DETERMINATION OF THE LEVELS OF LEAD AND CHROMIUM IN COW OFFAL SOLD WITHIN OVIA NORTH-EAST OF BENIN - CITY

BY

FELIX PELUMI FAVOUR

PSC2105256

DEPARTMENT OF CHEMISTRY

FACULTY OF PHYSICAL SCIENCES

UNIVERSITY OF BENIN

SEPTEMBER 2025.

DETERMINATION OF THE LEVELS OF LEAD AND CHROMIUM IN COW OFFAL SOLD WITHIN OVIA NORTH-EAST OF BENIN - CITY

BY

FELIX PELUMI FAVOUR

PSC2105256

A PROJECT SUBMITTED TO THE DEPARTMENT OF CHEMISTRY, FACULTY OF PHYSICAL SCIENCE, UNIVERSITY OF BENIN, BENIN CITY.

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR'S DEGREE IN CHEMISTRY.

SEPTEMBER 2025.

CERTIFICATION

This is to certify that the project work titled **DETERMINATION OF THE LEVELS OF LEAD AND CHROMIUM IN COW OFFAL SOLD WITHIN OVIA NORTH-EAST OF BENIN – CITY** was carried out by **FELIX PELUMI FAVOUR** under the supervision of **PROFESSOR (MRS) J. E. UKPEBOR** in the **DEPARTMENT OF CHEMISTRY, FACULTY OF PHYSICAL SCIENCE, UNIVERSITY OF BENIN, BENIN CITY.**

______________________________ ______________________________

FELIX PELUMI FAVOUR **Date**

(Student)

______________________________ ______________________________

PROF. (MRS) J. E. UKPEBOR **Date**

(Project Supervisor)

______________________________ ______________________________

PROF. E.E.I IRABOR **Date**

(Head Of Department)

DEDICATION

This project is dedicated first to God Almighty, whose wisdom and strength have brought me this far. I also dedicate it to my loving mother and wonderful sisters, whose encouragement and care have been my greatest motivation.

ACKNOWLEDGEMENT

I give all glory and praise to God Almighty for His boundless grace, wisdom, and strength that enabled me to complete this project successfully.

My sincere appreciation goes to my supervisor, PROF. (MRS) J. E. UKPEBOR for her valuable guidance, encouragement, and support throughout the course of this work.

I am also deeply grateful to all my lecturers and the entire Department of Chemistry for their dedication and for imparting the knowledge that has contributed immensely to my academic growth.

Special thanks to my beloved mother and sisters for their unending love, prayers, and encouragement, which have been a great source of strength to me.

I would also like to appreciate my group members; KAREN, EMMANUEL, ESOSA, JULIANA and PAMELA. It was an honour working with you all and do accept my deepest thanks for all the efforts in order to make sure the project was successful.

Finally, I am thankful to my friends and colleagues who supported and motivated me in various ways throughout this journey.

TABLE OF CONTENTS

Contents

List of Tables

List of Figures

List of Abbreviations and symbols

AAS – Atomic Absorption Spectroscopy

WHO – World Health Organization

UBTH – University of Benin Teaching Hospital

UNIBEN – University of Benin

Pb – Lead

Zn – Zinc

Cd – Cadmium

Hg – Mercury

Ni – Nickel

HNO_3 – Nitric Acid

$HClO_4$ – Perchloric Acid

H_2O – Water (Distilled Water)

AAS – Atomic Absorption Spectroscopy

GFAAS – Graphite Furnace Atomic Absorption Spectroscopy

ppm – Parts per million

ppb – Parts per billion

NAFDAC – National Agency for Food and Drug Administration and Control

SON – Standards Organization of Nigeria

UV-Vis – Ultraviolet–Visible Spectroscopy

ABSTRACT

The concentrations of heavy metals; lead (Pb) and chromium (Cr) in cow offals (liver, kidney, intestine, and tripe "shaki") were investigated. A total of twelve samples were collected from three different abattoirs in Ovia North-East, Benin City, Nigeria: The University of Benin (UNIBEN), Ekosodin, and the University of Benin Teaching Hospital (UBTH), consisting of four cow offals from each location. Sampling was carried out twice at two-week intervals. Heavy metal extraction was performed using the standard wet-acid digestion method, and concentrations were determined via Atomic Absorption Spectrophotometry (AAS).

Results revealed that chromium (Cr) was detected in all samples, with concentrations ranging from 0.04 to 0.19 mg/kg, while lead (Pb) was variably detected, ranging from not detected (ND) to 0.10 mg/kg. The highest Cr concentration (0.19 mg/kg) was recorded in the kidney sample from UNIBEN (UN-K), while the lowest (0.04 mg/kg) was found in the liver sample from UNIBEN (UN-L). For lead, the highest concentration was observed in the kidney sample from Ekosodin (EK-K) at 0.10 mg/kg.

When compared with the Codex Alimentarius Commission/FAO/WHO permissible limits for heavy metals in edible offals; Pb: 0.50 mg/kg, Cr: 0.05 mg/kg some of the measured Cr values, particularly in the second sampling set, exceeded the recommended safety threshold, such as 0.19 mg/kg in UN-K and 0.16 mg/kg in EK-S. These findings indicate potential contamination and raise concerns about food safety and public health, particularly among populations with high offal consumption.

These results underscore the importance of regular monitoring, improved waste and feed management, and regulatory oversight of abattoir practices to limit environmental and food-chain exposure to toxic metals.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Heavy metals are unique group of naturally occurring substances found in the environment, which may be released into the environment by anthropogenic process. The World Health Organization has reported heavy metals like cadmium (Cd), lead (Pb), copper (Cu), and mercury (Hg) as the major contaminants of public health concern (WHO, 2003). Heavy metals are components of earth's crust and are essential nutrients for plants and animals but at trace levels. However, all metals can be harmful at high concentrations and prolonged exposure. Via ingestion heavy metal could be a potential cause of lung, kidney, liver, digest tract and pancreas cancers (Jaishankar *et al*., 2014). Also heavy metals could cause oxidative cellular stress, respiratory problems, cardiovascular disease, nervous system toxicity and kidney damage via inhalation (Krishnamurti *et al*., 1987).

Heavy metals are of particular concern due to their non-biodegradable nature, their ability to bioaccumulate in living organisms, and their long biological half-lives. Once introduced into the environment, they can persist for decades and enter the food chain through air, water, and soil, eventually accumulating in also animal tissues such as liver, kidney, and intestines organs known for filtering and storing toxins (Alloway *et al.*, 2013). These offal meats are often consumed for their nutritional content, yet they are the most likely to accommodate these toxic substances if contamination occurs.

Environmental pollution plays a critical role in the spread and concentration of heavy metals in edible animal products (Munir *et al.*, 2022). Pollution in urban and semi-urban environments like Benin City, where markets and slaughter points are often located in open-air settings, can result from various activities; Industrial emissions, automobile exhaust, waste disposal, roadside refuse burning, and dust storms all contribute to the environmental load of pollutants. These pollutants settle on soil, water, plants, and even directly on exposed meat in markets, particularly when meats are sold in uncovered conditions in busy areas with high vehicular and human activity. In places like the open markets around the University of Benin, Ugbowo campus, pollution from fumes, dust, and contaminated runoff is likely to affect the quality of meat sold to the public. Slaughtered animals exposed to polluted environments during transportation or processing may already have bioaccumulated heavy metals in their tissues, and additional contamination may occur during handling, storage, or display.

Pollutants in the environment include a range of substances: physical (such as dust and heat), chemical (like fertilizers, pesticides, and toxic metals), and biological such as pathogens (El Kamel *et al.,* 2021). Among these, chemical pollutants are of major concern due to their persistence and toxicity. Heavy metals are a significant class of chemical pollutants that find their way into animal products through both environmental exposure and biological accumulation. As livestock graze or are reared in contaminated environments, or fed with polluted water and fodder, heavy metals accumulate in their organs. The sale of these organs in local markets without proper sanitary measures further raises the risk of human exposure.

In this project, focus is placed on two key heavy metals: lead (Pb), and chromium (Cr). Lead exposure can severely impair the nervous system and cognitive development, especially in children (CDC, 2022). Chromium, depending on its valency, may be essential or toxic; hexavalent chromium (Cr VI) is carcinogenic and can damage the respiratory tract, skin, and internal organs (ATSDR, 2012).

These metals can enter meat through various routes; contaminated feed, polluted water sources, airborne deposition on exposed meat, and contact with contaminated surfaces during slaughtering and processing (Munir *et al.*, 2022).

In market environments like those around the University of Benin (UNIBEN) campus in Ugbowo, Edo State, the likely sources of heavy metal pollutants include automobile emissions from heavy traffic, waste dumps near market sites, open burning of refuse, contaminated water used in meat processing, and general atmospheric dust. The open display of meat, which is already prone to accumulating metals, increases the risk of contamination from the surroundings. Long-term consumption of such contaminated meat can lead to the gradual accumulation of heavy metals in the human body, potentially causing chronic illnesses, including liver and kidney damage, neurological disorders, and increased cancer risk (Tchounwou *et al.,* 2012). Therefore, determining the concentration of these metals in offal meats from various locations around Ugbowo is essential for assessing food safety and public health risk.

1.1.1 BACKGROUND OF STUDY

The increasing concern over food safety in developing countries has necessitated the monitoring of toxic substances in commonly consumed food items. Among these toxicants, heavy metals remain particularly significant due to their non-biodegradable nature, persistence in the environment, and tendency to bioaccumulate in animal tissues. Offal meats such as liver, kidney, and intestines are widely consumed for their nutritional value, yet they are also recognized as major sites for the accumulation of toxic substances, including heavy metals, due to their physiological roles.

In urban markets where slaughtering and meat handling occur under minimal hygienic conditions, offal meats are often exposed to environmental contaminants. These include dust, fumes, wastewater, and particles originating from vehicular emissions, open waste disposal, and industrial discharge. The environment around the University of Benin (Ugbowo Campus) in Edo State is characterized by growing human activity, road traffic, and open markets, all of which increase the potential for contamination of meat products.

Previous studies have reported the presence of heavy metals such as lead (Pb), cadmium (Cd), zinc (Zn), and chromium (Cr) in meat sold in open markets (Jankeaw *et al.,* 2015). These metals, depending on their concentration and frequency of exposure, pose various health risks ranging from renal dysfunction and neurological disorders to carcinogenic effects. The accumulation of these metals in edible animal parts raises public health concerns, especially where food inspection, regulation, and awareness are inadequate.

1.1.2 STATEMENT OF PROBLEM

The increasing contamination of environmental and food sources with heavy metals poses a significant threat to public health. Among the most concerning of these are lead (Pb), cadmium (Cd), zinc (Zn), and chromium (Cr), due to their widespread distribution, bioaccumulation potential, and toxicity even at low concentrations. These metals are introduced into the environment through diverse anthropogenic activities such as mining, smelting, battery production, fossil fuel combustion, electroplating, waste incineration, and the overuse of chemical fertilizers and pesticides (Darwish *et al.*, 2023; Li *et al.*, 2018; Singh and Ghosh, 2016).

Lead has been associated with a range of adverse effects including neurological impairment, renal dysfunction, reproductive toxicity, and interference with bone development, particularly in children under six years of age (CDC, 2006; Pearce, 2007). Exposure to lead may occur through ingestion of contaminated food and water, inhalation of polluted air, and dermal absorption from cosmetics (Health Canada, 2010; Łodyga-Chruścińska *et al.*, 2017). In children, blood lead levels above 10 µg/dL have been linked to cognitive deficits, although more recent thresholds recommend a reference level of 3.5 µg/dL to account for potential toxicity at even lower concentrations (CDC, 2021; NHANES, 2011–2014).

Cadmium, a non-essential and highly toxic element, accumulates in the liver, kidneys, and bones, and has been associated with kidney failure, osteoporosis, reproductive disorders, and certain cancers (ATSDR, 2008; IARC, 2010; Mañay *et al.*, 2008). Inhalation of cadmium fumes, as seen in small-scale gold mining and industrial processes, poses an acute risk, while long-term ingestion through contaminated rice, leafy vegetables, seafood, and tobacco smoke contributes to chronic exposure (Reddy *et al.*, 2011; Taha *et al.*, 2013). Cadmium is also a significant contaminant in cosmetics, especially lipsticks and pigments, and is frequently detected above regulatory limits (Lara-Torres *et al*., 2021).

Zinc, though essential for human health, exhibits toxicity at elevated concentrations. While it plays a vital role in immune regulation, enzymatic function, and cellular metabolism, excessive zinc interferes with copper absorption and impairs gastrointestinal and immune functions (Zaynab *et al*., 2022). Sources of zinc overload include industrial effluents, dietary supplements, and contaminated food and water (Sani *et al*., 2017). Industrial waste and agricultural runoff are leading contributors to zinc pollution in aquatic and terrestrial systems (Nuapia *et al*., 2016).

Chromium exists in both trivalent [Cr(III)] and hexavalent [Cr(VI)] forms. While Cr(III) is considered biologically essential, Cr(VI) is highly toxic and recognized as a carcinogen by the International Agency for Research on Cancer (IARC, 2010). Exposure to Cr(VI) has been linked to respiratory illnesses, skin irritation, organ toxicity, and DNA damage (Zeinali *et al*., 2022). Chromium contamination in food, water, and soil is often the result of tanning industries, improper waste disposal, and industrial processes (Singh and Ghosh, 2016; Kanpur study, 2016). In cosmetics, chromium compounds are commonly found in colored products such as eyeshadow and lipsticks, raising concerns over dermal absorption and systemic toxicity (Navarro-Tapia *et al*., 2017; European Regulation No. 1223/2009).

Moreover, cumulative and synergistic effects arising from co-exposure to these metals are often overlooked in regulatory assessments, despite clear evidence of their interactions at biochemical and cellular levels (Flora *et al*., 2008; Edwards and Prozialeck, 2009). Several studies have shown that zinc competes with cadmium and lead for binding sites, while cadmium interferes with iron, copper, and selenium metabolism, thereby exacerbating toxicity (Hussain *et al*., 2012; Spungen, 2018). Individuals with mineral deficiencies, such as low dietary iron, are especially vulnerable to increased absorption of toxic metals (Reddy *et al*., 2011).

Compounding this issue is the detection of these metals in consumer products, especially cosmetics. Investigations have shown that many personal care products exceed permissible limits for lead, cadmium, and chromium, posing a chronic exposure risk through dermal absorption and accidental ingestion (Łodyga-Chruścińska *et al*., 2017; Navarro-Tapia *et al*., 2017). In regions where skin-lightening products, traditional eyeliners, and beauty creams are widely used, the risk of bioaccumulation and systemic toxicity is particularly high (Lara-Torres *et al*., 2021).

Given the confirmed adverse effects of these metals and their frequent occurrence in environmental and consumer sources, there is a pressing need for systematic investigation. This study aims to assess the levels, pathways, and health risks associated with lead, cadmium, zinc, and chromium in selected matrices, to support evidence-based regulatory measures and contribute to improved public health outcomes.

1.1.3 SCOPE OF WORK

This study is concerned with the evaluation of heavy metal contamination in selected offal meats, specifically kidney, liver, tripe, and intestine, obtained from local market. The research is focused on two heavy metals of public health concern which include lead, and chromium. These metals were selected due to their known toxic effects and their potential to accumulate in animal organs consumed by humans. The study is limited to the collection and laboratory analysis of offal meat samples using appropriate analytical techniques to determine the presence and concentration of the selected metals. The geographical scope of the study is restricted to specific markets within a defined area and does not cover all possible sources of offal meats or broader regional distributions.

The findings are intended to inform consumers, public health professionals, and regulatory authorities about the potential risks associated with the consumption of contaminated offal meats and to contribute to ongoing efforts aimed at improving food quality and safety.

1.1.4 JUSTIFICATION OF THE STUDY

This research is significant as it brings attention to the critical health risks associated with the consumption of meats sold in market square environments, with particular focus on offal meats. These internal organs, such as liver, kidney, and intestines, are known to bioaccumulate heavy metals due to their physiological roles in filtration, detoxification, and metabolism. The study specifically investigates the presence and concentration of lead and chromium, which have been widely recognized for their toxicological impact on human health.

Heavy metals such as lead and cadmium have no known biological function and are toxic even at low exposure levels. Zinc, although essential in trace amounts, becomes harmful when excessively consumed. Chromium in its hexavalent form is a potent environmental and dietary contaminant. The identification of these metals in offal meats is particularly alarming given the frequency with which such products are consumed, often without awareness of their potential health implications. This study is timely and relevant, especially in regions where regulatory oversight of food products is limited, and where environmental pollution from industrial, agricultural, and waste disposal activities is prevalent. The research emphasizes the urgency of addressing contamination through improved food safety monitoring, stricter enforcement of permissible limits, and public education on the risks of long term heavy metal exposure.

The findings from this study will provide evidence to support the development of more effective food quality control policies, enhance consumer awareness, and guide interventions aimed at reducing the burden of chronic diseases linked to toxic metal exposure. It also contributes to the growing scientific literature on environmental contaminants in the food chain and lays a foundation for further studies on dietary risk assessment, particularly in vulnerable populations such as children, pregnant women, and individuals with nutrient deficiencies. By highlighting the intersection of environmental pollution, food safety, and public health, this research advances the understanding of how daily dietary choices can contribute to cumulative toxic metal exposure and associated health risks.

1.1.5 LIMITATIONS

Despite the relevance and significance of this study, certain limitations must be acknowledged which may affect the generalization and interpretation of the findings.

1. Sample size and coverage: The study may be limited by the number of offal meat samples collected and the geographical coverage of the sampling locations. Market square meats from selected locations may not represent the contamination levels across all markets or regions, especially in areas with different environmental conditions or agricultural practices.

2. Scope of heavy metals analysed: While the study focuses on lead, cadmium, zinc, and chromium, other potentially toxic metals such as mercury, arsenic, and nickel were not included. This limited scope may overlook the full spectrum of heavy metal contamination in offal meats.

3. Temporal variation: Samples were likely collected during a specific period, and seasonal changes in environmental pollution, animal diet, and slaughterhouse practices could influence heavy metal concentrations. The study does not account for such temporal variations.

4. Absence of human health data: Although the study highlights health risks based on established toxicity levels, it does not include direct biological measurements such as blood or urine samples from consumers. Therefore, the findings cannot establish a direct correlation between offal meat consumption and health outcomes in the population.

5. Lack of detailed source attribution: The study does not extensively investigate or identify the specific sources of heavy metal contamination such as feed, water, environmental exposure, or processing methods. Without this information, proposing precise control strategies becomes more challenging.

6. Variability in animal species and age: Differences in animal species, age, health status, and metabolic processes can influence the accumulation of metals. However, the study may not have differentiated or controlled for these biological variables.

7. Analytical constraints: Depending on the sensitivity and precision of the instrumentation used, there may be limitations in detecting very low concentrations of metals or distinguishing between different chemical forms, such as trivalent and hexavalent chromium.

1.1.6 AIM AND OBJECTIVES

AIM

The aim of this study was to determine the concentration of selected heavy metals, (Lead, Chromium), in cow offal sold in market square environments, and to evaluate the potential public health risks associated with their consumption.

OBJECTIVES

The objectives for this study are;

1. To determine the concentrations of Lead and Cadmium in the samples using an Atomic Absorption Spectrophotometer
2. To compare the results obtained with limits set by regulatory bodies and make suitable recommendations

1.2 LITERATURE REVIEW

1.2.1 ENVIRONMENTAL POLLUTION

Environmental pollution refers to the unwanted release of substances or energy into Earth's natural resources; land, air, or water that causes short or long-term damage to the environment and harms the health and well-being of living organisms (Hussain, 1998). Environmental pollution reflects a measurement of contamination of the living and nonliving (physical and biological) constituents of the earth, in a manner and to an extent, to adversely affect the normal optimum environmental processes (Kemp, 1998).

Human activities that results in the degradation or depreciation of the quality of the natural environment is regarded as pollution.

Environmental pollution is not a new phenomenon, yet it remains the world's greatest problem facing humanity, and the leading environ-Mental causes of morbidity and mortality. In 2015 it was predicted that ill-health caused by Pollution accounted for 9 million premature deaths, which is more than three times the number of deaths from malaria, AIDS, and tuberculosis put together (Landrigan *et al*., 2017).

Generally, environmental pollution is greater in middle- and low-income countries than in developed countries, possibly due to poverty, poor legislation, and being unaware of Pollution forms. It is likely that humans face pollution daily without knowing it or we may have possibly become immune to it in our fast-paced lives (Muralikrishna and Manickam, 2017). As unlikely as it may seem, being unaware of the forms of pollution results in Humans performing activities that yield deleterious by-products in forms and quantities That the environment can no longer counterbalance without outright deformation of its system. For instance, deforestation, burning of bushes, dumping of agricultural and household Wastes in water bodies, use of chemicals in harvesting aquatic animals, and improper disposal of electronic wastes, all contribute to air, land, and water pollution.

1.2.1.1 LEAD (Pb)

Lead is a toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world. It is a cumulative toxicant that affects multiple body systems, including the neurological, hematological, gastrointestinal, cardiovascular and renal systems. Children are particularly vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage.

Lead exposure causes a significant burden of disease: the Institute for Health Metrics and Evaluation has estimated that in 2017, lead exposure accounted for 1.06 million deaths and 24.4 million disability-adjusted life years due to long-term effects on health. Reductions in the use of lead in petrol (gasoline), paint, plumbing and solder have resulted in substantial reductions in blood lead concentrations globally. However, significant sources of exposure to lead still remain, particularly in developing countries and those in economic transition. Further efforts are required to continue to reduce the use and releases of lead, and to reduce environmental and occupational exposures, particularly for children and women of childbearing age. Lead is found at low levels in Earth's crust, mainly as lead sulphide (galena). However, the widespread occurrence of lead in the environment is largely the result of human activity, such as mining, smelting, refining and recycling of lead. Other sources of lead in the environment include natural activities, such as volcanic activity, geochemical weathering and sea spray emissions, and remobilization of historic sources, such as lead in soil, sediment and water from mining areas. As lead is an element, once it is released into the environment, it persists. Because of this persistence and potential for global atmospheric transport of lead, atmospheric emissions affect even the most remote regions of the world.

1.2.1.2 CADMIUM (Cd)

Cadmium is the seventh most toxic metal. Cadmium is a heavy metal, responsible for major environmental and health concerns. It is widely distributed in the Earth's crust at a concentration of approximately 0.1 mg/kg. The extensive levels of cadmium compounds are found in sedimentary rocks and phosphates. Once this metal enters the human body, it accumulates inside the body throughout life. This metal was used in World War I as a substitute for tin and as a pigment in paint industries. Cadmium is a highly toxic heavy metal that poses serious risks to human health. It primarily affects the kidneys, skeletal system, and respiratory system, and is classified as a human carcinogen. Although cadmium naturally occurs in the environment through volcanic activity, weathering, and river transport, human activities have significantly increased its levels in air, water, and soil. Major anthropogenic sources include mining, smelting, fossil fuel combustion, tobacco smoking, waste incineration, and the production of phosphate fertilizers.

1.2.1.3 ZINC (Zn)

Zinc is the 23rd most abundant element in the Earth's crust and its concentrations are rising unnaturally, due to addition of zinc through human activities. Zinc is a lustrous bluish-white metal and found in group IIB of the periodic table. It is brittle and crystalline at ordinary temperatures, but it becomes ductile and malleable when heated between 110°C and 150°C. It is a fairly reactive metal that will combine with oxygen and other non-metals, and will react with dilute acids to release hydrogen. Most zinc is added during industrial activities, such as mining, coal and waste combustion and steel processing. Zinc is widely used in industries such as galvanization, paint, batteries, smelting, fertilizers and pesticides, fossil fuel combustion, pigment, polymer stabilizers, etc., and the wastewater from these industries is polluted with zinc, due to its presence in large quantities. Electroplating is one important process involved in surface finishing and metal deposition for better life of articles and for decoration. Although several metals can be used for electroplating, nickel, copper, zinc and chromium are the most commonly used metals, the choice depending upon the specific requirement of the articles. During washing of the electroplating tanks, considerable amounts of the metal ions find their way into the effluent. When it is present in less quantity in human’s body, it affects considerably human’s health. Although humans can handle large extent of zinc, too much of it can still cause eminent health problems. Zinc is an essential trace element for both plants and animals and plays a vital role in various enzymatic and biological processes. However, excessive concentrations of zinc in the environment can be harmful. Industrial processes such as galvanization, battery manufacturing, and mining contribute significantly to zinc pollution.

1.2.1.4 CHROMIUM (Cr)

Chromium is a heavy metal found in the atmosphere, water, soil, and living organisms. It exists in several oxidation states, but trivalent chromium (Cr^{3+}) and hexavalent chromium (Cr^{6+}) are the most environmentally and biologically significant. While trivalent chromium is a trace element beneficial to human metabolism in small amounts, hexavalent chromium is highly toxic and classified as a human carcinogen.

Hexavalent chromium is widely used in industrial processes such as electroplating, leather tanning, stainless steel production, and dye manufacturing. These activities release chromium into the environment, especially when waste is not properly treated. Airborne chromium particles from industrial emissions can travel long distances and eventually settle on exposed surfaces.

1.2.2 SOURCES, EXPOSURE, AND ENVIRONMENTAL IMPACTS OF HEAVY METALS.

1.2.2.1 LEAD

The sources of lead vary with different countries based on old and new usage of lead products. It is not limited to the processing of gold ore and recycling of used lead products. It is found that the decrease in blood lead levels in the population of the countries in which unleaded gasoline is in usage.

A recent study has reported elevated blood levels in pregnant women in a rural village in Bangladesh. In this study, they found more than 30% of the women they sampled were had lead levels in blood in the range of above 5 μg/dL(Forsyth *et al.*, 2018). They found the major source of lead exposure to these women were identified as food storage cans. Nearly 18% of food storage cans (out of the tested) were having lead soldering insides and are responsible for lead contamination in these women. Another study in China determined the blood lead levels (BLL's) in children who are taking treatment in lead specialty clinics. In this study, they found the BLL's ranging from 5 to 126 μg/dL (Ying *et al.*, 2017). The major reasons they found for the higher lead levels in their blood as industrial sources and folk medicine which is popular in China. Another important thing was determined as it is difficult to find lead poisoning in children due to non-specific symptoms. A very recent study from Australia determined the higher lead levels in children due to the high concentration of lead in soil and pretty dish dust at their premises. This study found that the population who are living in old houses built before 1940 are diagnosed with higher lead levels due to pretty dish dust (Taylor *et al*., 2021).

In Nigeria, lead poisoning in the population was observed in the area of Zamfara State which contains gold mining activities. Mahuta reported that in Nigeria, the sources of the lead include mining of gold, lead pipes used for drinking water, and cultural usage of lead.

Based on the studies in all parts of the world it is assumed that the sources of lead are historical usage of lead, industrial activities, and leaded gasoline. Major studies reported that children are the most common victims of lead poisoning (Mahuta, M.A., *et al.*, 2020). The way of exposure includes the inhalation through the nose and ingestion through drinking water and soil.

The Types of carcinogenic effects of lead toxicity was explained in the figure below. The lead toxicity in humans causes intestinal cancer, lung cancer, and the central nervous system.

Figure 1.1. Carcinogenic effect of Lead (Source: www.goggle.com)

1.2.2.2 CADMIUM

The major exposure of cadmium by human beings is through contaminated food and water. Cigarette smoke is the way of exposure through the inhalation route. The toxicity of cadmium is due to accumulation in plants and animals for nearly 25–30 years. Microbial fermentation is one of the effective methods to remove cadmium from food. Another major source of cadmium in the environment is phosphate fertilizers and the waste incineration process. Blood cadmium levels are having a huge difference between smokers and non-smokers of cigarettes.

The presence of lead and cadmium in the human body can reach the brain and can cause Alzheimer's disease. After the exposure to the cadmium, in human, it can accumulate at the kidney, due to this reason urinary cadmium levels had been considered as biomarkers for cadmium levels in humans.

In case of occupational exposure to cadmium includes the workers at battery production, pigment industries, and electroplating. Because of long time accumulation in the human body even in small quantities is toxic and carcinogenic. Another important source of cadmium in the soil is sewage sludge which can make the cadmium almost the same amount as fertilizers consumption. Cadmium shows its toxic effects on the gastric system and leads to gastric cancer, breast cancer, lung cancer, and it also affects the excretory system and leads to renal cancer.

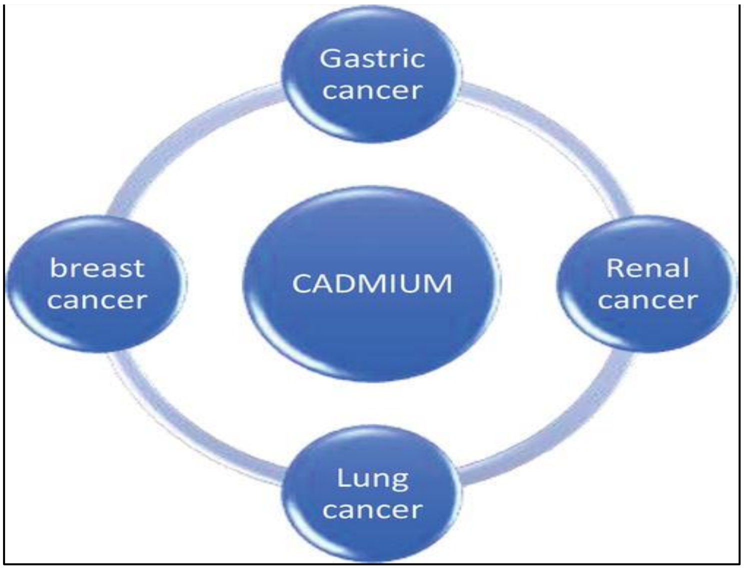

Figure 1.2. Carcinogenic effect of cadmium (Source: www.google.com)

1.2.3 ZINC (Zn)

The main sources of zinc in urban areas are worn tyres, painted buildings and galvanized and coated roofs. When it rains enough to create run-off, traces of zinc from these sources get washed out and enter the environment through stormwater run-off. Most of the zinc found in run-off is in a dissolved form (zinc ions), which is the form most available to organisms. Further urban sources of zinc are treated effluents and sludge from wastewater treatment plants.

In rural areas, zinc-based pesticides and animal medicines are key sources of zinc entering soil and surface water. This is because zinc is incorporated into agricultural products such as drenches and sheep dip to treat facial eczema. It is also found in some multipurpose plant pesticides. When the organic compound of the pesticide degrades, the zinc which does not degrade gets released. This means it has the potential to accumulate in receiving environments such as soils, sediments and organisms.

1.2.2.4 CHROMIUM

Unrestricted discharge of toxic hexavalent chromium [Cr(VI)] has threatened the environment. Many studies have recently shown its concentration has increased in the environment, especially in surface and ground waters, surpassing the prescribed limits for Cr freshwater, wastewater effluents, and soil (Oliveira, 2012). Cr(VI) is an influential toxic metal that directly or indirectly affects terrestrial plants, aquatic phytoplankton, and other creatures (Stambulska *et al*., 2018)

1.2.3 OFFAL MEATS

Offals are all the noncarcass parts of slaughtered animals except hide and skin. Most offals have the potential to be used as human food, but this potential can only be realized if the offals are collected hygienically, inspected, and passed fit for human consumption, then cleaned and prepared appropriately. The offal meats we are concerned with are certain cow parts, which include kidney, liver, intestine, and tripe.

1.2.3.1 KIDNEY

Cow kidney is a nutrient-dense organ meat, rich in protein, iron, vitamin B12, and other essential vitamins and minerals. A 3-ounce serving provides a good source of protein, iron, and vitamin B6. It also contains significant amounts of vitamin B12, selenium, and riboflavin.

Figure 1.3. Diagram of a Cow kidney. (Source: www.google.com)

1.2.3.2 LIVER

Cow liver stands out as one of the richest dietary sources of Vitamin A, crucial for vision, immune function, and maintaining healthy skin. The Vitamin A in beef liver is in the form of retinol, the active form, which is more readily used by the body compared to the beta-carotene found in plant sources.

Figure 1.4 Diagram of a Cow liver. (Source: www.google.com)

1.2.3.3 INTESTINE

Cow intestine are a culinary ingredient with a chewy texture and a mild flavour, used in various cuisines around the world. They are typically sourced from the stomach chambers or the small and large intestines of the cow.

Figure 1.5 Diagram of a Cow Intestine. (Source: www.google.com)

1.2.3.4 TRIPE

Cow tripe is a type of edible lining from the stomach of a cow, specifically from the rumen, which is the first compartment of a cow's four-chambered stomach. It's a popular ingredient in many cuisines worldwide. Tripe is a nutrient-rich food, providing high-quality protein, vitamins B12 and B6, and minerals like selenium, zinc, and iron. It's also relatively low in fat and calories.

Tripe is often cooked in soups, stews, or stir-fries and is prized for its unique texture and flavour. Its versatility and nutritional benefits make it a valuable addition to various dishes.

Figure 1.6 Diagram of a Cow tripe. (Source: www.google.com)

1.2.4 HEALTH EFFECTS OF CONSUMUNG OFFAL MEATS CONTAMINATED WITH HEAVY METALS.

Offal meats including; kidney, tripe, intestine, and liver, are nutrient-rich foods consumed globally. However, these meats can be contaminated with heavy metals like cadmium, zinc, lead, and chromium, posing significant health risks to consumers. This project explores the health effects of consuming offal meats contaminated with these heavy metals.

1.2.4.1 HEALTH EFFECTS OF HEAVY METALS CONTAMINATION

1.2.4.1.1 CADMIUM

Kidney damage: Cadmium accumulation in kidneys can cause damage, leading to chronic kidney disease and kidney failure.

Bone damage: Cadmium exposure can cause bone demineralization, leading to osteoporosis and increased risk of fractures.

Cancer risk: Cadmium is classified as a human carcinogen, and prolonged exposure can increase cancer risk.

1.2.4.1.2 LEAD

Neurological damage: Lead exposure can cause neurological damage, including developmental delays, cognitive impairment, and memory loss.

Organ damage: Lead accumulation can damage organs like kidneys, liver, and brain.

Cardiovascular disease: Lead exposure can increase cardiovascular disease risk.

1.2.4.1.3 ZINC

Gastrointestinal problems: Excessive zinc consumption can cause gastrointestinal problems, including nausea, vomiting, and diarrhea.

Toxicity: High levels of zinc can be toxic, causing symptoms like abdominal pain, headaches, and fatigue.

1.2.4.1.4 CHROMIUM

Skin irritation: Chromium VI exposure can cause skin irritation, including redness, itching, and ulcers.

Respiratory problems: Chromium VI exposure can cause respiratory problems, including asthma and chronic obstructive pulmonary disease (COPD).

Kidney damage: Chromium VI exposure can damage kidneys, leading to chronic kidney disease.

1.2.5 PRINCIPLE OF ATOMIC ABSORPTION SPECTROSCOPY

Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample. A detector measures the wavelengths of light transmitted by the sample, and compares them to the wavelengths which originally passed through the sample. A signal processor then integrates the changes in wavelength absorbed, which appear in the readout as peaks of energy absorption at discrete wavelengths. The energy required for an electron to leave an atom is known as ionization energy and is specific to each chemical element. When an electron moves from one energy level to another within the atom, a photon is emitted with energy E. Atoms of an element emit a characteristic spectral line. Every atom has its own distinct pattern of wavelengths at which it will absorb energy, due to the unique configuration of electrons in its outer shell. This enables the qualitative analysis of a sample. The concentration is calculated based on the Beer-Lambert law. Absorbance is directly proportional to the concentration of the analyte absorbed for the existing set of conditions. The concentration is usually determined from a calibration curve, obtained using standards of known concentration. However, applying the Beer-Lambert law directly in AAS is difficult due to: variations in atomization efficiency from the sample matrix, non-uniformity of concentration and path length of analyte atoms (in graphite furnace AA).

Three steps are involved in turning a liquid sample into an atomic gas:

1. Desolvation – the liquid solvent is evaporated, and the dry sample remains;

2. Vaporization – the solid sample vaporizes to a gas; and

3. Volatilization – the compounds that compose the sample are broken into free atoms.

To measure how much of a given element is present in a sample, one must first establish a basis for comparison using known quantities of that element to produce a calibration curve. To generate this curve, a specific wavelength is selected, and the detector is set to measure only the energy transmitted at that wavelength. As the concentration of the target atom in the sample increases, the absorption will also increase proportionally. A series of samples containing known concentrations of the compound of interest are analyzed, and the corresponding absorbance, which is the inverse percentage of light transmitted, is recorded. The measured absorption at each concentration is then plotted, so that a straight line can then be drawn between the resulting points. From this line, the concentration of the substance under investigation is extrapolated from the substance's absorbance. The use of special light sources and the selection of specific wavelengths allow for the quantitative determination of individual components in a multielement mixture.

1.2.5.1 COMPONENTS OF ATOMIC ABSORPTION SPECTROSCOPY INSTRUMENT

Light source: The light source is usually a hollow-cathode lamp of the element that is being measured. Lasers are also used in research instruments. Since lasers are intense enough to excite atoms to higher energy levels, they allow atomic absorption and atomic fluorescence measurements in a single instrument, however through this narrow-band light source, only one element can be measured at a time.

Light Separation and Detection: In atomic absorption spectroscopy (AAS), spectrometers use monochromators and detectors for uv and visible light. The main purpose of the monochromator is to isolate the absorption line from background light due to interferences. Simple dedicated atomic absorption spectroscopy instruments often replace the monochromator with a bandpass interference filter, which is further connected with photomultiplier tubes as the most detectors for atomic absorption spectroscopy.

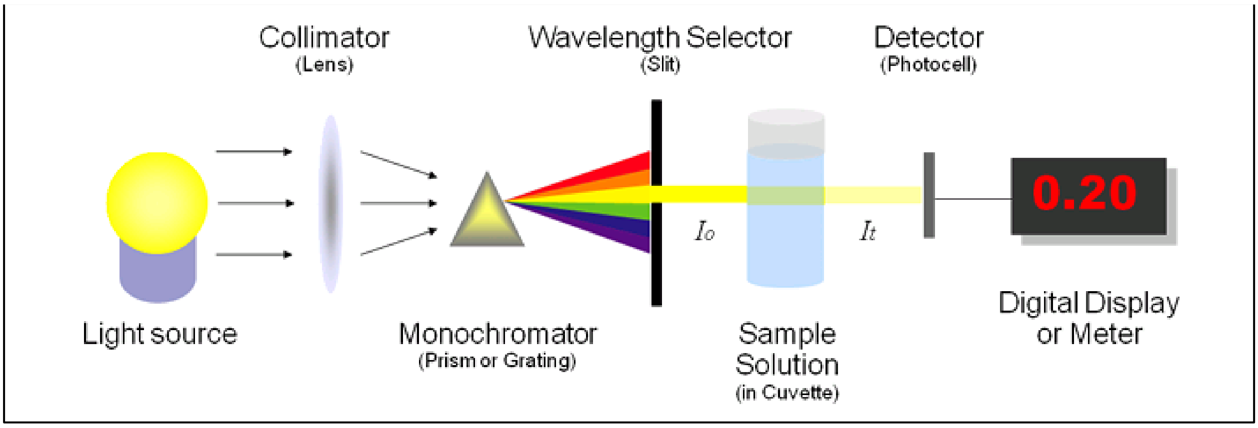

Figure 1.7. Schematic diagram of a spectrophotometer (www.google.com)

1.2.5.2 APPLICATION ATOMIC ABSORPTION SPECTORSCOPY

It is used for various purposes from petrol industry to mining and from detection of trace elements to food and drug inspections, health industry, etc. It is mainly employed for;

1. Qualitative and quantitative analysis.
2. Determination of metallic elements in biological system.
3. Determination of metallic element in food industry.
4. Determination of Ca, Mg, Na, K in serum.
5. Determination of lead in petrol.

1.2.5.3 LIMITATIONS OF ATOMIC ABSORPTION SPECTROSCOPY

1. Single-element analysis: AAS is typically used for analyzing one element at a time, which can be time-consuming for multi-element analysis.
2. Matrix effects: The presence of other elements or substances in the sample can interfere with the analysis, affecting accuracy.
3. Sample preparation: AAS requires samples to be in a specific form (e.g., liquid or dissolved), which can be challenging for certain sample types.

4. Calibration requirements: AAS requires calibration with standards of known concentration, which can be labor-intensive.
5. Limited dynamic range: AAS may not be suitable for samples with very high or very low concentrations of the target element.
6. Interference from other elements: Spectral interferences can occur when other elements in the sample absorb radiation at similar wavelengths.
7. Instrumental limitations: AAS instruments can be prone to drift, noise, and other instrumental limitations that affect accuracy.

1.2.5.4 BENEFITS OF ATOMIC ABSORPTION SPECTROSCOPY

1. High sensitivity: AAS can detect trace amounts of elements in a sample.
2. High accuracy: AAS provides accurate results when properly calibrated and operated.
3. Specificity: AAS can selectively measure specific elements in a sample.
4. Quantitative analysis: AAS allows for precise quantification of element concentrations.
5. Wide range of applications: AAS is used in various fields, including environmental monitoring, pharmaceuticals, food safety, and metallurgy.

In conclusion, Atomic Absorption Spectroscopy is a precise method for analysing heavy metal concentration by measuring the absorption of light by free atoms in a sample.

CHAPTER TWO

MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 REAGENTS USED

- Nitric acid (HNO_3)
- Perchloric acid ($HClO_4$)
- Distilled water (H_2O)

2.1.2 APPARATUS USED

- 250ml Conical flask
- 100ml Volumetric flask
- 250ml Beaker
- Funnel
- 100ml Measuring cylinder
- Whatman No.42 filter paper
- Sample bottles
- Wash bottles
- Stirrer
- spatula

2.1.3 INSTRUMENT USED

- New Life Medical England Laboratory Oven
- Sharp Dry Blender, Model : EM-11
- Atomic Absorption Spectroscopy AAS (Make: Buck Scientific, Model: 210VGP)
- Hot plate (Make: Infitek, Model: HPT-320-5B)

2.2 METHODS

2.2.1 SAMPLING LOCATION

Samples were obtained from abattoirs located in the Ovia North-East of Benin City. These include University of Benin Abattoir, University of Benin Teaching Abattoir, and Ekosodin Abattoir.

2.2.2 SAMPLE COLLECTION AND PREPARATION

A total of twelve cow offal samples were collected from three different abattoirs, with each location contributing samples of kidney, liver, intestine, and tripe. The samples were collected twice from each location at two-week intervals. Upon collection, the samples were labeled according to their source and organ type.

Afterwards, the samples were dried in the laboratory oven at 200°C and blended for acid digestion to commence. The samples were grounded into a fine powder using an electric blender and stored in well-labeled sample bottles used for acid digestion.

Table 2.1: Sample Identification

Sample Code	Sample name	Sample Code	Sample Name	Sample Code	Sample Name
EK-K	Ekosodin Kidney	UN-K	Uniben Kidney	UB-K	UBTH Kidney
EK-S	Ekosodin Shaki (Tripe)	UN-S	Uniben Shaki	UB-S	UBTH Shaki (Tripe)
EK-L	Ekosodin Liver	UN-L	Uniben Liver	UB-L	UBTH Liver
EK-I	Ekosodin Intestine	UN-I	Uniben Intestine	UB-I	UBTH Intestine

2.2.3 SAMPLE DIGESTION

Before the digestion process, all glassware and apparatus to be used were thoroughly washed and rinsed with distilled water. 8mL of concentrated nitric acid (HNO_3) was added to 1g of the dried sample placed in a 250mL beaker, 2mL of perchloric acid ($HClO_4$) was added to the mixture. The digestion was carried out by heating the mixture until the brown nitrogen dioxide fumes turned white, indicating near completion of oxidation. After cooling, the mixture was filtered through Whatman No. 42 filter paper, and the filtrate was diluted to 100mL with distilled water in the 100mL volumetric flask.

All samples were stored in acid-washed containers until they are ready for analysis. Heavy metal concentrations (Pb, Cr) were then determined using an atomic absorption spectrophotometer. The digestion procedure was based on the method described by Luo et al. (2021), with slight modifications.

Figure 2.2: Sample Digestion.

CHAPTER THREE

RESULTS AND DISCUSSION

3.1 RESULTS AND DISCUSSION

The concentration of heavy metals in cow offal (kidney, liver, tripe, and intestine) samples purchased from selected abattoirs (UNIBEN, UBTH, and EKOSODIN) in Ovia North East local government area of Edo using an atomic absorption spectrophotometer are presented below:

Table 3.1: Concentration of selected metals in mg/kg for the first set of samples.

S/N	**Sample code**	**Concentration (mg/kg)**	
		Pb	**Cr**
1.	EK-K	ND	0.05
2.	EK-S	0.01	0.11
3.	EK-L	ND	0.08
4.	EK-I	ND	0.07
5.	UN-K	ND	0.16
6.	UN-S	ND	0.04
7.	UN-L	ND	0.09
8.	UN-I	ND	0.11

9.	UB-K	ND	0.06
10.	UB-S	ND	0.06
11.	UB-L	ND	0.05
12.	UB-I	0.02	0.12

ND: NOT DETECTED

Table 3.2 Concentration of selected metals in mg/kg for the second set of samples.

S/N	**Sample code**	**Concentration (mg/kg)**	
		Pb	**Cr**
1.	EK-K	0.1	0.05
2.	EK-S	ND	0.16
3.	EK-L	ND	0.09
4.	EK-I	ND	0.09
5.	UN-K	0.01	0.19
6.	UN-S	0.01	0.05
7.	UN-L	0.01	0.04
8.	UN-I	0.01	0.13

9.	UB-K	0.01	0.08
10.	UB-S	0.01	0.06
11.	UB-L	ND	0.06
12.	UB-I	0.01	0.15

ND: NOT DETECTED

3.2 DISCUSSION

3.2.1 CHROMIUM

Chromium was detected in all the samples collected from Ekosodin, UBTH, and Uniben for both sampling periods, confirming the consistent presence of this heavy metal in meats from the studied locations. In the first collection, chromium concentrations ranged from 0.05–0.16 mg/kg in the kidney, 0.04–0.06 mg/kg in the tripe, 0.05–0.09 mg/kg in the liver, and 0.07–0.12 mg/kg in the intestines.

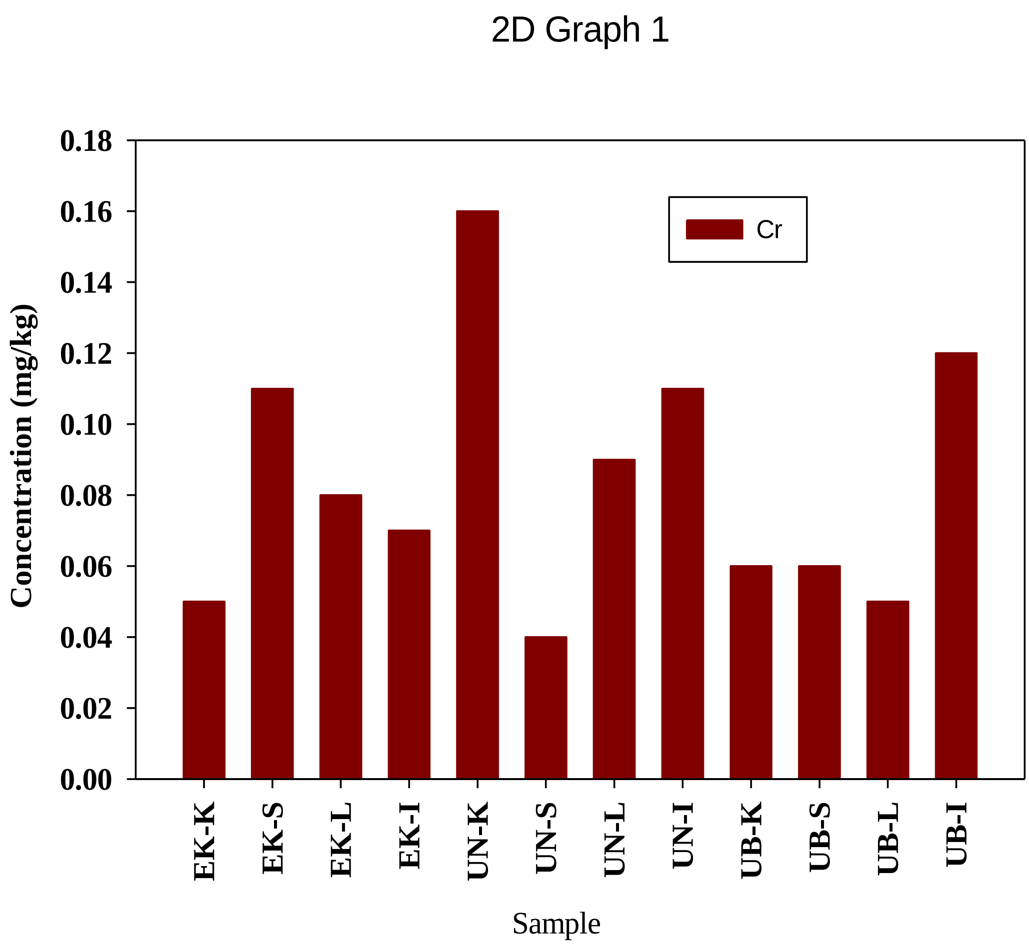

Figure 3.1: Bar chart Concentration of Chromium (mg/kg) in cow offal samples collected during the first sampling.

In the second set of samples, obtained two weeks later, chromium levels remained comparable, ranging from 0.05 – 0.19 mg/kg in the kidney**,** 0.05 – 0.16 mg/kg in the tripe**,** 0.04 – 0.09 mg/kg in the liver**,** and 0.09 – 0.13 mg/kg in the intestines**.**

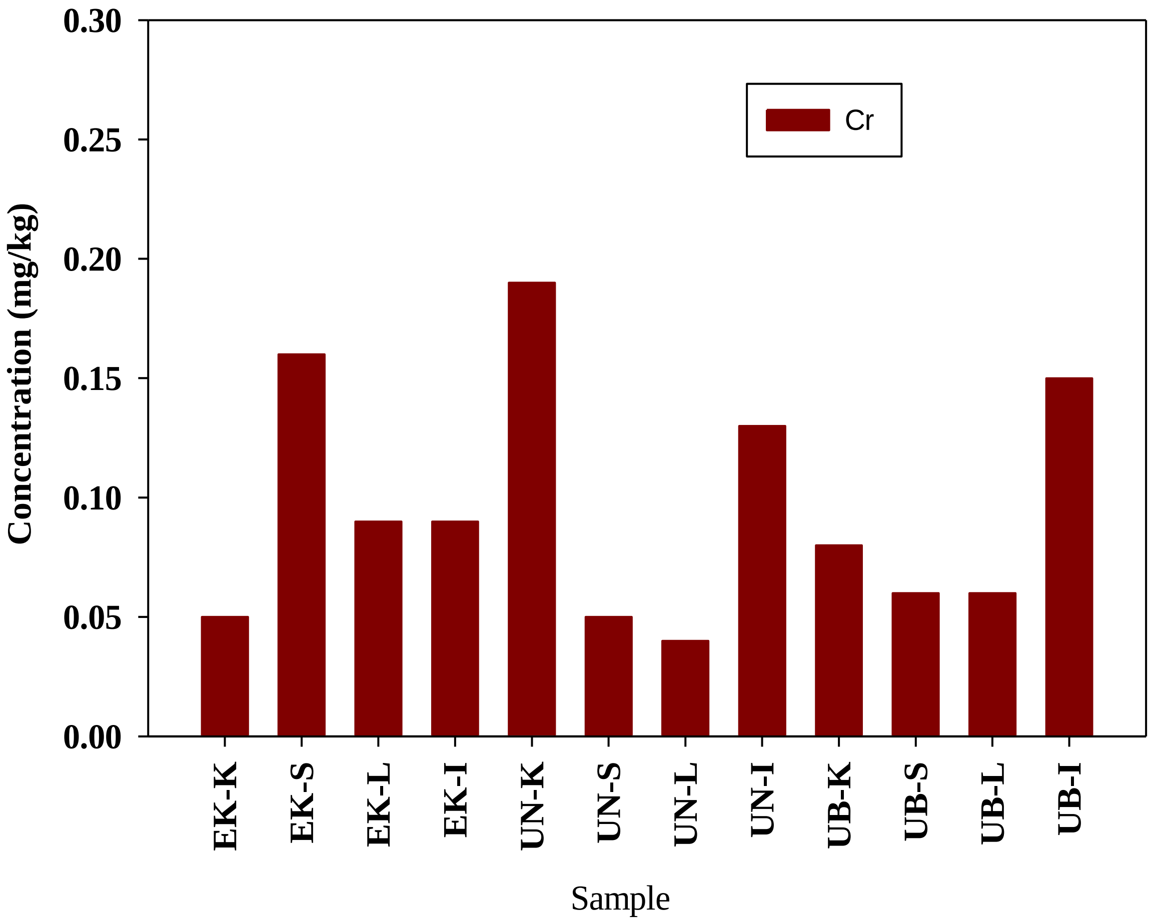

Figure 3.2: Bar chart Concentration of Chromium (mg/kg) in cow offal samples collected during the second sampling.

The repetition of sample collection at two-week intervals was designed to reduce the likelihood of experimental error and to determine whether contamination was incidental or persistent. The similarity in results across both rounds demonstrates that chromium contamination is not random but recurrent, strongly suggesting a stable source of exposure. Possible contributors include contaminated livestock feed, water supplies, or environmental pollution from agricultural or industrial activities.

As observed in both collections, the kidney consistently showed the highest accumulation of chromium, with concentrations reaching 0.19 mg/kg in the second sampling. This finding is expected, given the kidney's central role in the filtration and excretion of metals. The intestines also recorded elevated values**,** likely reflecting direct contact with ingested contaminants. Conversely, the tripe and liver exhibited relatively lower concentrations, though still above the threshold of concern in some cases.

3.2.1.1 COMPARISON WITH WHO LIMIT

The values obtained from both sets of samples were compared with the World Health Organization permissible limit of 0.05mg/kg.

This comparison provides insight into whether the levels found in cow organs pose potential risks to consumers and helps determine the extent to which the recorded concentrations exceed internationally recognized safety standards.

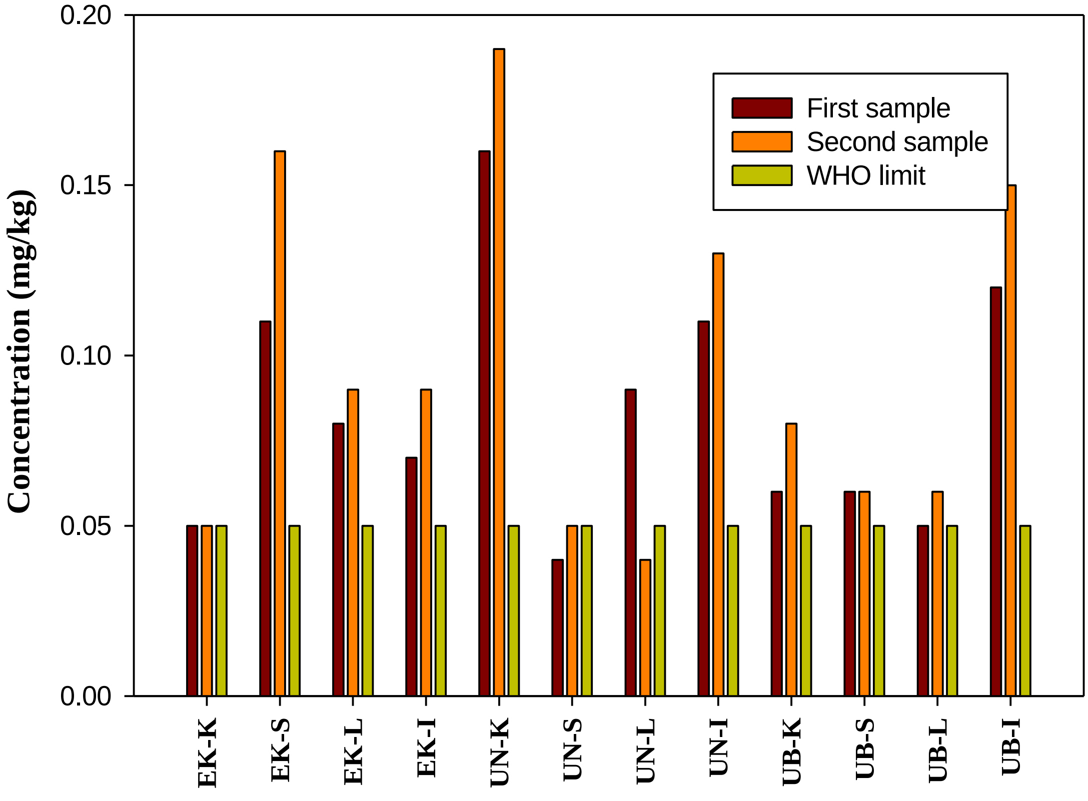

Figure 3.3: Bar chart Concentration of Chromium (mg/kg) in cow offal samples collected during the two sampling period compared with WHO limit.

When benchmarked against the WHO-referenced permissible limit of 0.05 mg/kg for chromium in meats (Ihedioha *et al*., 2014;), many of the recorded values either met or exceeded safety guidelines. Repeated detection at or above this limit across both sampling periods highlights a potential public health risk**,** particularly for populations with high consumption of organ meats. Chronic dietary exposure to elevated chromium has been linked to oxidative stress, gastrointestinal irritation, kidney dysfunction, and liver toxicity (Martins *et al*., 2021).

The findings therefore emphasize the urgent need for continuous monitoring of meat products**,** regulation of livestock rearing practices, and public sensitization on the risks of heavy metal contamination in foods. Since chromium is an essential trace element at very low levels, but toxic at higher concentrations, maintaining the delicate balance between nutritional benefit and toxicological risk remains a major public health priority.

3.2.2 LEAD (Pb)

The determination of lead concentrations in edible animal tissues collected from Ekosodin, UBTH, and UNIBEN during two sampling periods revealed notable spatial and temporal variations. In the first sampling period, lead was not detected in any kidney or liver samples, suggesting minimal contamination at that time or possibly efficient detoxification and excretion mechanisms in the sampled animals. Trace amounts were only observed in tripe (NOT DETECTED –0.01 mg/kg) and intestines (NOT DETECTED – 0.02 mg/kg), which could reflect low-level environmental exposure, likely originating from feed, water, or surrounding soil.

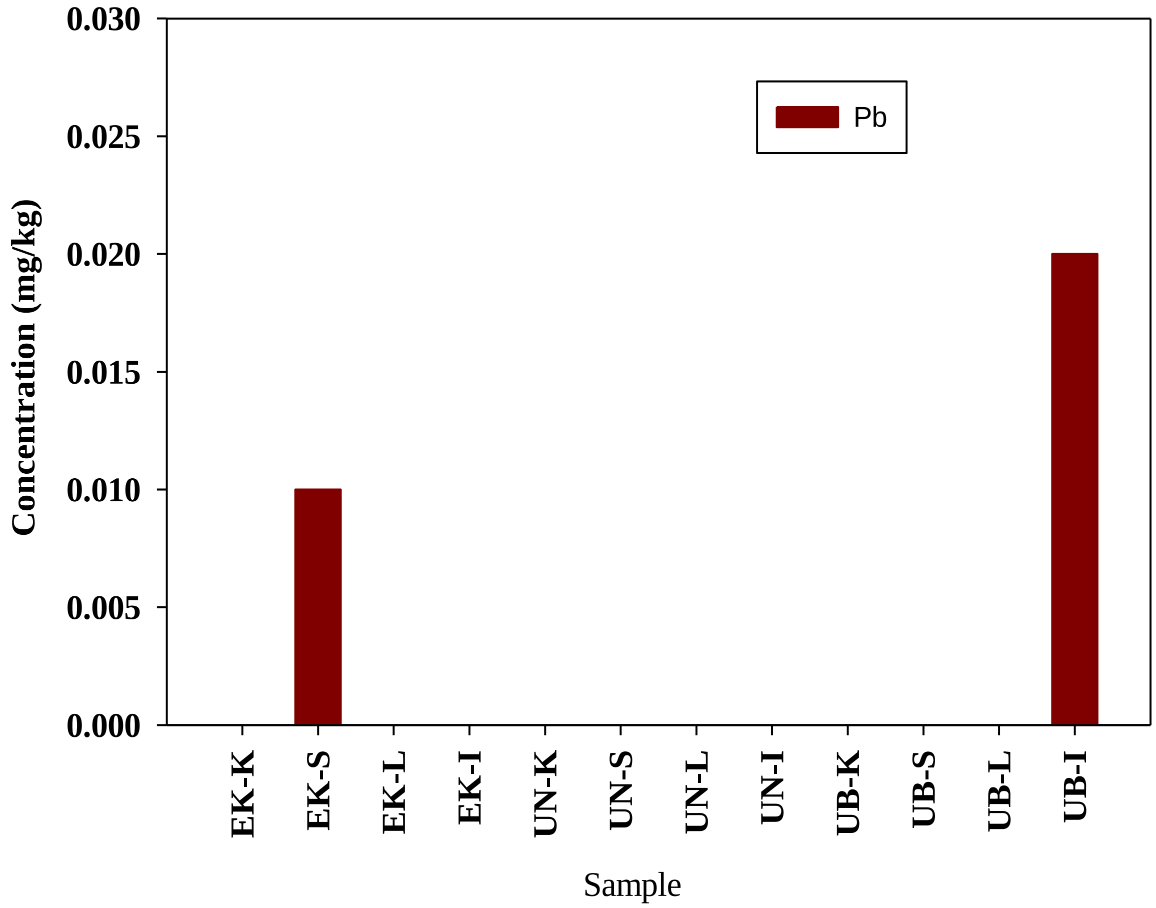

Figure 3.4: Bar chart Concentration of Lead (mg/kg) in cow offal samples collected during the first sampling.

By contrast, the second sampling period showed a marked increase in contamination levels. Lead was detected in most kidney samples (0.01–0.1 mg/kg) and in tripe, liver, and intestines (NOT DETECTED –0.01 mg/kg each).

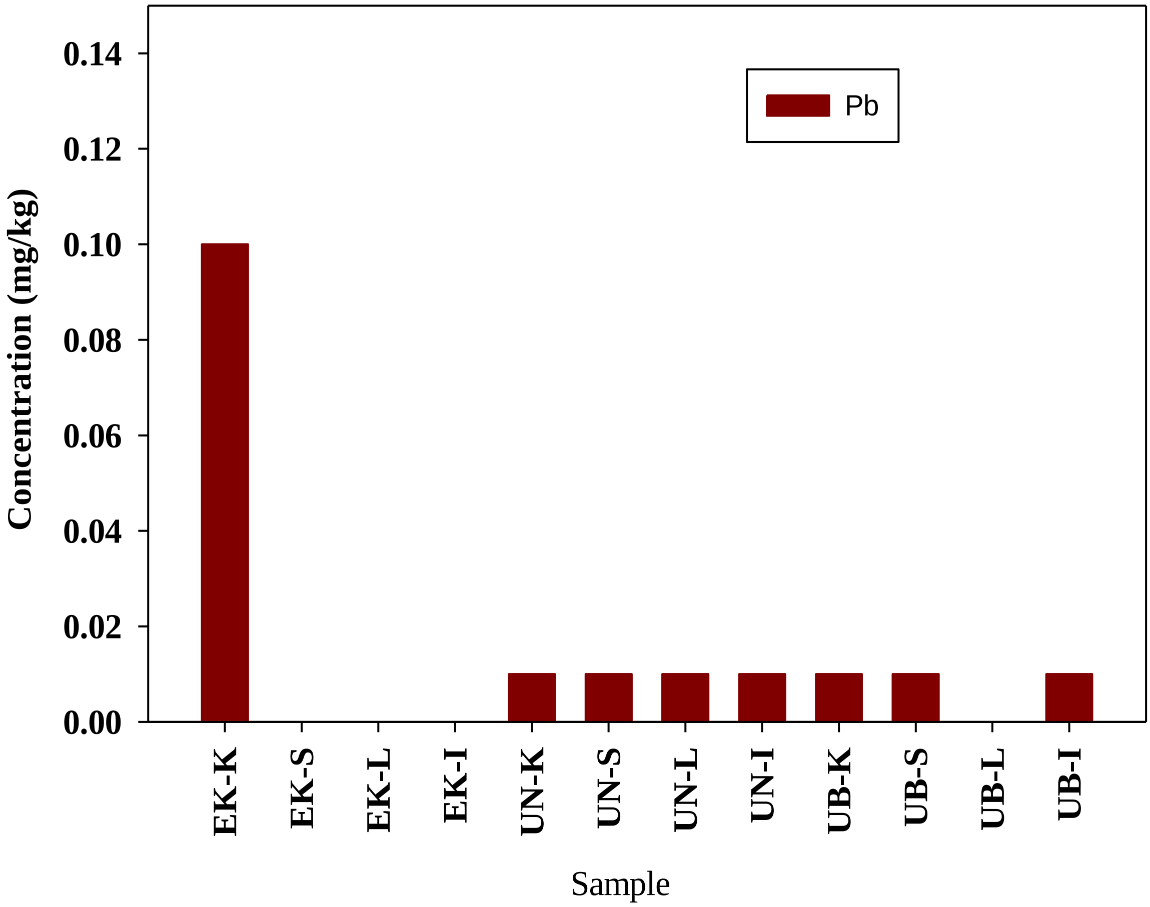

Figure 3.5: Bar chart Concentration of Lead (mg/kg) in cow offal samples collected during the second sampling.

The kidney's higher values are consistent with its role as a primary organ for heavy metal accumulation and excretion. The presence of lead in multiple tissue types across different locations during this period suggests either a change in environmental conditions such as increased pollution from vehicular emissions, industrial activities, or contaminated water sources or possible differences in animal feeding practices between the two collection times.

The concentrations observed, while still relatively low, raise potential concerns about bioaccumulation and food safety. The differences between locations (Ekosodin, UBTH, and UNIBEN) and periods also highlight the need for continuous monitoring to identify specific contamination sources and assess potential risks to public health.

3.2.2.1 COMPARISON WITH WHO LIMIT

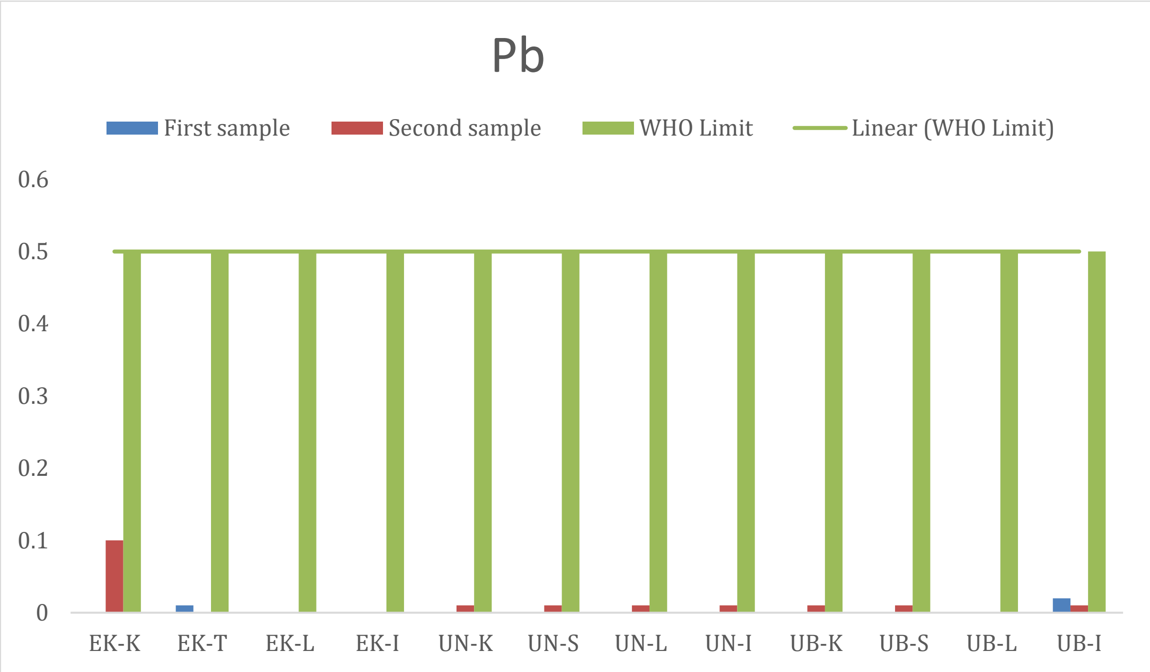

Figure 3.6: Bar chart Concentration of Chromium (mg/kg) in cow offal samples collected during the two sampling period compared with WHO limit.

The FAO/WHO Joint Expert Committee on Food Additives (JECFA) and Codex Alimentarius establish a maximum permissible level for lead in edible offals such as liver, kidney, tripe, and intestines at 0.5 mg/kg to minimize chronic lead exposure risks through diet (Codex Alimentarius Commission 1995; JECFA, 2010). This standard helps ensure food safety by limiting lead content in commonly consumed animal products.

In the two sampling rounds conducted at Ekosodin, Uniben, and UBTH abattoirs, lead concentrations detected in cow offals ranged from 0.01 to 0.10 mg/kg, all well below the recommended threshold. Initial sampling detected lead only in tripe (0.01 mg/kg) and intestine (0.02 mg/kg), while the second sampling showed slightly higher but still acceptable levels, including 0.10 mg/kg in liver samples.

These findings indicate that the offal sampled are within internationally accepted safety limits and can be considered safe for human consumption regarding lead contamination. However, given lead's cumulative toxicity, continuous monitoring remains crucial.

According to WHO, lead exposure poses significant health risks, even at low levels, affecting multiple organ systems, especially the nervous system, kidneys, and hematopoietic system (WHO et.al., 2010). Lead is a potent neurotoxin that can impair cognitive development in children and cause cardiovascular, renal, and reproductive issues in adults.

In this context, while detected levels in the offal are below the Codex limit, cumulative intake from multiple sources may pose risks. Thus, adherence to safe limits and regular surveillance of lead in food remain essential to protect public health.

3.3 RECOMMENDATION

To ensure food safety and protect public health, routine monitoring of heavy metals in cow offal from abattoirs such as Ekosodin, Uniben, and UBTH should be conducted (Ihedioha et al., 2014; Martins et al., 2021). Regulatory agencies need to enforce compliance with international standards like those of WHO and Codex Alimentarius (WHO, 2011; FAO/WHO, 2019). Environmental assessments of the abattoir surroundings, including soil, water, and livestock feed, are important to identify and control contamination sources (MedDocs, 2020). Public awareness campaigns should educate consumers about the risks of heavy metal exposure from offal consumption and promote dietary diversification (Martins et al., 2021). Additionally, further research with larger sample sizes and investigation of other toxic metals is necessary to better understand contamination patterns and potential health risks (Ihedioha et al., 2014).

3.4 CONCLUSION

The analysis of cow offals (liver, kidney, tripe, and intestine) collected from Ekosodin, Uniben, and UBTH abattoirs revealed detectable levels of lead and chromium, with chromium found in all samples and lead detected in several, especially in the second sampling. While all lead concentrations were below the Codex/JECFA permissible limit of 0.5mg/kg (Codex Alimentarius Commission, 1995; JECFA, 2010), many chromium levels exceeded the WHO-referenced safety threshold of 0.05 mg/kg (Ihedioha et al., 2014).

This indicates a possible contamination pathway, either environmental (soil, water, feed) or processing-related, and raises concern for chronic exposure to heavy metals via offal consumption. Even low levels of repeated intake may lead to bioaccumulation and health complications such as kidney and liver damage, neurotoxicity, and oxidative stress (Martins et al., 2021; WHO, 2010).

REFERENCES

Afzal, M., & Mahreen. (2024). Emerging insights into the impacts of heavy metals exposure on health, reproductive and productive performance of livestock. Environmental Science and Pollution Research, 31, 12345–12360.

Alloway, B.J., (2013):. Heavy metals in soils: trace metals and metalloids in soils and their bioavailability. 3rd Ed. Dordrecht: Springer.

CDC, 2006. Preventing lead poisoning in young children. Atlanta: Centers for Disease Control and Prevention.

CDC, 2021. Blood lead reference value. Atlanta: Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (2022). Lead poisoning prevention. CDC.

Codex Alimentarius Commission. (1995). General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995). FAO/WHO.

Darwish, M., El-Sheikh, M.A. and Ahmed, S., (2023): Heavy metal contamination in environmental and food sources: A review. Environmental Science and Pollution Research, 30(12), pp.12345-12360.

Das, P., Samantaray, S., Rout, G.R. Studies on cadmium toxicity in plants : A review. Environmental Pollution 1997, 98, 29-36.

Edwards, J.R. and Prozialeck, W.C., 2009. Cadmium, diabetes and chronic kidney disease. Toxicol Appl Pharmacol, 238(3), pp.289-293.

El Kamel, A. (2021). Pollutants—Focus on solving environmental pollution problems. Pollutants, 1(1), 65.

Flora, S.J.S., Mittal, M. and Mehta, A., 2008. Heavy metal induced oxidative stress & its possible reversal by chelation therapy. Indian Journal of Medical.

Health Canada, 2010. Lead in consumer products. Ottawa: Health Canada.

Hussain, S. *et al.*, 2012. Cadmium toxicity in plants: Impacts and remediation strategies. Environmental Science and Pollution Research, 29(3), pp.324–338.

Hussain, M. (1998). Environment and Pollution. New Delhi: Anmol Publications.

Ihedioha JN, Okoye COB, Onyechi UA. Health risk assessment of zinc, chromium, and nickel from cow meat consumption in an urban Nigerian population. Int J Occup Environ Health. 2014;20(3):215–220.

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals.

Jankeaw, M., Tongphanpharn, N., Khomrat, R., Boonthai Iwai, C. & Pakvilai, N. (2015) 'Heavy Metal Contamination in Meat and Crustacean Products from Thailand Local Markets', International Journal of Environmental and Rural Development, 6(2), pp. 153-158.

Joint FAO/WHO Expert Committee on Food Additives (JECFA). (2010). Lead (Food Additives Series 44).

Krishnamurti, C.R., 1987. Toxic metals in the environment: Part I – Principles and concepts. New York: Marcel Dekker.

Landrigan, P.J., *et al*., 2017. Pollution and health: a global review. Microorganisms for Sustainable Environment and Health.

Lara-Torres, L.C., Martínez-Gutiérrez, F. and Medina-Ramírez, I.E., 2021. Toxic metals in skin-lightening cosmetics: A review. Environmental Health and Toxicology, 36(4), e2021005.

Łodyga-Chruścińska, E., Dobrzyńska, M.M. and Wrześniok, D., 2017. Risk of exposure to heavy metals from cosmetics. Ecological Chemistry and Engineering S, 24(1), pp.135–146.

Martins AC, Morcillo P, Santos DB. Chromium exposure and toxicity in humans: A review. Environ.Res.2021;192:110294.

MedDocs Online. Heavy metals in slaughtered cow meat in Kaduna State, Nigeria. Ann Epidemiol Public Health. 2020.

Munir, N., Jahangeer, M., Bouyahya, A., El Omari, N., Ghchime, R., Balahbib, A., et al. (2022). Heavy Metal Contamination of Natural Foods Is a Serious Health Issue: A Review. Sustainability, 14(1), 161.

Muralikrishna, I.V. and Manickam, V., 2017. Environmental Management: Science and Engineering for Industry. 2nd ed. New Delhi: New Age International Publishers.

Navarro-Tapia, E., Tresserra-Rimbau, A. and Milà-Villarroel, R., 2017. Presence of toxic elements in cosmetics and personal care products: A systematic review. Environmental Research, 156, pp.452–464.

NHANES, 2011–2014. National Health and Nutrition Examination Survey. Hyattsville, MD: National Center for Health Statistics.

Nuapia *et al*., 2016. Assessment of heavy metal pollution in surface water and sediments of Wouri River, Cameroon. International Journal of Environmental Monitoring and Analysis, 4(5), pp.190-199.

Pearce, E.N., 2007. Lead toxicity: Health effects and public health concerns. Journal of Clinical Endocrinology & Metabolism, 92(1), pp.15-16.

Pechova, A. and Pavlata, L., 2007. Chromium as an essential nutrient: a review. veterinary medicine, 52(1), pp.1-18.

Reddy, J.M., Wadhwani, A., Saini, M. and Lamba, S., 2011. Effect of mineral deficiency on heavy metal absorption: A review. International Journal of Nutrition and Metabolism, 3(4), pp.32–38.

Sani *et al*., 2017. Sources and effects of zinc pollution in the environment. Journal of Environmental Chemistry and Ecotoxicology, 9(1), pp.1-10.

Singh, L. and Ghosh, M., 2016. Chromium contamination and effect on environment. International Journal of Environmental Sciences, 6(4), pp.692–701.

Spungen, J.H., 2018. Toxicological profile for cadmium. Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta: U.S. Department of Health and Human Services.

Stambulska, U., Piechalak, A. and Tomaszewska, B., 2018. Chromium(VI) toxicity in plants. Ecotoxicology and Environmental Safety, 148, pp.720–729.

Tchounwou, P.B., Yedjou, C.G., Patlolla, A.K., & Sutton, D.J. (2012). Heavy metal toxicity and the environment. Molecular, Clinical and Environmental Toxicology, 101, 133-164.

World Health Organization, 2003. Health risks of heavy metals from long-range transboundary air pollution. Copenhagen: WHO Regional Office for Europe.

Zeinali, T., Mirzaei, M., Kalantari, H., Yari, A. and Ghaneian, M.T., 2022. Chromium (VI) in environmental samples and its health effects: A review. Environmental Monitoring and Assessment, 194(3), p.161.

Zaynab *et al*., 2022. Toxicity of zinc in humans: Health impacts and regulatory perspectives. Environmental Toxicology and Pharmacology, 90, p.103742.