was not controlled (statistics on their numbers, selection, manner of keeping and slaughtering, meat quality) [3]. Globally, consumption of goat meat is lower than consumption of beef, but goats undoubtedly serve as a major source of red meat for the people, particularly in developing countries like Nigeria [4].

Heavy metals are naturally present in the environment, their occurrence, however, has gradually been increasing with the increase in industrialization. Accumulation of toxic metals in the environment as a result of pollution by industrial and urban activities has generated global health concerns due to the risks of such chemical ending up in the food chains [5]. The effects of heavy metals toxicity have been described in animals under relatively low concentrations of exposure [6], the earliest effect of heavy metal toxicity is the disruption of trace element metabolism [5,7]**.**

The health risk assessment of heavy metal contamination in goat meat is of great concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentrations

[8,9]. In other cases, contaminated animal feed and rearing of livestock in proximity to polluted environment were reportedly responsible for heavy metal contamination in meat [10,11].

The aim of this research is to determine the level of heavy metals (Pb, Cd, Ni) concentrations in goat meat organs and to assess the health risk associated with the consumption of these meat organs consumed within Kaduna metropolis, Nigeria.

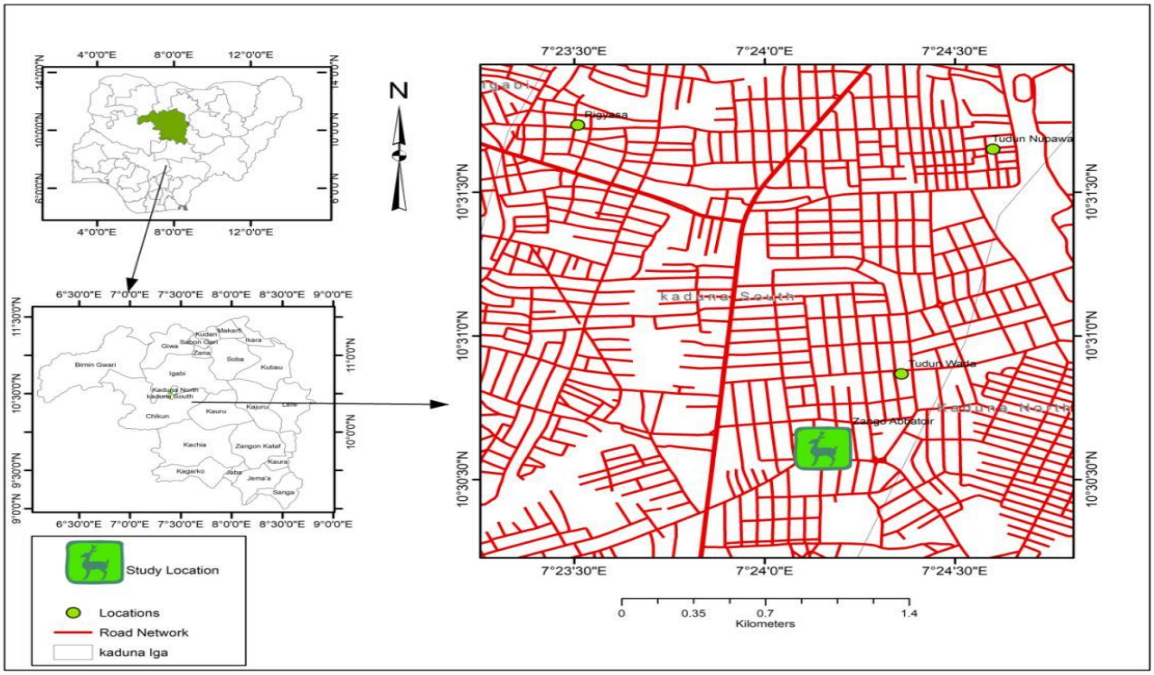
II. Materials and Method

2.1 Study Area

Kaduna state occupies central portion of Northern Nigeria. Founded in 1917 as an administrative headquarters of Northern Nigeria, it is presently one of the most important cities in the country. As at 1991 census it had a population of 993,600 but projected to be about 1.56 million people according to census 2006. Kaduna metropolis has a total land area of about 3,080km^2 (1,190 sq mi) and is located on latitude 10052' north of the equator and longitude 70 44' east of Greenwich meridian. It is located between Latitudes 100 52' and 100 30'N and Longitudes 70 15' and 70 45' east [12].

Kaduna Zango abattoir is located at Zango road Tundun Wada Kaduna, Kaduna south local government area, Kaduna state, Nigeria. This area of study lies on the latitude of 10° 36' 33.5484" N and longitude 7° 25' 46.2144" E.

2.2 Map of the Study Area



Source: Geography Department, Kaduna State University (KASU)

2.3 Sample Collection and Preparation

Goat meat samples comprising of heart, liver, kidney and muscles slaughtered in Zango abbatoir within Kaduna metropolis, Kaduna State were purchased on each sampling day. Eighty (80) organs samples (heart, liver, kidney and muscles) were purchased within the span of three months August to October, 2021. Samples were cut by the butchers using stainless steel knife and put in acid-leached polythene bags and transported to Kaduna Polytechnic, department of chemistry research lab. The samples were placed in the watch glass and dried in an oven at 105^{0}C for six hours until constant weight was maintained. The dried samples were pulverized with a porcelain mortar and pestle and kept in acid leached nylon bags in a desiccator prior to digestion.

2.4 Digestion of Samples

Two (2 g) of each dried meat sample was weighed into a 100 mL polyethylene bottle 10 mL of the digestion mixture (3:2 65%v/v HNO_3 and 70% v/v $HClO_4$) were added to the meat samples [13]. The bottles were tightly closed and the contents were gently swirled and allowed to stand overnight. The samples were heated for 3 hours in a water bath adjusted to 70^{o}C with occasional swirling at 30 minutes interval to ensure complete digestion of the samples. Finally, the digest was allowed to cool and then transferred into a 20 mL

standard flask, rinsing with de-ionized water and later made up to mark with de-ionized water. The solutions were transferred into acid-leached --polyethylene bottles and kept at room temperature until analysis with AAS.

2.5 Risk Analysis of Heavy Metals

The amount of goat meat organs that can safely be consumed on a daily basis is calculated from combining equation for estimated daily intake (EDI) of heavy metals, target hazard quotient (THQ) and target cancer risk (TCR) [14].

2.5.1 Estimated Daily Intake of Heavy Metals (EDI)

The degree of toxicity of heavy metals to human being depends upon their daily intake rate [15]. The estimated daily intake of heavy metals (EDI) will be determined by the equation.

$$\mathbf{EDI}=\frac{Cm \times FIR}{BW} \quad \text{…….. (Equation 1)}$$

Where;
Cm= Concentration (mg/kg),
FIR= Food injection rate **(FIR)** (25g/day) as determined by issuance of food frequency questioneers,
BW= Average BW of adult men is assumed to be 60 kg as set by [16].

2.5.2 Target Hazard Quotient (THQ)

Hazardous Quotients is a complex parameter used for the estimation of potential health risk associated with long term exposure to chemical parameter [15]. The THQ is a ratio of a determined dose of a pollutant to reference dose level. If the ratio is less than 1, the exposed population is unlikely to experience obvious adverse effects. [17], and is based on the equation below:

$$\mathbf{THQ}=\frac{EFr \times ED \times FIR \times Cm \times 10^{-3}}{R_fD \times BW \times AT} \quad \text{……... (Equation 2)}$$

Where;
EFr= Exposure frequency (365 days/year × 53.4 years),
ED=Exposure duration for Adult men 53.4yrs [18],
FIR=Food ingestion rate (g/day/person),
Cm= Concentration (mg/kg),
BW=Average body weight,
AT=Average exposure time (365 days/year EFr × number of years),
R_fD=Oral reference dose for Pb=0.004 mg/kg/day, Cd=0.001 mg/kg/day, Ni=0.02 mg/kg/day [18],

2.5.3 Target Cancer Risk (TCR)

The target cancer risk (TCR) which assesses the potential carcinogenic risks associated with lifetime exposure to carcinogens, was calculated as described by [15], using the formula:

TCR = CSF×EDI ……... (Equation 3)

The CSF is the cancer slope factor set at **Pb**=0.008 mg/kg/day, **Cd**=0.38 mg/kg/day, **Ni**=3.0 mg/kg/day

III. Results and Discussion

Table 1: Concentrations (mg/kg) of Heavy Metals (Pb, Cd, Ni) in Goat Meat Organs for Adult men

HVMs	Organs	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
Pb	Heart	0.74 ±0.2	0.43±0.0	0.71 ±-0.0	0.51±0.0	0.39 ±0.0	0.01± 0.0	0.51±0.1	ND	ND	0.21±0.0
	Kidney	0.07±0.1	0.90±0.5	0.71±0.6	0.97±0.0	0.60 ±0.7	0.22±0.1	ND	0.22±0.1	ND	ND
	Liver	0.01±0.4	0.13±0.1	0.61±0.8	0.74±0.0	0.03 ±0.3	0.82 ±0.1	0.20 ±0.5	ND	0.21±0.2	0.01±0.1
	Muscle	0.00 ±0.4	0.08±0.0	0.56±0.7	0.56±0.0	0.24±0.0	0.39±0.5	0.22±0.0	0.39±0.0	0.02±0.0	0.77±0.1
Cd	Heart	ND	0.12±0.4	ND	ND	0.70±0.1	ND	ND	ND	ND	ND
	Kidney	ND	ND	ND	0.04±0.1	ND	ND	ND	ND	ND	ND
	Liver	0.30±0.7	0.02±0.1	0.32±0.1	0.49±0.5	0.40±0.1	0.10±0.2	0.70±0.0	0.08±0.3	0.70±0.0	0.70±0.0
	Muscle	ND	0.80±0.2	ND	0.20±0.1	0.00±0.0	ND	ND	ND	0.42±0.5	ND
Ni	Heart	0.30±0.1	0.21±0.0	0.90±0.3	0.49±0.5	0.40±0.2	0.24±0.1	ND	0.05±0.0	ND	ND
	Kidney	ND	0.80±0.0	ND	0.29±0.1	0.06±0.0	ND	0.12±0.0	ND	0.70±0.3	0.12±0.0
	Liver	0.10±0.0	0.39±0.2	0.88±0.1	0.02±0.12	ND	0.44±0.0	ND	0.44±0.2	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	0.02±0.1	0.71±0.3
HVMs	**Organs**	**G11**	**G12**	**G13**	**G14**	**G15**	**G16**	**G17**	**G18**	**G19**	**G20**
Pb	Heart	ND	ND	0.02±0.5	0.83±0.1	ND	0.01±0.4	ND	0.01±0.0	0.51±0.4	ND
	Kidney	0.70±0.0	ND	0.21±0.5	0.02±0.4	ND	0.11±0.0	0.03±0.6	0.22±0.8	ND	ND
	Liver	0.01±0.0	0.13±0.0	0.61±0.1	0.74±0.9	0.03±0.2	0.82±0.1	0.00±1.1	0.82±0.0	0.81±0.1	0.01±0.1
	Muscle	0.33±0.4	0.08±0.1	0.06±0.1	0.06±0.0	0.24±0.0	0.39±0.0	0.02±0.0	0.39±0.5	0.02±0.0	0.72±0.0
Cd	Heart	0.04±0.3	ND	0.00±0.7	ND	0.50±0.1	ND	0.00±0.6	ND	ND	ND
	Kidney	0.30±0.8	0.44±0.0	ND	0.99±0.3	ND	0.47±0.9	0.02±0.4	ND	ND	ND
	Liver	0.13±0.1	0.22±0.0	0.01±0.0	0.49±0.6	0.40±0.1	0.99±0.0	0.33±0.2	0.04±0.2	0.70±0.2	0.70±0.3
	Muscle	ND	0.09±0.0	ND	0.20±0.1	0.44±0.3	ND	ND	ND	ND	ND
Ni	Heart	0.01±0.1	0.05±0.3	0.70±0.9	0.09±0.5	0.49±0.1	0.75±0.7	ND	0.09±0.7	ND	ND
	Kidney	ND	0.80±0.0	ND	0.11±0.0	0.06±-0.0	ND	0.87±0.0	ND	0.12±0.0	0.12±0.0
	Liver	0.33±0.3	0.48±0.3	0.07±0.1	0.11±0.4	ND	ND	0.02±0.1	0.44±0.3	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Keys: HVMs;Heavy Metals, Pb;Lead, Cd;Cadmium, Ni;Nickel, ND;Not Detected, G1-G20 (Goat 1-20)

Table 2: Estimated Daily Intake (EDI) of Heavy Metals in Goat Meat Organs for Adult men

HVMs	Organs	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
Pb	Heart	0.31*	0.18*	0.30*	0.21*	0.16*	0.00	0.21*	ND	ND	0.09*
	Kidney	0.03*	0.38*	0.30*	0.40*	0.25*	0.09*	ND	0.09*	ND	ND
	Liver	0.00	0.05*	0.07*	0.31*	0.01*	0.34*	0.08*	ND	0.09*	0.00
	Muscle	0.00	0.03*	0.09*	0.23*	0.10*	0.16*	0.09*	0.16*	0.01*	0.32*
Cd	Heart	ND	0.05*	ND	ND	0.29*	ND	ND	ND	ND	ND
	Kidney	ND	ND	ND	0.02*	ND	ND	ND	ND	ND	ND
	Liver	0.05*	0.01*	0.13*	0.20*	0.16*	0.04*	0.29*	0.03*	0.29*	0.29*
	Muscle	ND	0.33*	ND	0.08*	0.00	ND	ND	ND	0.18*	ND
Ni	Heart	0.13*	0.09 *	0.38*	0.20*	0.16*	0.10*	ND	0.02*	ND	ND
	Kidney	ND	0.33*	ND	0.12*	0.03*	ND	0.12*	ND	0.29*	0.05*
	Liver	0.04*	0.16*	0.37*	0.01*	ND	0.18*	ND	0.18*	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	0.01*	0.30*
HVMs	**Organs**	**G11**	**G12**	**G13**	**G14**	**G15**	**G16**	**G17**	**G18**	**G19**	**G20**
Pb	Heart	ND	ND	0.01*	0.34*	ND	0.00	ND	0.00	0.21*	ND
	Kidney	0.29*	ND	0.09*	0.01*	ND	0.05*	0.01*	0.09*	ND	ND
	Liver	0.00	0.05*	0.25*	0.31*	0.01*	0.34*	0.00	0.34*	0.34*	0.01*
	Muscle	0.14*	0.03*	0.03*	0.03*	0.10*	0.16*	0.01*	0.16*	0.01*	0.30*
Cd	Heart	0.01*	ND	0.00	ND	0.21*	ND	0.00	ND	ND	ND

	Kidney	0.05*	0.18*	ND	0.41*	ND	0.2*	0.01*	ND	ND	ND
	Liver	0.05*	0.09*	0.00	0.20*	0.17*	0.41*	0.14*	0.02*	0.29*	0.29*
	Muscle	ND	0.04	ND	0.08	0.18	ND	ND	ND	ND	ND
Ni	Heart	0.00	0.02*	0.29*	0.04*	0.41*	0.31*	ND	0.04*	ND	ND
	Kidney	ND	0.33*	ND	0.05*	0.03*	ND	0.36*	ND	0.05*	0.05*
	Liver	0.14*	0.20*	0.00	0.05*	ND	ND	0.01*	0.18*	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

**Keys: ***EDI values that exceeded the WHO provisional permissible limit daily intake (PTDI). The PDI for Pb=0.002 mg/kg/day Cd=0.001 mg/kg/day and Ni=0.003 mg/kg/day

Table 3: Target Hazard Quotient (THQ) of Heavy Metals in Goat Meat Organs for Adult men

HVMs	**Organs**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**
Pb	Heart	>1	>1	>1	>1	>1	0	>1	ND	ND	>1
	Kidney	1	>1	>1	>1	>1	>1	ND	>1	ND	ND
	Liver	0	>1	>1	>1	0	>1	>1	ND	>1	0
	Muscle	0	>1	>1	>1	>1	>1	>1	>1	0	>1
Cd	Heart	ND	0.8	ND	ND	>1	ND	ND	ND	ND	ND
	Kidney	ND	ND	ND	>1	ND	ND	ND	ND	ND	ND
	Liver	>1	>1	>1	>1	>1	>1	>1	>1	>1	>1
	Muscle	ND	>1	ND	>1	0	ND	ND	ND	>1	ND
Ni	Heart	1	0.7	>1	>1	>1	0.8	ND	0.2	ND	ND
	Kidney	ND	>1	ND	0.9	0.2	ND	0.9	ND	>1	0.4
	Liver	0.3	1	>1	0.1	ND	0.1	ND	1	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	0.1	>1

HVMs	**Organs**	**G11**	**G12**	**G13**	**G14**	**G15**	**G16**	**G17**	**G18**	**G19**	**G20**
Pb	Heart	ND	ND	0	>1	ND	0	ND	0	>1	ND
	Kidney	>1	ND	>1	0	ND	>1	0	>1	ND	ND
	Liver	0	2	>1	>1	0	>1	0	>1	>1	0
	Muscle	>1	1	1	1	>1	>1	0	>1	0	1
Cd	Heart	>1	ND	0	ND	>1	ND	0	ND	ND	ND
	Kidney	>1	>1	ND	>1	ND	>1	>1	ND	ND	ND
	Liver	>1	>1	0	>1	>1	>1	>1	>1	>1	>1
	Muscle	ND	>1	ND	>1	>1	ND	ND	ND	ND	ND
Ni	Heart	0	0.2	>1	0.3	>1	>1	ND	0.3	ND	ND
	Kidney	ND	>1	ND	0.4	0.2	ND	0.3	ND	0.4	0.4
	Liver	1	>1	0	0.4	ND	ND	0.1	1	ND	ND
	Muscle	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Key: Target Hazard Quotient (THQ) <1 Indicate Non Cancer Health Risk

Table 4: Target Cancer Risk (TCR) of Heavy Metals in Goat Meat Organs for Adult men

HVMS	**Organs**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**
Pb	**Heart**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	ND	0.00
	Kidney	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	ND	ND
	Liver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.09	0.00
	Muscles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Cd	**Heart**	ND	0.02	ND	ND	0.11	ND	ND	ND	ND	ND
	Kidney	ND	ND	ND	0.01	ND	ND	ND	ND	ND	ND
	Liver	0.02	0.00	0.05	0.08	0.06	0.02	0.11	0.01	0.11	0.11
	Muscles	ND	0.13	ND	0.03	0.00	ND	ND	ND	0.07	ND

Ni	**Heart**	0.39	0.26	1.14**	0.60	0.48	0.30	ND	0.06	ND	ND
	Kidney	ND	0.99	ND	0.36	0.08	ND	0.36	ND	0.87	0.15
	Liver	0.12	0.48	1.11**	0.03	ND	0.54	ND	0.54	ND	ND
	Muscles	ND	ND	ND	ND	ND	ND	ND	ND	0.03	0.90
HVMs	**Organs**	**G11**	**G12**	**G13**	**G14**	**G15**	**G16**	**G17**	**G18**	**G19**	**G20**
Pb	**Heart**	ND	ND	0.00	0.00	ND	0.00	ND	0.00	0.00	ND
	Kidney	0.00	ND	0.00	0.00	ND	0.00	0.00	0.00	ND	ND
	Liver	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Muscles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cd	**Heart**	0.00	ND	0.00	ND	0.08	ND	0.00	ND	ND	ND
	Kidney	0.02	0.07	ND	0.16	ND	0.08	0.00	ND	ND	ND
	Liver	0.02	0.03	0.00	0.08	0.06	0.16	0.05	0.01	0.11	0.11
	Muscles	ND	0.02	ND	0.03	0.10	ND	ND	ND	ND	ND
Ni	**Heart**	0.00	0.06	0.87	0.12	1.23**	0.93	ND	0.12	ND	ND
	Kidney	ND	0.99	ND	0.15	0.09	ND	1.08**	ND	0.15	0.15
	Liver	0.42	0.60	0.00	0.15	ND	ND	0.03	0.54	ND	ND
	Muscles	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Key: Target Cancer Risk (TCR) Value>1 or with double asterisk (**) indicate Carcinogenic Risk

Heavy Metal Concentration

The mean concentrations of some heavy metals (Pb, Cd, Ni) in goat meat organs (G1 to G20) for adult men in Kaduna metropolis, Kaduna state, Nigeria are presented in Table 1.

Lead: Table 1 has revealed the level of Pb concentrations in different goat (G1-G20) meat organs (heart, kidney, liver, muscles). The highest concentration of (0.97 mg/kg) was observed in the kidney of goat (G4) and this value is higher than 0.1 mg/kg [19]. Similarly, [20] in his work reported higher concentration of Pb than the permissible limit in the liver and kidney of animals. [21] showed that 86% samples of liver and 100% samples of kidney were contaminated above the limits set by the country's regulations. [15] in his work on the distribution of heavy metals in the liver, kidney, heart, pancreas and meat of cow, buffalo, goat, sheep and chicken from Kohat market Pakistan found that the kidney of goat showed the highest concentration of (2.7 mg/kg). Lead affects every organ and system in the body, exposure to high levels damage the brain, liver and kidney and ultimately causes death. High level of exposure in adult men can damage the organs for sperm production. In pregnant and adult women, high level exposure to lead and can cause miscarriage [22]. According to [23] detoxification of metals by the liver organs mostly gets accumulated in the kidney. The higher mean concentration of Pb shown in the kidney and liver than the other organs indicates that kidney and liver are target tissues for monitoring metal contamination in animals because both organs function in removing toxic metals from the body [24].

Cadmium: The results presented in Table 1 revealed the mean concentration for Cd varied (G1-G20) across the samples (0.99-0.01 mg/kg). The highest Cd concentration was observed in the liver (0.99 mg/kg) of (G16). The mean Cd concentration was generally high in liver of slaughtered goat at Zango abattoir than other tissues and organs with the overall mean concentration of 0.99 mg/kg. The mean concentrations of Cd in most of the organs found were above the safety limits of 0.05 mg/kg recommended by [19]. This finding is in agreement to the findings of [25] and [26] who observe higher concentration of cadmium in liver of goat than other tissues and organs. This may be as a result of liver being an organ of detoxification of toxic substances such as heavy metals**,** lead from blood and other tissue may be mobilised and taken to the liver through circulation for detoxification to take place [27,28]. Cadmium is toxic to virtually every system in the animal body. It is almost absent in the human body at birth, however, accumulated with age. Cadmium accumulated in the kidney and liver over a long time have been reported by [29] that Cadmium interacts with a number of minerals mainly Zn, Fe, Cu, and Se due to chemical similarities and competition for binding stage. It is also reported that Cadmium can affect Ca, P and bone metabolism in both industrial and people exposed to Cadmium in general environment [30]. From the result of these study, the concentration of cadmium (Cd) content in all the samples studied were found to be higher than the permissible limit 0.005 mg/kg set by [19]. These might be as a result of rearing of these animals in a polluted environment.

Nickel: The results presented in (Table 1) have shown that the highest and lowest mean concentrations for Ni were varied (0.88-0.01 mg/kg) across the samples (G1-G20). The highest concentration of Ni was observed in the liver (G3). The mean concentrations of Ni in most of the organs were found to be less than (0.5 mg/kg) recommended by [19]. Similarly, [15] in his work found out that the highest concentration (0.275 mg/kg) was found in sheep kidney while the lowest (0.025 mg/kg) was in buffalo kidney. Nickel has been proved to be essential for poultry, pig, and rat under experimental conditions. Nickel is poorly absorbed from ordinary diets [31]. Absorbed nickel will be accumulated in liver, kidney and lung [32]. Nickel plays a vital role in different animals such as cows, goats and sheep [33,34]. The adverse effects of nickel deficiency in animals are numerous which include delayed skin eruptions, gestation period, and low number of offspring, reduced haemoglobin, anaemia and haematocrit values, and impaired activity of several enzymes [19]. Although a diseases caused due to nickel deficiency has not been reported in animals and humans, but some evidences regarding its importance in livestock and humans have been suggested by some researchers [35,36]. However, information on optimal and deficient nickel levels for animals, humans as well as plants is limited.

Risk Assessment (EDI, THQ, TCR)

EDI: The EDI values for Pb, Cd and Ni in goat meat organs were presented in (Table 2). Although, most EDI values were above the PTDI set by the [19], (Pb=0.002 mg/kg/day Cd=0.001 mg/kg/day and Ni=0.003 mg/kg/day) for the respective EDI (refer to Table 2). The degree of toxicity of heavy metal to human being depends upon their daily intake rate [39]. Similar study has been found by [40], reported that EDI is higher for the entire goat carcasses processed for human consumption in South-Eastern Nigeria as compared with standards. This study also reported that the highest intake of Pb, Cd, and Ni with the consumption of goat meat organs and these values exceeded from permissible limits [19].

THQ: Hazardous Quotients is a complex parameter used for the estimation of potential health risk associated with long term exposure to chemical parameter [41]. THQ values were calculated on the basis of the oral reference dose. From the obtained results (Table 3) was revealed that the THQ values for heavy metals Pb, Cd, Ni were >1 in goat meat organs (heart, kidney, liver, muscles). All most all the TH values recorded greater than one, thus, the consumption of goat meat organs in the study area carries very high non-carcinogenic risk.

TCR: The target cancer risk (TCR) of Pb, Cd and Ni for adult men through the consumption of goat meats organs are presented in Table 4. The TCR values of 1.14, 1.11, 1.23 and 1.08 computed for Ni in the heart, liver, heart and kidney might pose a health hazard among adult men who consume goat meat organs like heart, liver and kidney from Kaduna metropolis. Similarly, [40] has computed 1.4761 for Pb in muscle tissues and this might pose risk of cancer among children who consume goat carcass muscles from Enugu State.

IV. Conclusion

The results of this study showed that goats slaughtered at Zango abattoirs were exposed and contained different concentration of Pb, Cd and Ni in their organs. The amounts of these heavy metals in the studied samples were found to be above the WHO permissible limit. The health status of adult men respect to contamination by heavy metals (Pb, Cd and Ni) in Kaduna Metropolis was also evaluated through EDIs, THQs and TCR in this study. Based on the analysis obtained, there is significant risk of human adult men exposure of heavy metals regarding consumption of meat organs (heart, kidney, liver, muscles) obtained from Zango Abbatoir within Kaduna Metropolis. The consumption of meat in which metal concentrations beyond the tolerated dose were detected might be harmful to the health of the consumers. However, the study is of the view that the consumption of some of the goat meat organs in Kaduna metropolis could result in an increase in heavy metals in the human body beyond acceptable limits through bioaccumulation.

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B1 Muktar, et. al. "Health Risk Assessment of Heavy Metals (Pb, Cd, Ni,) Consumed in Goat Meat Organs within Kaduna Metropolis, Kaduna State, Nigeria." *IOSR Journal of Applied Chemistry (IOSR-JAC)*, 15(03), (2022): pp 25-32.